NUREG-0170
VOL. 1

FINAL ENVIRONMENTAL STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY AIR AND OTHER MODES

Docket No. PR-71, 73 (40 FR 23768)

December 1977

Office of Standards Development
U. S. Nuclear Regulatory Commission

Reprinted October 1985

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

December 1977

Docket No. PR-71, 73 (40FR23768)

TO RECIPIENTS OF THE TRANSPORTATION
FINAL ENVIRONMENTAL STATEMENT (NUREG-0170)

Enclosed for your information is a final environmental statement dealing with the transportation of radioactive material by air and other modes. The document has been prepared in support of the Nuclear Regulatory Commission's advanced notice of rule making proceeding published in the Federal Register on June 2, 1975 (40FR23768), a copy of which is enclosed for your use.

Pursuant to the National Environmental Policy Act of 1969 and the Commission's regulations in 10 CFR Part 51 "Licensing and Regulatory Policy and Procedures for Environmental Protection," the Commission's Office of Standards Development issued a draft environmental statement on Transportation in March, 1976. After consideration of the 28 letters of comment received from the public and from Federal, State and local agencies, a final environmental statement on the Transportation of Radioactive Material by Air and Other Modes has been issued and designated NUREG-0170.

Taking into account the conclusions of the final environmental statement, public comments received on the proceeding, and other information, the Nuclear Regulatory Commission will consider the disposition of the rule making proceeding announced on June 2, 1975. Persons with views on the content or conclusions of the final environmental statement which may be helpful to the Commission in its deliberation should file such comments by March 15, 1978, with the U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, Attention: Director, Office of Standards Development. If sufficient need for clarification of the final environmental statement becomes apparent, the Office of Standards Development will consider holding one or more public meetings for this purpose.

Robert B. Minogue

Robert B. Minogue, Director
Office of Standards Development

Enclosures:
1. Advanced Notice of Rule Making Proceeding
2. Final Environmental Statement

NUCLEAR REGULATORY COMMISSION

[10 CFR Parts 71 and 73]

RADIOACTIVE MATERIAL

Packaging and Transportation by Air

Following its organization under the Energy Reorganization Act of 1974 (Public Law 93-438), the Nuclear Regulatory Commission (NRC) has stated its intention of reviewing those of its regulations and procedures pertaining to the licensing and regulation of nuclear facilities and materials which were originally promulgated by the Atomic Energy Commission, with a view to considering what changes should be made. As part of that effort, the NRC is initiating a rule making proceeding concerning the air transportation of radioactive materials, including packaging, with a view to the possible amendment of its regulations in 10 CFR Parts 71 and 73, adopted pursuant to the Atomic Energy Act of 1954, as amended. The NRC considers the re-evaluation of these particular regulations to be especially timely in view of concerns that have been recently expressed by public officials and others as to the safety and security of air shipment of plutonium and other special nuclear materials through highly populated metropolitan areas.

The Department of Transportation (DOT) has overlapping jurisdiction over safety in packaging and transportation by air of radioactive materials under the Transportation of Explosives and Other Dangerous Materials Act (18 U.S.C. 831–835) and the Transportation Safety Act of 1974 (Pub. L. 93–633, 88 Stat. 2156), and the Federal Aviation Administration has similar overlapping jurisdiction under the Federal Aviation Act of 1958 (49 U.S.C. 1421–1430, 1472(b)). It is expected that the expertise of these agencies will be utilized in the subject rule making proceeding.

Background of present regulations. Following a prohibition against shipment of radioactive material by mail in 1936 to protect unexposed film, safety regulations for shipping radioactive material were adopted by the Interstate Commerce Commission in 1948. Those regulations were based on a report of a National Academy of Sciences–National Research Council Subcommittee on Transportation of Radioactive Material. The basic principles reflected in those regulations were reviewed and adopted, with minor modifications and some elaboration, by the International Atomic Energy Agency (IAEA) in 1961 and reflected in recommended International Standards for the Safe Transport of Radioactive Material. In 1964, on the basis of shipping experience up to that date and an analysis of transportation accidents prepared by the United Kingdom Atomic Energy Authority, the IAEA issued revised transport regulations incorporating specific accident damage test standards which were incorporated into the NRC (then AEC) and DOT (then within the jurisdiction of the ICC) regulations by 1968. Except for changes in the regulations to deal with specific problems (e.g., leak testing of packages containing liquids, prompt pickup and monitoring of packages, restrictions on shipments of plutonium on passenger aircraft, opening and closing procedures), the safety regulations have remained essentially the same since that time.

The safety standards for transportation, as set forth in NRC's regulation in 10 CFR Part 71 and DOT regulations in 49 CFR Parts 170–178, are based on two main considerations: (1) Protection of the public from external radiation and (2) assurance that the contents are unlikely to be released during either normal or accident conditions of transport or, if the container is not designed to withstand accidents, that its contents are so limited in quantity as to preclude a significant radiation safety problem if released. These safety standards are applicable to packages used in all models of transport and were developed with the objective of providing an acceptable level of safety for transport of radioactive material by any mode.[1] With respect to air shipments, it was considered that, taking into account the high integrity of the packaging[2] and the low accident probability for air transportation (no more than one accident per 100 million miles, the risk of an air accident resulting in a release of radioactive material from a package was small.

NRC packaging standards are applicable to shipments by NRC licensees, while DOT regulations are applicable to transportation of radioactive material by land in interstate and foreign commerce, on civil aircraft, and on water. DOT regulations in Title 49 of the Code of Federal Regulations and FAA regulations in 14 CFR Part 103 cover labeling and conditions for shipment and carriage as well as certain packaging. NRC regulations exempt carriers from their application in view of the controls exercised over carriers by DOT and its component parts, including FAA.

For the purpose of developing and implementing consistent, comprehensive and effective regulations for the safe transport of radioactive material and to avoid duplication, the DOT (then ICC) and the AEC (NRC's predecessor) entered into a Memorandum of Understanding in 1966 which was superseded by a revised Memorandum of Understanding signed on March 22, 1973. Under the revised memorandum, the AEC (now NRC) develops performance standards for package designs and reviews package designs for Type B[3] fissile and large quantity packages. The DOT develops safety standards governing handling and storage of all radioactive material packages while in possession of a common, contract or private carrier, as well as standards for Type A packages.[4] DOT requires AEC (now NRC) approval prior to use of all Type B, fissile and large quantity package designs. DOT is the National Competent Authority with respect to foreign shipments under the IAEA transport standards. IAEA Certificates of Competent Authority are issued by DOT with technical assistance provided by NRC as requested.

Re-evaluation of present regulations. Consistent with the considerations expressed in the first paragraph of this notice, the NRC has decided that its regulations governing air transportation of radioactive material, including packaging, should be re-evaluated from the standpoint of radiological health safety and prevention of diversion and sabotage as well. In connection with this re-evaluation, the NRC has instructed its staff to commence preparation of a generic environmental impact statement on the air transportation of radioactive materials, including packaging and related ground transportation. The statement will be directed at air transportation. However other transportation modes—land and water transport—will be considered in light of the requirement of the National Environmental Policy Act of 1969 (NEPA) that the relative costs and benefits of alternatives to certain proposed Federal actions be fully considered. It is anticipated that the draft generic environmental impact statement will be available by the time that any proposed changes to the regulations eventuating from this rule making proceeding are published for comment in the FEDERAL REGISTER. While the generic impact statement is in preparation, impact statements or impact appraisals for individual NRC licensing actions related to the transportation of radioactive materials, such as import licenses for significant quantities of plutonium and other special nuclear material, will be prepared as required by NEPA and 10 CFR Part 51.

In order to aid the NRC in this re-evaluation of existing regulations pertaining to radioactive material transported by air, interested persons are invited to submit information, comments and suggestions with respect to those aspects of the above-referenced NRC regulations. The NRC is particularly interested in receiving views on the following:

1. Whether radioactive materials should continue to be transported by air, considering the need for, and the benefits derived from such transportation, the risks to public health and safety and the common defense and security associated with such transportation, and the relative risks and benefits of other modes of transport.

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[1] In contrast to the safety standards described above, NRC's requirements for the physical protection (security) of strategic quantities of special nuclear material, including plutonium, in 10 CFR Part 73, are specific as to the mode of transport.

[2] Container designs required to meet accident conditions are evaluated under current regulations against the following accident test conditions in sequence: 30-foot free drop of the container in the most damaging position onto a flat, essentially unyielding surface, 40-inch drop onto a steel bar to test the ability to withstand puncture, 30-minute fire test at 1475° F and 3-foot water immersion test for eight hours. The puncture test and the drop test are engineering qualification tests. The test conditions were chosen to provide reproducible laboratory conditions representative of severe transportation accident environments. For example, a 30-foot drop onto an unyielding surface produces impact or shock loads which are more severe than drops of several thousand feet onto targets such as land, water, or even city streets which would tend to yield when struck by the package. Because of the conservatism of most designs, packages, when subjected to tests involving free fall from much greater heights than 30-feet, have either remained undamaged or continued to contain their contents. For example, a number of packages which pass the NRC qualification tests have also been tested under extra severe conditions such as a 250-foot free fall onto an essentially unyielding surface. Packages currently approved for bulk shipment of plutonium oxide and nitrate will survive such test conditions. These extra severe tests provide added assurance that containers in much the same manner as aircraft flight recorders, could survive severe air accidents. A description of these tests is set forth in SC-DR-72 0597 (Sept. 1972), "Special Tests for Plutonium Shipping Containers 6M, SP5795, and L-10", a copy of which is available for public inspection at the Commission's Public Document Room, 1717 H Street NW., Washington, D.C.

[3] A Type B package is required for quantities in excess of a few millicuries and up to 20,000–50,000 curies, depending upon the radionuclide. Such packages are required to be designed to withstand accident conditions as well as normal conditions of transport.

[4] A Type A package is required for less than Type B quantities of radioactive material and is required to be designed to withstand normal conditions of transport only.

2. Assuming a justifiable need for air transportation of radioactive materials, to what extent should safety requirements be based on:

(a) Accident probabilities;

(b) Packaging;

(c) Procedural controls;

(d) Combinations of the above?

3. What is the relative risk of transport of radioactive material by air compared to other modes of transport, and to other hazards faced by the public which may or may not be the subject of regulation?

4. Are improvements in applicable regulations necessary, and if so, what improvements should be considered?

Documentation supporting the views expressed by interested persons would be helpful to the NRC in re-evaluation of its regulations relating to air transportation of radioactive materials and consideration of possible changes to such regulations

It should be noted that there are some related issues which will be, or are presently, the subject of consideration in other rule making proceedings and, therefore, will not be included in this proceeding They are:

1. Physical security protection requirements for strategic quantities of special nuclear material that would apply to all modes of transport (39 FR 40036).

2. Requirements for advance notice of shipments of strategic quantities of special nuclear material (40 FR 15098).

3 Quality assurance requirements for packages for all special nuclear material (38 FR 35190).

4 Radiation levels from radioactive material transported in passenger aircraft.

If it subsequently appears that additional issues should more properly be treated in a separate proceeding, or proceedings, appropriate notices to that effect will be published in the FEDERAL REGISTER.

Interested persons should send comments and suggestions, with supporting documentation, to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Section by August 1, 1975. Copies of comments received may be examined in the NRC Public Document Room at 1717 H Street NW., Washington, D.C.

After comments have been received and considered, the NRC will publish its views as to NRC rules pertaining to air transportation of radioactive material in the FEDERAL REGISTER. When the aforementioned draft environmental impact statement is prepared, notice of its availability will be published in the FEDERAL REGISTER and opportunity for public comment afforded pursuant to NRC regulations implementing the National Environmental Policy Act of 1969 (10 CFR Part 51). In addition, background information on the subject of regulation of transportation of radioactive materials has been placed in the NRC Public Document Room at 1717 H Street NW., and at its local public document rooms throughout the nation. Copies of such background information are available upon request in writing to the Office of Standards Development, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

Interim evaluation. Recently there have been several requests that air shipments of plutonium and other special nuclear materials (and related ground transportation of special nuclear materials incidental thereto) be suspended pending reexamination of presently applicable regulations In assessing the appropriateness of such action at this time, the NRC has considered the following:

1. In more than 25 years of shipping special nuclear material, including plutonium, in civilian aircraft, there have been no air accidents involving the material

2 The experience in shipping thousands of packages per year of all forms of radioactive materials by all modes of transport under existing NRC, DOT, and FAA regulations has been very favorable.

3 The requests that have been received do not set forth any significant new information which would indicate that present package or security requirements are inadequate.

4. In view of the physical security measures now required by 10 CFR Part 73, the protection provided against severe accidents by the high integrity packaging required by NRC, DOT, and FAA regulations (summarized supra), the consistency of these requirements with international standards, the low accident probability (supra), and the favorable experience to date, the risk involved in the transportation of radioactive material under currently effective regulations is believed to be small.

Accordingly, it is presently the view of the NRC, subject to consideration of comments to be received, that its currently effective regulations can continue to be applicable during the period in which this rule making proceeding is in progress. More particularly, in light of present information as to the safety and security of air shipments of radioactive material, the Commission finds no sound basis, for the reasons stated above, for requiring the suspension of such shipments.

Notwithstanding the foregoing, in view of the concerns expressed and the fact that requests have been received for the suspension of air shipments of plutonium and other special nuclear materials, comments are specifically invited on the matter of whether suspension or other limitations on the air transportation of plutonium and other special nuclear materials are justified during the period that the subject rule making proceeding is being conducted. Views on this particular matter, together with the supporting basis for these views, should be submitted to the Secretary of the Commission, U.S. Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Section by July 2, 1975. The NRC will decide, after evaluating the views and comments received, whether a different course should be pursued during the pendency of this rule making proceeding and publish its conclusions in the FEDERAL REGISTER. Currently effective regulations will continue to be applied until a decision on this matter is made.

As indicated above, related specific issues will be, or are presently, the subject of consideration in other rule making proceedings, and the NRC will continue to take appropriate action, as justified by the circumstances, to assure that the risk associated with the transportation of radioactive materials remains small

Dated at Washington, D.C. this 29th day of May 1975.

For the Nuclear Regulatory Commission.

SAMUEL J CHILK,
Secretary of the Commission

[FR Doc 75-14519 Filed 5-30-75;8:45 am]

NUREG-0170
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Docket No. PR 71, 73 (40 FR 23768)

Manuscript Completed: December 1977
Date Published: December 1977

Office of Standards Development
U. S. Nuclear Regulatory Commission

SUMMARY AND CONCLUSIONS

This Final Environmental Statement was prepared by the staff of the Office of Standards Development of the U. S. Nuclear Regulatory Commission (NRC), Washington, D.C. 20555. Mr. Donald R. Hopkins is the NRC Task Leader for this statement (telephone: 301-443-6910).

1. This action is administrative.

2. This Final Environmental Statement has been prepared in connection with NRC reevaluation of its present regulations governing air transportation of radioactive materials in order to provide sufficient analysis for determining the effectiveness of the present rules and of possible alternatives to these rules. This statement is not associated with any specific rule change at this time but will be used as a partial basis for determining the adequacy of the present transportation regulations. If a rule change results from consideration of this statement, a separate or supplementary environmental statement will be issued with respect to that action.

When NRC was beginning work on this environmental statement, consideration was given to covering all aspects of the environmental impact resulting from the transport of radioactive material by air. At the Federal level, both the NRC and the Department of Transportation, particularly the Federal Aviation Administration (FAA), are involved in regulating the safety of such transport. Therefore, NRC proposed to the FAA that the statement be cosponsored by both agencies and that both the shipper-packaging aspects and the carrier-transport aspects be covered. In a meeting in early 1975, the FAA declined to actively support the development of such a statement. As a result, the scope of the statement was limited to the shipper-packaging aspects. The statement deals with the carrier-transport area only to the extent necessary to determine the influence of the conditions of transport on the shipper-packaging area, e.g., exposures of personnel from packages of radioactive materials under normal and accident conditions.

Development of the statement began with consideration of transport of radioactive materials by air. However, in order to examine the environmental impact of alternatives, other modes of transport were examined, again primarily from the standpoint of the effect such transport would have on packaging as related to exposure of people under both normal and accident conditions. During the development of the statement, special interest arose in the alternative of transporting irradiated nuclear fuel by special trains. Some detail was added in the section on special trains but the statement scope was not sufficiently broad to deal thoroughly with this subject. A separate statement on the use of special trains for transporting irradiated nuclear fuel has been issued by the Interstate Commerce Commission (ICC) with NRC cooperation. Some of the same methodology used in this generic statement is used in the ICC study.

As a result of the limitations on the scope of this generic statement, only limited study of the conditions of transport, carrier controls, and routing has been undertaken. For example, no evaluation has been made of safety aspects of the vehicles or of items related to carrier controls other than those directly affecting the shipper-packaging area.

Except as noted, this statement does not specifically consider facets unique to the urban environment such as high population densities, diurnal variation in population, convergence of transportation routes, shielding effects of buildings, or the effect of local meteorology on accident consequences. A separate study specific to such considerations is being conducted and will result in a separate environmental statement specific to such an urban environment.

This statement was started in May 1975 and was completed prior to President Carter's April 7, 1977, message on nuclear power policy regarding deferral of commercial reprocessing and recycling of plutonium. Therefore, the 1985 projection of numbers and types of nuclear fuel cycle shipments and their environmental impact that has been used in this study reflects the potential development of plutonium recycle to the extent described in the NRC's generic environmental statement on mixed oxide fuel (GESMO). Since the analysis on non-fuel-cycle shipments remains valid, as does the analysis of all 1975 radioactive material shipments, this statement is issued with the caveat that it does not reflect changes in national energy policy originating with the President's April 7, 1977, message.

Although this statement has not been modified to reflect the President's policy message, it is the NRC staff's judgment, based on related analyses, that the results presented as realistic in this statement would continue to be realistic and the conclusions reached would be essentially the same if changes were made in accordance with the President's message.

3. The environmental impact of radioactive material shipments in all modes of transport under the regulations in effect as of June 30, 1975, is summarized as follows:

a. Radiation exposure of transport workers and of members of the general public along the transportation route occurs from the normal permissible radiation emitted from packages in transport. More than half of the 9800 person-rem exposure resulting from 1975 shipments was received by transport workers associated with the shipments. The remaining 4200 person-rems was divided among approximately ten percent of the U.S. population. None of these exposures would produce short-term fatalities. On a statistical basis, expected values for health effects that may result from this exposure are 1.7 genetic effects per year and 1.2 latent cancer fatalities distributed over the 30 years following each year of transporting radioactive material in the United States at 1975 levels (Chapter 4, Section 4.9). More than half of this effect results from the shipment of medical-use radioactive materials where the corresponding benefit is generally accepted (Chapter 1, Table 1-2).

b. Transportation accidents involving packages of radioactive material present potential for radiological exposure to transport workers and to members of the general public. The expected values of the annual radiological impact from such potential exposure are very small, estimated to be about one latent cancer fatality and one genetic effect for two hundred years of shipping at 1975 rates (Chapter 5, Section 5.9). More than two-thirds of that impact is attributable to nuclear fuel cycle and other industrial shipments (Chapter 1, Table 1-2).

c. Radiological impacts from export and import shipments were evaluated separately and were determined to be negligible compared to impacts from domestic shipments (Chapter 5, Section 5.7).

d. The principal nonradiological impacts from the use of resources for packaging materials and from the use of, and accidents involving, a relatively small number of dedicated transport vehicles were found to be two injuries per year and less than one accidental death per four years (Chapter 5, Section 5.8).

e. Examination of the consequences of a major accident and assumed subsequent release of radioactive material indicates that the potential consequences are not severe for most shipments of radioactive material (Chapter 5, Section 5.6). The consequences are limited by one or more parameters: short half-life, nondispersible form, low radiotoxicity. However, in the unlikely event of a major release of plutonium or polonium in a densely populated area, a few individuals could suffer severe radiological consequences. One early fatality would be expected, and as many as 60 persons would be exposed to radiation dose levels sufficient to produce cardiopulmonary insufficiency and fatalities in some cases. The latent cancer fatalities associated statistically with such a major release are estimated to be as many as 150 over a 30-year period (Chapter 5, Section 5.6). Costs for land reclamation associated with such an unlikely accident could range from 250 million to 800 million dollars for 1975 shipments and up to 1.2 billion dollars for 1985 shipments. The probability of such an event is estimated to be no greater than 3×10^{-9} per year for 1975 shipping rates (Chapter 5, Section 5.6). It should be noted that, to obtain the above result, all of the following conditions would have to occur:

(1) A low-probability, extra severe accident would have to involve a vehicle carrying a bulk shipment of plutonium or polonium in an extreme-population-density urban area. There are presently about 20 large-quantity shipments of polonium per year and one of plutonium (Chapter 5, Section 5.2.2);

(2) One or more of the packages of plutonium or polonium that are designed to withstand severe accident conditions would have to be subjected to the highest of the forces developed in the accident so as to cause gross failure of the package and subsequent release of a significant fraction of the radioactive contents from the package (Chapter 5, Section 5.2.3);

(3) The accident would have to create conditions in which plutonium or polonium released from the package would escape from the vehicle in which it was being transported, and a significant amount of material would have to become airborne in respirable form (Appendix A, Section A.4);

(4) The meteorological conditions at the time would have to be such that the plutonium or polonium remains airborne and is dispersed in a way that significant numbers of people would breathe the air containing the material in high concentrations (Chapter 5, Section 5.3); and

(5) Mitigating actions such as evacuation of persons from the area are not taken.

4. Principal alternatives considered are the following:

   a. Transportation mode shifts for various components of the industry (Chapter 6, Section 6.2).

   b. Operational constraints on transport vehicles to minimize accidents (Chapter 6, Section 6.3).

   c. Changes in packaging requirements to minimize release of radioactive materials in an accident (Chapter 6, Section 6.4).

   d. Changes in the physical properties of radioactive materials to minimize consequences in the event of a release (Chapter 6, Section 6.4.1).

Preliminary analyses were made of a number of alternatives to the present regulations and methods of transport. A few of the alternatives examined were found to be cost effective. However, the cost-effective alternatives dealing with changes in mode of transport did not significantly reduce the radiological impact; the others must be analyzed further to determine whether their adoption would reduce the radiological impact and achieve an impact level as low as is reasonably achievable (Chapter 6).

The alternative of reducing the amount of radioactive material transported, either generally or selectively, was not considered on the assumption that the benefits associated with the use of presently transported materials outweigh the small risk of their transportation.

While future rulemaking may depend in part for its justification on the analysis and conclusions of this statement, no rulemaking is proposed with its present issuance. The primary function of this statement is to establish the NRC staff view of the environmental impact of present transportation of radioactive material and of the projected impact in 1985. This statement provides an overview of a number of alternatives to present transportation requirements and of the changes in impact produced by those alternatives. While this overview serves to limit the number of alternatives worthy of further consideration, any detailed study of alternatives in support of rulemaking activities will be considered separately.

The alternatives considered in this statement are limited to those possible with existing transportation systems. While it might be possible to conceptualize new transportation systems that might reduce environmental impact, it is considered unlikely that any could be justified on a cost-benefit basis because of the present low risk.

5. The following Federal, State, and local agencies commented on the Draft Environmental Statement (NUREG-0034) made available in March 1976. Their comments, along with those from other parties, are in Appendix J.

a. Tennessee Valley Authority
b. Department of Health, Education, and Welfare
c. Environmental Protection Agency
d. Department of the Interior
e. Federal Energy Administration
f. Energy Research and Development Administration
g. Department of Transportation
h. State of New Mexico
i. State of New York
j. State of Georgia
k. City of New York

6. A draft of this Final Environmental Statement was made available to the public in February 1977 at the NRC Public Document Room in Washington, D.C., and at NRC's field offices in King of Prussia, Pennsylvania; Atlanta, Georgia; Glen Ellyn, Illinois; Arlington, Texas; and Walnut Creek, California. Public comments received on that draft are contained in Appendix K.

7. This Final Environmental Statement was made available to the public, to the Council on Environmental Quality, and to the above specified agencies in December 1977.

8. On the basis of the analysis and evaluation set forth in this statement and after weighing the small adverse environmental impact resulting from transportation of radioactive materials and the costs and benefits of the alternatives available for reducing or avoiding the adverse environmental effects, the staff concludes that:

a. Maximum radiation exposure of individuals from normal transportation is generally within recommended limits for members of the general public (Chapter 3, Section 3.5). There are transportation operations at a few locations where some transport workers receive radiation exposures in excess of the recommended limits established for members of the general public. In most cases, these operations employ radiation safety personnel to establish safe procedures and to train and monitor transport workers as though they were radiation workers.

b. The average radiation dose to the population at risk from normal transportation is a small fraction of the limits recommended for members of the general public from all sources of radiation other than natural and medical sources (Chapter 3, Section 3.5) and is a small fraction of natural background dose (Chapter 3, Section 3.3).

c. The radiological risk from accidents in transportation is small, amounting to about one-half percent of the normal transportation risk on an annual basis (Chapter 4, Section 4.9).

d. For the types and numbers of radioactive material shipments now being made or projected for 1985, there is no substantial difference in environmental impact from air transport as opposed to that of other transport modes (Chapter 4, Tables 4-15 and 4-17 and Appendix I, Table I-9).

e. Based on the above conclusions, the NRC staff has determined that the environmental impacts of normal transportation of radioactive material and the risks attendant to accidents involving radioactive material shipments are sufficiently small to allow continued shipments by all modes. Because transportation conducted under present regulations provides adequate safety to the public, the staff concludes that no immediate changes to the regulations are needed at this time. The staff has already upgraded its regulations on transportation quality assurance while this environmental statement was being prepared and has begun studies of transportation through urban areas and of emergency response to transportation accidents and incidents. In addition, the staff is continuing to study other aspects of transportation, such as the accident resistance of packages and the physical/chemical form of the radioactive contents, to maintain the present high level of safety and to determine the cost-effectiveness of changes that could further reduce transportation risk.

9. Based on considerations related to security and safeguards for strategic special nuclear materials (uranium enriched to 20% or more in the U-235 isotope, U-233, and plutonium), spent fuel, and other radioactive materials in transit, the staff concludes that:

a. Existing physical security requirements are adequate to protect at a minimum against theft or sabotage of significant quantities of strategic special nuclear materials in transit by a postulated threat consisting of an internal threat of one employee occupying any position and an external threat of a determined violent assault by several well-armed, well-trained persons who might possess inside knowledge or assistance.

b. The level of protection provided by these requirements reasonably ensures that transportation of strategic special nuclear material does not endanger the public health and safety or common defense and security. However, prudence dictates that safeguards policy be subject to close and continuing review. Thus, the NRC is conducting a public rulemaking proceeding to consider upgraded interim requirements and longer-term upgrading actions. The objective of the forthcoming rulemaking proceeding is to consider additional safeguards measures to counter the hypothetical threats of internal conspiracies among licensee employees and determined violent assaults that would be more severe than those postulated in evaluating the adequacy of current safeguards.

c. The use of the ERDA (now the Department of Energy (DOE)) transport system is not, at this time, considered to be necessary for the protection of significant quantities of privately owned strategic special nuclear material because the present level of transport protection provided by the licensed industry is considered to be comparable to that presently required by ERDA (DOE). Similarly, the use of Department of Defense escorts is not presently needed to protect domestic shipments against the postulated threat because the physical protection deemed necessary to defeat this threat can and is being provided by the private sector.

d. Shipments of radioactive materials not now covered by NRC physical protection requirements, such as spent fuel (containing fission products and irradiated special nuclear materials) and large-source nonfissile radioisotopes, do not constitute a threat to the public health and safety either because of their limited potential for misuse (due in part to the hazardous radiation levels that preclude direct handling) or because of the protection afforded by safety provisions, e.g., shipping containers.

Based on the above conclusions, the NRC staff has determined that the risks of successful theft of a significant quantity of strategic special nuclear material or sabotage of radioactive materials in transit resulting in a significant radiological release are sufficiently small to constitute no major adverse impact on the environment.

10. The validity of the risk assessment has been seriously challenged within the NRC staff. The challenge is with respect to the assessment of the overall level of accident risk and the relative levels of risk of the various types of shipments on which the total accident risk is based. The challenge results from the acknowledged conservative assumptions used in the accident assessment where valid data are not available to support more realistic values for certain parameters. Principal among these are package release fractions (Chapter 5, Table 5-8), particle size (Appendix A, Table A-7), fraction of released materials becoming airborne (Appendix A, Table A-7), and areas contained within dose isopleths (Chapter 5, Figure 5-7). These assumptions are not applied uniformly in the accident analysis over the various types of shipments (e.g., more data is available on plutonium shipment behavior in an accident situation than is available for polonium shipments; therefore, more conservative assumptions were applied to the polonium accident assessment). The resulting challenge is that the assessment is excessively conservative and shows the total accident risk to be greater than a more realistic assessment would show and that the values of risk assessed for different types of shipments may incorrectly show that certain types of shipments are more hazardous than others. However, since the conclusion drawn from the accident assessment is simply that the total accident risk is small compared to the normal transportation risk, the assessment is considered to support that limited conclusion and therefore to be adequate for that purpose, at this time. Nonetheless, further studies to develop additional data and refine the assessments are planned for the future; some are already underway in connection with the generic study on Transport of Radionuclides in Urban Environs and other detailed accident studies. Furthermore, rulemaking actions to reduce the risk in specific areas will not be taken until a more realistic risk assessment has been completed and the specific costs and the benefits have been evaluated.

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DETAILED SUMMARY

INTRODUCTION

This document is an assessment of the environmental impact from transportation of shipments of radioactive material into, within, and out of the United States. It is intended to serve as background material for a review by the United States Nuclear Regulatory Commission (NRC) of regulations dealing with transportation of radioactive materials. The impetus for such a review results not only from a general need to examine regulations to ensure their continuing consistency with the goal of limiting radiological impact to a level that is as low as reasonably achievable, but also from a need to respond to current national discussions of the safety and security aspects of nuclear fuel cycle materials.

The report consists of eight chapters and related appendices. The structure of the report and its content are indicated in the following outline of its chapters:

1. Introduction - The background of the study, uses of radioactive materials, and shipping activities in various major segments of the nuclear industry are discussed.

2. The Regulations Governing the Transportation of Radioactive Materials - The regulations are reviewed together with supporting information indicating the intent and basis for many of the transportation safety regulations.

3. Radiological Effects - The mechanism for radiological impact, the appropriate protection guidelines, and the health effects model used in this assessment are discussed.

4. Transport Impacts Under Normal Conditions - The environmental impacts, both radiological and nonradiological, that result from normal transportation are assessed in terms of a standard shipments model designed to represent current transport conditions.

5. Impacts of Transportation Accidents - The radiological and nonradiological impacts that result from accidents involving vehicles carrying radioactive material shipments are discussed.

6. Alternatives - Assessment is made of differences in radiological impact that would result from modifying the transport mode of certain shipments, adding operational constraints, changing form and quantity restrictions, and raising packaging standards. Cost-benefit tradeoffs are discussed.

7. Security and Safeguards - The need for security of certain radioactive material shipments is discussed together with an assessment of the present physical security requirements applied to various modes of transport.

8. Comments on NUREG-0034 and Major Changes That Have Occurred Since NUREG-0034 was Issued - Major changes from the draft assessment (NUREG-0034) are identified.

DESCRIPTION OF THE ENVIRONMENTAL IMPACT OF EXISTING ACTIVITIES

The environmental impact of radioactive material transport can be described in three distinct parts: the radiological impact from normal transport, the risk of radiological effects from accidents involving vehicles carrying radioactive material shipments, and all nonradiological impacts.

Radiological impacts in normal transport occur continuously as a result of radiation emitted from packages both aboard vehicles in transport and in associated storage. The radiation exposure of specific population groups such as crew, passengers, flight attendants, and bystanders is calculated in the report using a computer model that considers, for the principal radionuclides shipped, radiation exposure rates, shipment information, traffic data, and transport mode splits. Using this computer model, it was estimated that the total annual population exposure resulting from normal transport is about 9790 person-rem. The largest percentage of this population exposure (some 52%) results from the shipment of medical-use radionuclides. The remaining portion results from industrial shipments (about 24%), nuclear fuel cycle shipments (8%), and waste shipments (15%). Shipments by truck produce the largest population exposure, resulting from relatively long exposure times at low radiation levels of truck crew and large numbers of people surrounding transport links.

The individual radiation exposures in all modes are generally at low radiation levels and in most cases take on the character of a slight increase in background radiation. The analysis shows that radiation exposure from normal transportation, averaged over the persons exposed, amounts to 0.5 millirem per year compared to the average natural background exposure of about 100 millirem per year. Based on the conservative linear radiation dose hypothesis, this would result in a total of 1.2 latent cancers distributed statistically over the 30 years following each year of transporting radioactive material in the United States at 1975 levels. This can be compared to the existing rate of more than 300,000 cancer fatalities per year from all causes.

In the accident case, risk to the population from accidents involving vehicles carrying radioactive materials was estimated in terms of the number of latent cancer fatalities and early deaths that might occur on annual and single-accident bases. The analysis resulted in estimates of annual societal risk of 5.4×10^{-3} latent cancer fatalities and 5×10^{-4} early fatalities for each year of shipments at 1975 levels. These values can be compared to the 1100 (in 1969) early fatalities from electrocution each year. The latent cancer fatalities from transport accidents are related principally to industrial and fuel cycle shipments rather than to medical shipments, which are the dominant causes of latent cancer fatalities related to normal transport. This results principally from the larger quantities of more toxic materials associated with industrial and fuel cycle shipments.

In spite of their low annual risk, specific accidents occurring in very-high-density urban population zones can produce as many as one early fatality, 150 latent cancer fatalities, and decontamination costs estimated to range from 250 million to 800 million dollars for 1975 shipments and from 250 million to 1.2 billion dollars for 1985 shipments (1975 dollars). Although such accidents are possible, their probability of occurrence is very small (estimated to be no greater than 3×10^{-9} per year based on 1975 shipping rates).

Nonradiological impacts on safety were estimated to be two injuries per year and one fatality every five years from accidents involving vehicles used for the exclusive-use transport of nuclear materials. Accidents involving vehicles carrying radioactive materials in conjunction with carriage of other goods are not considered to be chargeable as radioactive material shipments since the total number of radioactive material packages transported annually is less than 10^{-5} of all goods transported annually in this manner.

RELATIONSHIP OF PROPOSED ACTIVITIES TO OTHER GOVERNMENT ACTIVITIES

Safety and safeguarding of radioactive material shipping is regulated by the NRC and the Department of Transportation in conjunction with cooperating State agencies. The interaction of these agencies is governed by either an agreement or a Memorandum of Understanding that defines the coordination of their activities.

PROBABLE IMPACT OF PROPOSED ACTIONS ON THE ENVIRONMENT

Any rule changes proposed as a result of this environmental assessment will be proposed in a future action. The impact on the environment of those rule changes will be considered separately with that action.

ALTERNATIVES TO EXISTING ACTIVITIES

Alternatives to the existing practices in the shipment of radioactive material are discussed in Chapter 6. Mode shifts, operational constraints, and package standards revisions were found to produce only small changes in the population exposure associated with normal transportation. Although large percentage decreases in the existing risk from transportation accidents result from some of these alternatives, the significance of these decreases is lessened by the following considerations:

1. Because the existing risk (annual early deaths plus latent cancer fatalities) from transportation accidents is a small percentage of the risk from normal transportation, large decreases in accident risk result in insignificant changes in the total (accident plus normal) risk; and

2. Because the existing risk from transportation accidents is so small, large relative decreases are actually small absolute decreases in effects (e.g., reduction in numbers of deaths or illnesses).

Where the cost-benefit ratio for an alternative is adverse, i.e., where the social and economic costs outweigh the decreases in environmental impact, better alternatives should be sought. It has been found, for example, that risk from an accident involving plutonium or polonium-210 is reduced by changing the physical form of these materials. This technique may be capable of producing a decrease in accident risk of 0.005 latent cancer fatalities per year (a 30% reduction) for large shipments of highly toxic materials. Detailed information on the feasibility of this alternative is not yet adequate to permit the determination of its associated costs.

UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

The principal unavoidable environmental effect was found to be the population exposure resulting from normal transport of radioactive materials. Since the electromagnetic radiation emitted from a package cannot be reduced to zero by any finite quantity of shielding, the transport of radioactive materials will always result in some population exposure.

The much smaller unavoidable risk from accidents that have the potential for releasing radioactive material from packages will always be present but such accidents have a very small probability of occurrence.

The unavoidable nonradiological impact resulting from transport of radioactive material in exclusive-use vehicles amounts to about two injuries and one fatality every five years, mostly from accidents involving transportation of fuel and waste to and from nuclear power plants. This is because exclusive-use vehicles are predominantly used for such shipments. Other nonradiological impacts such as the use of vehicle fuel and other resources were found to be insignificant.

SHORT-TERM USE OF THE ENVIRONMENT VERSUS LONG-TERM POSITIVE EFFECTS

The most obvious and important short-term effect is the population radiation exposure from normal transport, which statistically amounts to 1.2 latent cancer fatalities per year. An additional short-term effect is the small annual accident risk.

Balanced against these risks are long-term positive results from the shipment of radioactive material in such areas as:

1. National Health - The use of radiopharmaceuticals in the diagnosis and treatment of illnesses provides a benefit in lives saved.

2. Oil Exploration - The use of radioactive material in well logging and flow tracing provides technology for intelligent exploitation of our oil resources and aids in optimizing the use of this valuable national energy resource.

3. Quality Control - The use of radionuclides for gauging the thicknesses of metal and paper, measuring product density, and locating levels of contents in small packages and in large holding tanks provides a capability to minimize waste of resources and optimize quality in finished goods.

4. Electricity Generation - The use of nuclear fuels in reactors allows production of electricity for society with lower fuel costs and lower levels of chemical pollutants to the environment than is possible by more conventional methods of generating electricity.

5. Industry - Radionuclides are used in many manufactured devices and consumer products ranging from home smoke detectors to antistatic devices.

IRREVERSIBLE COMMITMENT OF RESOURCES

The only irreversible commitment of resources determined in this assessment was that resulting from use of fuels to operate the transportation network. To the extent that the resources are committed to the transportation of radioactive materials alone, the quantity of fuels used is an infinitesimal quantity, since transportation of radioactive material normally occurs incidental to the movement of general goods in commerce. Only those portions of the fuel and other resources attributable to sole-use shipments are committed directly, and that activity is less than 10^{-5} of the nation's total transportation activity, making this irreversible commitment of resources negligibly small.

CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND SCOPE OF THIS ENVIRONMENTAL STATEMENT

The purpose of this environmental statement is to assess the impact upon the environment resulting from the transportation of radioactive materials within the United States and from export and import shipments of such materials. The radiological impacts of transportation accidents involving radioactive materials are evaluated from a risk point of view, although the consequences of certain "worst-case" accidents are also evaluated. The data base for this assessment is the 1975 Survey (Ref. 1-1) of radioactive material shipments in the United States. All shipments exclusive of weapons, weapon components, and shipments in military vehicles are considered. Fuel cycle shipments, shipments of medical- and industrial-use isotopes, and waste shipments are specifically included. The expected radiological impacts in 1985 are also evaluated in terms of projections of the 1975 shipment data under certain growth assumptions.

1.2 BACKGROUND

Chapters 1 through 6 of this document are the result of a study begun in May 1975 by Sandia Laboratories under contract with the Nuclear Regulatory Commission (NRC). NRC, organized under the Energy Reorganization Act of 1974, has the responsibility of ensuring the safe use of radioactive materials through licensing and regulation. Soon after its inception, NRC stated that it intended to review those regulations and procedures originally set up by the Atomic Energy Commission (AEC) pertaining to the licensing and regulation of nuclear facilities and materials to determine what changes, if any, should be made. This environmental statement is, in part, an attempt to provide the technical data necessary for NRC to reevaluate the rules governing the transportation of radioactive materials.

In addition, there has been some expression of concern by members of Congress and the public about the safety and security of air shipments of plutonium and other special nuclear material (SNM) in the vicinity of populated areas. For example, the NRC authorization bill enacted into law on August 9, 1975, includes an amendment by Congressman Scheuer that states:

> The Nuclear Regulatory Commission shall not license any shipments by air transport of plutonium in any form, whether exports, imports or domestic shipments; provided, however, that any plutonium in any form contained in a medical device designed for individual human application is not subject to this restriction. This restriction shall be in force until the Nuclear Regulatory Commission has certified to the Joint Committee on Atomic Energy of the Congress that a safe container has been developed and tested which will not rupture under crash and blast-testing equivalent to the crash and explosion of a high-flying aircraft.

Pending satisfaction of this Congressional restriction, NRC has ordered the cessation of plutonium air shipments by its licensees.

The NRC announced its initiation of a rule-making proceeding concerning the air transportation of radioactive materials, including packaging, and invited comments by the public on the existing regulations (Ref. 1-2). Of particular interest were views and comments on:

1. Whether or not radioactive materials should continue to be transported by air;
2. The extent to which safety requirements should be based on accident probabilities, packaging, procedural controls, or combinations of these;
3. The relative risk of transport of radioactive materials by air compared to other modes of transport; and
4. What improvements, if any, in the applicable regulations should be considered.

In order to determine the quantities and types of shipments of radioactive materials currently being transported, NRC contracted with Battelle Pacific Northwest Laboratories in Richland, Washington, to conduct a survey (Ref. 1-1) of the transportation of radioactive materials. Questionnaires requesting data on the numbers and characteristics (e.g., quantity and external radiation level per package) of radioactive materials shipments were sent to about 2,300 of the approximately 18,000 licensees. Detailed questionnaires were mailed to special nuclear material (SNM) licensees who shipped 1 gram or more of SNM between March 1, 1974, and February 28, 1975, and to approximately 150 "major shippers," i.e., licensees who were known to have shipped large numbers of packages or large quantities of radioactive material. Questionnaires requesting only summary information were sent to a sampling of the licensees selected from lists supplied by NRC and by the agreement states (listed in Chapter 2). Data derived from that survey were used for this assessment, as explained in Appendix A.

Section 1.3 of this chapter contains a brief discussion of accident experience in the transportation of radioactive materials. Section 1.4 is an overview of the current industrial and medical uses of radioisotopes and their respective transportation requirements. Section 1.5 identifies the standard-shipments model on which the environmental assessment is based. Section 1.6 is a general discussion of the approach taken in the impact assessment. Finally, Section 1.7 contains an outline of the contents of each of the remaining chapters.

1.3 ACCIDENT EXPERIENCE IN THE TRANSPORTATION OF RADIOACTIVE MATERIALS (Ref. 1-3)

There are approximately 500 billion packages of all commodities shipped each year in the United States. About 100 million of these involve hazardous materials, including flammables, explosives, poisons, corrosives, and radioactive materials. There were over two million packages of radioactive materials transported in 1975. Thus, about 2 percent of hazardous material shipments involve radioactive materials.

Radioactive materials transportation has an excellent record of safety. Of the more than 32,000 hazardous materials transport incidents reported to the DOT during 1971-1975, only 144, or 0 45 percent, were noted to involve radioactive materials. Incidents involving flammable liquids, on the other hand, resulted in over 16,000 reports to the DOT. In only 36 of the 144 reported radioactive materials incidents was there any indication of release of contents or excessive radiation levels. In most cases, the releases involved only minor contamination from packages containing only small quantities of radioactive material.

Seventy-four of the 144 reported* radioactive materials transportation incidents involved air carriers and forwarders, 65 involved highway carriers, and 5 involved rail carriers. About 40 percent of the reported aircraft incidents occurred during handling and typically involved a package falling from a cargo-handling cart and then being run over and crushed by a vehicle.

About 13 percent of the highway incident reports resulted from vehicular accidents in which packages were burned, thrown from moving vehicles, or rolled on by vehicles. Only one of these reports indicated a release of contents. Five reports were submitted by rail carriers in the same five-year period. Two of these involved derailments of flat cars carrying large packagings, but neither incident involved a release.

1.4 AN OVERVIEW OF RADIOISOTOPE USES

Radionuclides used in the practice of nuclear medicine constitute the largest fraction of the packages of radioactive material transported annually in the United States. Other radioisotopes are finding extensive applications in well-logging, in industrial radiography, as large-curie teletherapy and irradiator sources, in some consumer products, and in the manufacture of certain types of gauges. Some fissile materials, such as U-235, are used as nuclear reactor fuel; others, such as Pu-239, are produced as byproduct material in nuclear reactors. These, together with relatively small amounts of radioactive material used in research, constitute the primary applications of radioisotopes.

1.4.1 MEDICAL APPLICATIONS

During the past 25 years, clinical applications of radioactive materials have become a major branch of medicine (Ref. 1-4). In particular, gamma-ray-emitting isotopes are now commonly used for the purpose of imaging specific areas or organs in the body. The normal technique used in a scanning procedure is to give the patient an injection of the isotope in the appropriate chemical form to localize it in the desired organ or system, and collect the emitted gamma radiation on an imaging device.

In 1972, some 6,355,000 procedures were performed in 3,300 hospitals in 1,500 cities in the United States using radiopharmaceuticals (Refs. 1-5 and 1-6). Radioisotopes of iodine were among the first such materials used. Their use in the study of thyroid physiology and in the diagnosis and treatment of thyroid disorders (300,000 to 540,000 administrations/year (Ref. 1-6)) still make them an important part of the current practice of nuclear medicine.

An example of the rapid growth of the use of organ-imaging techniques is the increased application of Tc-99m, an unstable daughter of Mo-99. Tc-99m is not, in itself, a natural

*Radioactive material incident reports are required by Title 49 of the Code of Federal Regulations (see Section 2.1 of Chapter 2 of this environmental statement).

component of any biological system, but its desirable properties (a six-hour half-life and 140-kev gamma ray which is well-matched to existing monitoring instruments) make it ideal for imaging. Because of these properties, relatively large amounts of Tc-99m can be administered with little radiation dose. As a result, there has been extensive research to incorporate this isotope into medically useful forms that provide the necessary imaging and then are excreted. It is estimated that nearly 5.5 million examinations were performed in 1972 using technetium. At present, one of the most useful forms is a pertechnetate used for brain scanning (1,000,000 administrations/year in 1972 (Ref. 1-6)).

A major source for hospital administration of Tc-99m is the Mo-99 generator or "cow," which consists of an alumina column on which the Mo-99 is adsorbed. The daughter product, Tc-99m, may be eluted, i.e., "milked," by flushing the column with a sterile saline solution (Ref. 1-4).

Many other isotopes are now used in scanning procedures: Au-198 or I-131 for the liver (380,000 administrations/year in 1972 (Ref. 1-6)), I-131 for the lungs (246,000 administrations/year in 1972 (Ref. 1-6)), Hg-203 for the kidneys (67,000 in 1972 (Ref. 1-6)), etc.

Isotopes with more energetic emissions, such as Co-60 and Cs-137, are used in therapeutic situations where the radiation is used to destroy localized malignancies.

Because the Tc-99m generators last about a week and because of the way physicians who practice nuclear medicine schedule their patients, hospitals and pharmacies prefer to receive a fresh generator on Monday mornings. Thus, significantly more radiopharmaceutical shipments tend to occur over the weekend than during the week. Radiopharmaceutical packages are frequently picked up at the airport and delivered to the hospital by taxi, personal automobile, or courier service. In some cases, a freight forwarder is used.

Radiopharmaceutical packages shipped to hospitals or nuclear pharmacies contain at most a few curies of the radioactive material and usually much less. The packaging usually consists of several cardboard boxes, one inside another, with a "pig," i.e., lead-shielded enclosure, inside the innermost box. The radiopharmaceutical, usually a liquid, is contained in a glass or plastic vial inside the pig. The vial is surrounded by absorbent material to contain the liquid if the vial should break.

Radiopharmaceutical companies receive the raw materials used to produce radiopharmaceuticals. These materials are often shipped by cargo aircraft in large containers approved for up to thousands of curies. Some companies have plants at more than one location and require transport of large curie quantities of materials between locations.

Most radiopharmaceuticals are produced in New Brunswick, St. Louis, Boston, Chicago, and San Francisco. Because of their short half-lives, they are often flown to their destination on regularly scheduled passenger flights, although one large manufacturer now ships more than 50 percent of his packages by a courier service, using fixed-bed trucks. Because of new applications that are being discovered and because of the increased use of established techniques, the number of packages shipped is growing at a rate of approximately 10 percent per year (Ref. 1-7).

1.4.2 THE WELL-LOGGING INDUSTRY

Well-logging firms use radioisotopes in down-hole measurements to provide information on the underground strata and to assess a well's capability for secondary and tertiary recovery. In a typical logging operation, a neutron source and a gamma source are placed in an instrumentation package and lowered by means of a cable to the bottom of the bore hole. The package is then withdrawn slowly while the instrumentation detects the neutrons and gamma-rays backscattered from the surrounding strata, and the detected signals are displayed on a chart recorder. The results yield information about the properties of rock formations as a function of depth.

Typically, an americium-beryllium neutron source of 5 to 20 curies and a Cs-137 gamma-ray source of several curies are used. Each source is enclosed inside two small, stainless-steel cylinders, one inside the other, with welded end caps. Sources are fabricated in a hot cell by a service company, which purchases the radioisotopes from a company having access to a production reactor. Well-logging firms transport the sources to remote well sites (and often to off-shore locations) both in the United States and in foreign countries, including, for example, Canada, England (North Sea), Germany, Brazil, Venezuela, and Iran.

Many well-logging sources were shipped by passenger aircraft prior to the Federal Aviation Administration (FAA) rule change implementing provisions of the Transportation Safety Act of 1974. That Act prohibited the shipment on passenger aircraft of any radioactive materials other than those intended for research or medical use. Deliveries of sources to sites within approximately a 1000-mile radius of the logging firm are generally made by truck, while deliveries to off-shore well locations are frequently made by helicopter. Exports of sources to foreign countries, as well as long-distance shipments within the United States (e.g., to Alaska), are sent by ship or cargo aircraft.

Some logging firms and some oil companies also use radioactive tracers, usually I-131, Kr-85, or tritiated water, that are injected into a well to monitor its flow properties. These materials are typically shipped in a glass serum vial carefully packaged in a metal can inside a lead-shielded container. Surrounding this container is enough absorbent material to absorb the liquid contents in case of breakage.

1.4.3 THE RADIOGRAPHY INDUSTRY

Radiography sources are made primarily from one of two isotopes, Ir-192 or Co-60, both of which emit relatively high energy gamma-rays. The radiation is used to examine the structural integrity of welded joints, principally in large pipes, frames, and pressure vessels, or to determine the thickness of a material. The source is enclosed by two small, welded, stainless-steel capsules and is positioned at the end of a short flexible steel cable to facilitate handling in the radiography "camera." The gamma rays emitted by the source pass through the welded joint and expose a piece of photographic film. Voids show up as dark spots on the developed negative.

Only a few companies manufacture these sources (obtaining the raw materials from production reactors), but there are numerous radiographers who use them. Unlike the radiopharmaceutical industry, the radiography industry requires individual shipments of sizeable quantities of radioisotopes in both directions between manufacturer and user. A fresh source, typically 100 curies, is sent to a radiographer for use in his camera. When it has decayed to about 30 curies, the source is returned to the manufacturer in exchange for a replacement. The new source is returned in the same shielded container in which it is shipped and stored.

Radiography cameras are also used for field work (e.g., at pipeline installations), which results in the need for transport from field offices to remote sites. The units are fairly portable and are usually transported by small truck or van. However, the majority of radiography is done at fabrication plants and requires no transport except to and from the supplier.

1.4.4 LARGE CURIE SOURCES

Teletherapy sources containing large quantities of Co-60 (up to 10,000 curies) are fabricated and shipped to cancer treatment centers both in the United States and abroad. Overseas exports are transported by ship, while domestic shipments go by truck or rail. Irradiator sources, usually Co-60 or Cs-137, are used for research or in large-scale food sterilization operations and contain hundreds of thousands of curies. These sources are returned to the manufacturer after decaying to about 30 percent of their initial activity. They are shipped in large casks which, because of their weight, are transported by surface modes.

1.4.5 RADIOACTIVE GAUGING SOURCES

A number of different gauging techniques use radioactive materials fabricated in sealed-source form. Material thickness is measured by detecting the variation in beta or gamma radiation that is transmitted through the material. Examples are thickness measurements of paper, rubber, plastic sheet, metal foil, and pipe wall. The material level of solids or liquids is measured by detecting a change in transmitted radiation through tanks, bins, boxes, bottles, cans, or other containers. Fluid densities and bulk densities of solids are measured by detecting transmitted radiation. Coating thicknesses of adhesives, paints, or anticorrosives are measured by detecting transmitted or backscattered radiation. Moisture content is measured by detecting the degree of neutron thermalization.

A number of different isotopes, usually in sealed source form and including Ra-226, Cs-137, Co-60, Kr-85, Sr-90, Am-241, Pm-147, and Th-204, are used in the individual sources, which contain from a few millicuries up to several curies of activity. The radioactive materials used by the source manufacturers are obtained from suppliers of byproduct material. Bulk shipments (up to several hundred curies per shipment) are generally transported in shielded packages by motor freight. The gauging equipment may be shipped with the source intact, or the source may be shipped separately and installed at the site.

1.4.6 THE NUCLEAR POWER INDUSTRY

The basic nuclear fuel cycle associated with the production of electrical energy from fission is shown schematically in Figure 1-1. The part of the cycle that supplies new fuel for power production is referred to as the "front end" and involves U-233, U-235, U-238, Th-232, and Pu-239. The majority of currently operational power reactors are of the light-water reactor (LWR) variety, which has two principal types: pressurized water reactors (PWR) and boiling water reactors (BWR). Both types use slightly enriched uranium (approximately 97 percent U-238, 3 percent U-235) as fuel.

The material flow in the front end of the fuel cycle is approximately as follows: Ores containing 0.1 to 0.5 percent uranium (which has an isotopic content of 99.29 percent U-238 and 0.71 percent U-235) are concentrated as U_3O_8 (yellowcake) near the mine and shipped to a conversion plant. At the conversion plant, the U_3O_8 is converted to UF_6, which is shipped to a uranium enrichment plant to be enriched in the fissile isotope U-235. The enriched UF_6 is sent to a fuel fabrication facility, where it is converted to UO_2 and pressed into pellets. The pellets are fabricated into fuel rod assemblies, and completed fuel assemblies are sent to reactors.

After a fraction of the U-235 fuel has been consumed by fission, the reactor is shut down, and the irradiated fuel elements are removed and sent to a reprocessing plant. This procedure is part of the "back end" of the fuel cycle. At the reprocessing plant, the irradiated fuel is separated from the cladding and is processed in a bath of hot nitric acid. The principal components of irradiated fuel are long-lived fission products (such as Cs-137 and Sr-90), unfissioned fuel (U-233, U-235), and transuranic isotopes (Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Cm-244, etc.). After non-fuel materials are chemically separated, the recovered uranium is converted to UF_6 and returned to the enrichment plant, while the transuranic wastes are stored in liquid form. The high-level fission product wastes are required to be solidified within five years of generation (Ref. 1-9) and subsequently buried in a federal waste repository. Recovered plutonium is converted to PuO_2 and stored or shipped to fuel fabrication plants as required.

No commercial reprocessing plants were in operation in 1975, although at least one was under construction. In the interim, irradiated fuel assemblies were stored on site at the various power reactors. Several plans for disposal of intermediate and high-level wastes are currently being evaluated, but the final selection of the method of disposal and the repository site has not yet been made.

The high-temperature gas-cooled reactor (HTGR) uses the Th-232/U-233 portion of the fuel cycle shown in Figure 1-1. The unique aspect of the front end of the HTGR fuel cycle is the fuel element construction. The UO_2 and ThO_2 are converted to carbides, coated with graphite, blended, formed into cylinders, and inserted into graphite blocks. The mixed fuel is then sent to the HTGR, which uses helium gas as a heat transfer medium. During operation of the reactor, some of the thorium is converted to U-233. The spent fuel, after at least a 90-day cooling-off period at the reactor site, is sent to a reprocessing plant. The recovered U-235, now at reduced enrichment level, is returned for re-enrichment to 93 percent. The U-233 is shipped to a conversion plant,

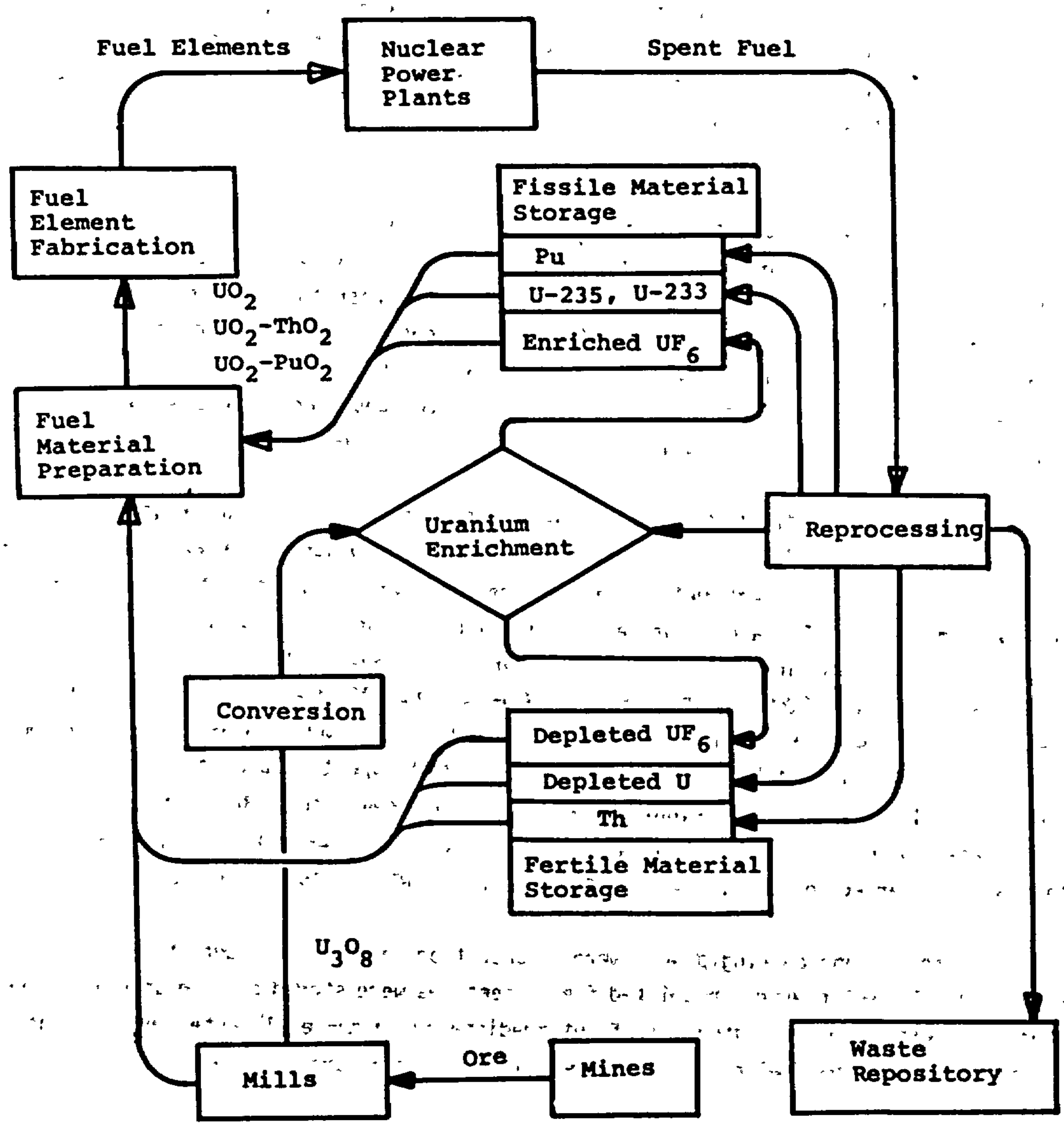

FIGURE 1-1. NUCLEAR FUEL CYCLE (Ref. 1-8).

where it is converted to a carbide to be used as a replacement fuel for U-235 in the reactor. Currently only one HTGR is licensed in the United States.

To conserve uranium resources and utilize the plutonium produced in the reactors, an alternative procedure has been evaluated in which plutonium oxide is mixed with uranium oxide. This oxide mixture is then "burned" in the reactor. Although an environmental impact assessment for mixed oxide fuels has been issued (Ref. 1-10), there is currently no recycling of plutonium except in a few experimental reactors.

Another reactor type is the liquid metal fast breeder reactor (LMFBR) (Ref. 1-11), in which plutonium is produced in the reactor from U-238 and subsequently used to fuel other reactors. This reactor can, in principle, produce more plutonium fuel than the U-235 fuel it consumes, thus conserving uranium resources.

The Naval Nuclear Propulsion Program uses highly enriched uranium (>90 percent U-235) in a PWR system. Like other reactor types, uranium is enriched as UF_6 by gaseous diffusion for fabrication into fuel elements. Because very ttle U-238 is present in the fuel, only very small quantities of plutonium are produced by neutron irradiation in the reactor. The recovered U-235 is re-enriched for reapplication to the fuel cycle.

Because of the large size of virtually all fuel cycle shipments, they are normally shipped in large containers that preclude modes of transport other than truck, rail, barge, or ship.

Certain quantities of "special nuclear materials" (SNM), such as plutonium, U-233, and U-235, or uranium enriched in these isotopes to a level of 20 percent or more, require physical protection against theft and sabotage during transport because it is conceivable that they could be made into a nuclear explosive device. The regulations that prescribe the safeguards for these materials are given in 10 CFR 70 and 10 CFR 73 and will be discussed in Chapter 2. The types of shipments requiring safeguarding include most plutonium shipments and all shipments of highly enriched uranium such as those involved in the HTGR and Naval Reactor Programs. Spent LWR fuel contains sizeable quantities of plutonium; however, the plutonium is not readily separable from the other radioactive material, and the radioactivity of the irradiated fuel material is sufficiently high that it is exempted from transportation safeguards requirements.

Much unirradiated SNM is transported in cargo aircraft and, prior to the previously mentioned DOT restrictions, some was transported by passenger aircraft. The other principal mode of transport is truck.

1.5 STANDARD SHIPMENTS

An assessment of the environmental impact of radioactive materials transportation requires a detailed knowledge of the package types, the principal transport modes, the number of packages transported per year, the average quantity of material per package, the average "transport index" or "TI" (a measure of the external radiation level), and the average distance traveled per shipment, for each type of radioactive material being shipped. To make this problem tractable, a list of "standard shipments" was compiled from the data obtained in the 1975 Survey (Ref. 1-1). This list is shown in Table 1-1, in which the total number of packages shipped per year in 1975 and the 1985 extrapolations are given for various isotope, package type, and transport mode combinations. The list is by no means complete, but the materials listed account for the vast majority of packages, curies, and TI reported in the 1975 Survey. A detailed discussion of the methods used to generate this list from the survey data is given in Appendix A.

Table 1-2 is a summary of radioactive material shipping activity both in 1975 and projected to 1985, listed by isotope use categories. The table lists the annual number of packages and curies, as well as the total TIs and shipment distances, for each category, as determined from the 1975 Survey data. Also shown are the contributions of each category to the annual expected latent cancer fatalities (LCF) resulting from normal transport and from transportation accidents. Detailed discussions of the methods used to obtain these results are presented in Chapters 4 and 5 and in related appendices.

1.6 METHOD USED TO DETERMINE THE IMPACT

Three circumstances under which impacts may be produced were considered: (1) normal transport conditions, (2) accidents involving the transport vehicle, and (3) theft or sabotage. The radiological impacts produced under each of these circumstances relate directly to the radiation emitted by the material. However, economic, legal, or social impacts may also occur. These impacts are more difficult to quantify than the radiological impacts.

1.6.1 NORMAL TRANSPORT CONDITIONS

Under normal transport conditions the radiological impact arises from routine exposure to freight handlers, aircraft passengers and crew, truck drivers, on-route bystanders, etc., resulting from the radiation emitted by the contained material or radioactive contamination of the package surface. Package shielding reduces but never completely eliminates this impact.

The radiological impacts are evaluated in terms of annual expected additional latent cancer fatalities, assuming a proportionality between population dose and numbers of additional latent cancer fatalities (see Chapter 3). The dose resulting from a given shipment is proportional to the total "transport index," or "TI" (see Chapter 2, Section 2.4) of all packages included in the shipment. Estimates of the total population dose are made by modeling the path of each package from the time it is presented for transport until it arrives at its ultimate destination. The population dose is computed for each standard shipment in Table 1-1 bv using the average TI, the average distance traveled, and the total packages per year. The methods of computing the dose depend on the transport mode. The total expected annual dose due to normal transport is given by the sum of the doses resulting from each standard shipment.

1.6.2 ACCIDENTS INVOLVING TRANSPORT VEHICLE

In the accident case, one considers the additional impact that could result from an accident involving a vehicle transporting one or more packages of radioactive material. Three possible

TABLE 1-1

STANDARD SHIPMENTS LIST - 1975 AND 1985 PROJECTIONS

Isotope	Package Type*	Transport Mode**	Packages per Year (1975)	Packages per Year (1985)
Various+	Limited++	AF	1.72×10^4	4.47×10^4
		P A/C	2.95×10^5	7.67×10^5
		T	3.91×10^5	1.02×10^6
Am-241	A	AF	521	1.22×10^4
		P A/C	4170	0
		T	2.04×10^4	5.3×10^4
	B	AF	7	161
		P A/C	55	0
		T	116	302
Au-198	A	AF	25	25
		P A/C	1820	1820
		T	2410	2410
Co-57	A	AF	267	694
		P A/C	9860	2.56×10^4
		T	6180	1.61×10^4
Co-60	A	T	1.77×10^4	4.6×10^4
	B	T	1460	3800

*For details of package terminology, see Chapter 2.

**AF - all-cargo aircraft; P A/C - passenger aircraft; T - truck; R - rail; S - ship; ICV - Integrated Container Vehicle.

+Modeled as I-131.

++Terminology recently applied by DOT to packages formerly referred to as "exempt."

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages per Year (1985)
Co-60	LQ1	T	101	262
	LQ2	T	4	10
	LSA	AF	45	1440
		P A/C	509	0
		T	5540	1.44×10^4
C-14	A	AF	1080	2810
		P A/C	1.94×10^4	4.97×10^4
		T	6660	1.73×10^4
Cs-137	A	AF	41	2920
		P A/C	1080	0
		T	3.1×10^4	8.06×10^4
	B	AF	5	13
		T	69	179
Ga-67	A	AF	175	455
		P A/C	7030	5.18×10^4
		T	1.29×10^4	0
H-3	A	AF	1300	3380
		P A/C	2.6×10^4	6.76×10^4
		T	1.1×10^4	2.86×10^4

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages Per Year (1985)
H-3	B	AF	18	47
		P A/C	364	946
		T	151	393
	LSA	AF	2	5
		P A/C	45	117
		T	18	47
Ir-192	A	AF	346	7500
		P A/C	2540	0
		T	1920	4990
	B	AF	1590	3.45×10^4
		P A/C	1.17×10^4	0
		T	1.37×10^4	3.56×10^4
I-131	A	AF	4720	4720
		P A/C	2.93×10^5	2.93×10^5
		T	1.08×10^5	1.08×10^5
	B	AF	13	13
		P A/C	310	310
		T	292	292
Kr-85	A	AF	136	354
		P A/C	1530	3980

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages per Year (1985)
Po-210	LQ	AF	1	32
		P A/C	11	0
		T	7	18
		R	1	3
P-32	A	AF	268	697
		P A/C	7940	2.06×10^4
		T	3820	9930
Ra-226	A	T	2.6×10^4	2.6×10^4
	B	AF	39	440
		P A/C	401	0
		T	2620	2620
Tc-99m	A	AF	1280	3330
		P A/C	3.01×10^4	7.83×10^4
		T	2.09×10^5	5.43×10^5
Tl-201	A	P A/C	0	7500
		T	0	4.25×10^4
Waste	A	T	1.31×10^5	3.41×10^5
	B	T	821	2130
	LSA	T	2.03×10^4	5.28×10^4
Xe-133	A	AF	875	2280
		P A/C	1.22×10^4	3.17×10^4
		T	1.29×10^4	3.35×10^4

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages per Year (1985)
Kr-85	A	T	3500	9100
		S	297	772
	B	AF	30	78
		P A/C	336	874
		T	634	1650
MF+MC*	A	T	2.15×10^4	8.9×10^4
	B	T	5000	2.07×10^4
	LQ	T	12	50
	LSA	T	3.33×10^4	1.38×10^5
Mo-99	A	AF	3200	8320
		P A/C	7.97×10^4	2.07×10^5
		T	5.49×10^4	1.43×10^5
	B	AF	109	283
		P A/C	2720	7070
		S	1880	4890
Po-210	A	AF	16	336
		P A/C	113	0
		T	81	211
		R	10	260

*Mixed corrosion products and mixed fission products.

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages per Year (1985)
Mixed*	A	AF	115	299
		P A/C	2260	5880
		T	2.7×10^4	7.02×10^4
	B	P A/C	8	21
		T	101	263
	LSA	AF	26	68
		P A/C	513	1330
		T	5830	1.52×10^4
Pu-238	A	AF	34	88
		P A/C	1980	5150
		T	3250	8450
	B	AF	2	288
		P A/C	109	0
		T	179	465
Pu-239	B	AF	17	182
		P A/C	165	0
		T	4030	4030
	LQ	AF	1	1
U-Pu Mixture	B	AF	8	33
		P A/C	58	240

*Treated as I-131 for purposes of radiobiological modeling.

TABLE 1-1 (continued)

Isotope	Package Type	Transport Mode	Packages per Year (1975)	Packages per Year (1985)
U-Pu Mixture	B	T	330	1370
Spent fuel	Cask	T	254	1530
		R	17	652
U_3O_8	LSA	T	5.4×10^4	2.24×10^5
		R	6.6×10^4	2.73×10^5
UF_6 (natural)	A	T	2050	8440
		R	2500	1.04×10^4
UF_6 (enriched)	B	T	485	2000
		S	106	439
UO_2 (enriched)	B	T	9690	4.01×10^4
		S	2130	8820
UO_2 fuel	B	T	1280	5300
		S	282	1170
Recycle Plutonium	B	ICV	0	41

TABLE 1-2

SUMMARY OF RADIOACTIVE MATERIAL SHIPPING AND ITS MAJOR RADIOLOGICAL IMPACTS

Shipment Type	Packages per Year	Curies per Year	TI per Year	Kilometers per Year	LCF (normal) per Year	Percent	LCF (acc) per Year	Percent
1975								
Limited	7.03×10^{5}	2.11×10^{3}	7.74×10^{3}	1.19×10^{9}	0.0077	0.6	5.78×10^{-5}	1
Medical	9.10×10^{5}	5.78×10^{6}	6.43×10^{5}	1.12×10^{9}	0.616	52	6.11×10^{-4}	13
Industrial	2.15×10^{5}	9.39×10^{6}	3.43×10^{5}	3.01×10^{8}	0.281	24	1.60×10^{-3}	34
Fuel cycle	2.04×10^{5}	5.32×10^{8}	5.69×10^{5}	2.09×10^{7}	0.104	9	1.85×10^{-3}	39
Waste	1.52×10^{5}	2.68×10^{5}	2.98×10^{6}	3.22×10^{6}	0.182	15	6.17×10^{-4}	13
TOTAL	2.19×10^{6}	5.48×10^{8}	4.54×10^{6}	2.64×10^{9}	1.19	100	4.73×10^{-3}	100
1985								
Limited	1.83×10^{6}	5.50×10^{3}	2.02×10^{4}	3.11×10^{9}	0.020	0.7	1.51×10^{-4}	1
Medical	1.71×10^{6}	1.50×10^{7}	1.20×10^{6}	1.92×10^{9}	1.17	38	1.51×10^{-3}	9
Industrial	5.63×10^{5}	2.47×10^{7}	8.79×10^{5}	8.84×10^{8}	0.676	22	4.49×10^{-3}	27
Fuel cycle	8.36×10^{6}	8.41×10^{9}	2.46×10^{6}	7.16×10^{7}	0.469	15	7.88×10^{-3}	48
Waste	6.27×10^{5}	1.11×10^{6}	1.23×10^{7}	1.33×10^{7}	0.752	24	2.54×10^{-3}	15
TOTAL	5.57×10^{6}	8.45×10^{9}	1.68×10^{7}	5.97×10^{9}	3.08	100	1.66×10^{-2}	100

hazardous conditions may arise in such an accident:

1. A loss of shielding efficiency of the package,
2. A loss of containment and subsequent dispersal of the radioactive material, and
3. Accidental assembly of a critical mass (in fissile material shipments).

The first condition could result in persons near the accident being directly exposed to radiation. The second could ultimately result in direct exposure and intake of the radioactive material into humans by inhalation or ingestion of the dispersed material. The third case could result in neutron irradiation of persons in the vicinity of the accident at the time it occurs.

Accident risk is defined as the product of the probability of an accident and its consequences. The risk calculations incorporate accident rates and package release fraction estimates, both of which are functions of accident severity. Dispersible materials are assumed to be aerosolized in severe accidents, and the aerosol cloud is assumed to drift downwind according to a Gaussian diffusion model. Inhalation of the aerosolized debris by persons downwind from the accident produces doses to various internal organs. Nondispersible materials are assumed to undergo a partial loss of shielding and create a direct exposure hazard. The contributions of each standard shipment to the accident risk are summed to obtain the total risk. Radiological accident risks are expressed in terms of annual expected latent cancer fatalities and early fatality probabilities.

The consequences of postulated accidents involving certain large quantity shipments are also evaluated. The results are presented in terms of the number of persons receiving greater than specific doses of interest and in terms of the area that is contaminated to greater than a given level.

1.6.3 THEFT OR SABOTAGE

Certain quantities of SNM, such as plutonium or highly enriched uranium, are possible targets for theft, since they might be used to make a nuclear explosive device. Other radionuclides in large quantities may also become targets for theft or sabotage. The need for security of certain radioactive material shipments is discussed in Chapter 7, together with an assessment of the present physical security requirements applied to various modes of transport.

1.7 THE CONTENTS OF OTHER CHAPTERS OF THIS DOCUMENT

Chapter 2 discusses the federal regulations that apply to the transport of radioactive materials and the safeguarding of SNM. It is the environmental impact resulting from the transportation of radioactive materials under these regulations that is the subject of this report. Chapter 3 is a general discussion of the biological effects of radiation exposure. It includes a summary of the health effects model used in this assessment. The case of normal transport of radioisotopes and the associated environmental impact is discussed in Chapter 4. In Chapter 5 the impact due to accidents is discussed. Chapter 6 includes a discussion of alternatives to present shipping practice, including transport mode shifts, and their effect on the environmental impact.

The diversion of SNM and an evaluation of the steps taken to avoid such diversion are discussed in Chapter 7. Chapter 8 contains responses to comments received concerning the draft versions of this document. Specific subjects such as the standard shipments model, plutonium, etc., are addressed in the appendices.

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1-10. U.S. Nuclear Regulatory Commission, Final Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in Light Water Reactors, NUREG-0002, August 1976.

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CHAPTER 2

REGULATIONS GOVERNING THE TRANSPORTATION OF RADIOACTIVE MATERIALS

2.1 INTRODUCTION

The objective of this chapter is to summarize the federal regulations pertaining to the transportation of radioactive materials. For complete details of transportation regulations, the interested reader is referred to the appropriate sections in the Code of Federal Regulations (some of which are provided in Appendix B to this document).

Three basic safety requirements that must be met when transporting radioactive materials are:

1. Adequate containment of the radioactive material;
2. Adequate control of the radiation emitted by the material; and
3. Prevention of nuclear criticality, i.e., prevention of the accumulation of enough fissile material in one location under conditions that could result in a nuclear chain reaction.

In addition, certain strategic quantities and types of special nuclear material (SNM) require physical protection against theft and sabotage during transit.

The purpose of the regulations is to ensure that these requirements are met. In the subsequent sections of this chapter, the regulations relating to each of these safety requirements are discussed.

NRC regulations provide the standards that must be met rather than attempting to specify how they are to be met. An example of the application of this basic concept is the fact that the regulations do not prohibit the shipment of any specific radioisotope,* as long as the basic safety standards are met.

Section 2.2 of this chapter is a discussion of the various regulatory agencies and their respective regulations. Section 2.3 discusses the regulations and standards designed to ensure the containment of radioactive material during transport, including the classification of radioactive materials for shipment, Type A packaging standards, Type B packaging standards, and packaging for large quantities, limited items, limited quantities, and low specific activity (LSA) materials. Section 2.4 discusses the standards for radiation control during transport and introduces the concept of the transport index.

The special regulations applicable to fissile materials for criticality control are discussed in Section 2.5. Section 2.6 outlines the responsibilities of a licensee who receives a shipment of radioactive material and discusses procedures for picking up, receiving, and opening

*Plutonium air shipments are presently prohibited by NRC order in compliance with Public Law 94-79 (Scheuer Amendment).

packages. The labeling requirements for packages are covered in Section 2.7. In Section 2.8 the responsibilities of the carrier, including vehicle placarding and stowage, are discussed. Section 2.9 covers the requirements for the reporting of incidents and decontamination procedures. Finally, in Section 2.10 the requirements for the safeguarding of special nuclear material in transit are discussed.

2.2 REGULATORY AGENCIES

The transportation of radioactive byproduct, source, and special nuclear materials within the United States is regulated by the Nuclear Regulatory Commission (NRC). The Department of Transportation (DOT) regulates all radioactive materials in interstate commerce. International shipments, in most cases, are consistent with the standards of the International Atomic Energy Agency (IAEA), with the DOT serving as the USA "competent authority." Certain "limited" (formerly called "exempt") quantities may be shipped by mail, and such shipments are regulated by the U.S. Postal Service. Shipments that are neither in interstate or foreign commerce nor in air transportation, as defined in the Federal Aviation Act of 1958, are controlled by NRC and by various state agencies.

The Nuclear Regulatory Commission was established by the Energy Reorganization Act of 1974, which went into effect on January 19, 1975. This act also created the Energy Research and Development Administration (ERDA) and abolished the Atomic Energy Commission (AEC). The licensing and related regulatory authority held by the AEC under the Atomic Energy Act of 1954, as amended, was transferred to the NRC. The authority of the AEC operating divisions to approve the use of radioactive material packages by their prime contractors was assumed by ERDA in this reorganization. Later, Section 301(a) of Public Law 95-91, enacted August 4, 1977, transferred all functions of ERDA to the Secretary of Energy. The special package approval authority is being phased out as NRC is able to review the large number of packages in use by prime contractors, and it is expected to expire in 1978. Approvals were issued only in accordance with the same package standards used by the AEC regulatory staff, and now by NRC.

Chapter I of Title 10 of the Code of Federal Regulations contains the rules and regulations of the NRC, including rules and definitions relating to the issuance of general and specific licenses for receiving, acquiring, owning, possessing, using, and transferring byproduct material, source material, and special nuclear material. A transfer of a nonlimited quantity of these materials can take place only between persons who are licensed either by the NRC or by certain "agreement states," a term to be explained later in this section.

The parts of Title 10, Chapter I that most directly pertain to radioactive material transportation are Parts 20, 70, 71, and 73, which deal with "Standards for Protection Against Radiation," "Special Nuclear Material," "Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions," and "Physical Protection of Plants and Materials," respectively. In referring to these and other regulations in the Code of Federal Regulations, an abbreviated form will be used: "10 CFR 71.35(a)," meaning "Paragraph (a) of Section 71.35 of Part 71 of Title 10 in the Code of Federal Regulations."

The AEC, through formal agreements with certain "agreement states," transferred to those states the regulatory authority over byproduct material, source material, and subcritical quantities of special nuclear material. These agreement states are Alabama, Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Kansas, Kentucky, Louisiana, Maryland, Mississippi, Nebraska, Nevada, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Oregon, South Carolina, Tennessee, Texas, and Washington. These states have adopted a uniform set of rules requiring an intrastate shipper of radioactive materials to conform to the DOT requirements for packaging, labeling, and marking.

DOT, under the Department of Transportation Act of 1966, the Transportation of Explosives Act, the Dangerous Cargo Act, the Federal Aviation Act of 1958, and the Transportation Safety Act of 1974, has regulatory responsibility for safety in transportation. The organizational unit of DOT concerned specifically with safety in the transport of radioactive and other hazardous materials is the Office of Hazardous Materials Operations within the Materials Transportation Bureau.

The DOT regulations governing carriage of radioactive materials by rail and by common, contract, or private carriers by public highway (e.g., truck) are found in 49 CFR 171-179, which make up Subchapter C, "Hazardous Materials Regulations." The DOT regulations regarding packaging of radioactive materials are found in 49 CFR 173, "Shippers -- General Requirements for Shipments and Packagings," and 178, "Shipping Container Specifications"; they are consistent with the NRC guidelines in 10 CFR 71. The DOT regulations governing the carriage of radioactive materials by air are in 49 CFR 175, "Carriage by Aircraft." The DOT regulations in 49 CFR 176, "Carriage by Vessel," apply to the carriage of radioactive and other hazardous materials by barge or ship.

Certain "limited" quantities of radioactive material may be shipped through the mail. The regulations of the U.S. Postal Service, found in 39 CFR 123-125, pertain to such shipments. The criteria used to determine how much radioactive material can qualify as "limited" are discussed later in this chapter.

In order to carry out their respective regulatory functions for the safe transport of radioactive materials with as little duplication of effort as possible, the Interstate Commerce Commission (ICC) and the AEC (now the NRC) signed a "memorandum of understanding" in 1966. It has been superseded by a revised memorandum of understanding between DOT and AEC signed on March 22, 1973.

According to the memorandum, the DOT regulations (49 CFR 171-179)* concerning packaging, marking, and labeling apply to shippers, and the regulations concerning vehicle placarding, loading, storage, monitoring, and accident reporting apply to carriers. All packagings for shipment of fissile material or for Type B or large quantities of radioactive material require approval by the NRC. In case of a transportation accident, incident, or suspected leakage from a package of radioactive material discovered while in transit, the DOT investigates the occurrence and prepares an investigation report. If, however, an accident or incident occurs, or

*As of April 15, 1976, the DOT Regulations for Transport of Hazardous Materials, formerly located in 49 CFR 170-189, 14 CFR 103 (air shipments), and 46 CFR 146 (water shipments) were consolidated into 49 CFR.

suspected leakage is discovered other than during transit, the occurrence is investigated by the NRC. The DOT is recognized as the "national competent authority" with respect to the administrative requirements of the International Atomic Energy Agency (IAEA) for the safe transport of radioactive materials. The two agencies (NRC and DOT) have agreed to cooperate via exchange of information in the development and enforcement of the regulations.

2.3 REGULATIONS DESIGNED TO ENSURE ADEQUATE CONTAINMENT

The regulations to be discussed in this section provide standards for packaging and define limits for the package contents. The terms "package" and "packaging" are defined in 10 CFR 71.4, "Definitions," as follows:

> (k) "Package" means packaging and its radioactive contents;
>
> (l) "Packaging" means one or more receptacles and wrappers and their contents, excluding fissile material and other radioactive material, but including absorbent material, spacing structures, thermal insulation, radiation shielding, devices for cooling and for absorbing mechanical shock, external fittings, neutron moderators, nonfissible neutron absorbers, and other supplementary equipment.

In defining the packaging standards and the package content limits, the consequences of loss of containment must be considered. In the event that some of the radioactive contents escape from the package, a potential hazard to transport workers and to the general public exists resulting from the external radiation emitted from the exposed radionuclide and from the often more serious problem of intake into the body, particularly through inhalation.

Since the radiotoxicity of radionuclides varies over eight orders of magnitude (Ref. 2-1), a realistic set of standards should take into account which isotope is being transported. For this reason each radioisotope is classified, for transport purposes, into one of seven transport groups, labeled by Roman numerals I through VII according to their relative toxicity and potential hazard. A list of the radionuclides and their respective transport groups may be found in Appendix C, "Transport Grouping of Radionuclides," to 10 CFR 71 (shown in Appendix B to this environmental statement) and in 49 CFR 173.390, "Transport Groups of Radionuclides."

Another approach is used in the 1973 revised regulations of the International Atomic Energy Agency, in which each radionuclide is assigned a value according to its individual radiotoxicity. In this approach the transport groups become unnecessary.

Radioisotope quantities in each transport group are classified in order of increasing quantity, as "limited," "Type A," "Type B," and "large" quantity. The reason for this classification will become apparent in the next section. The limits for these quantity groupings are shown in Table 2-1.

Certain physical forms of a radioactive material of any of the seven transport groups are classified as "special form" and are subject to the quantity limits shown in the line in Table 2-1 entitled "Special Form." A special-form material is essentially nondispersible in water,

TABLE 2-1

QUANTITY LIMITS FOR THE SEVEN TRANSPORT GROUPS AND SPECIAL FORM

Transport Group	Limited Quantity* (Curies)	Type A Quantity** (Curies)	Type B Quantity** (Curies)	Large Quantity** (Curies)
I	$\leq 10^{-5}$	10^{-5} to 10^{-3}	10^{-3} to 20	>20
II	$\leq 10^{-4}$	10^{-4} to 5×10^{-2}	5×10^{-2} to 20	>20
III	$\leq 10^{-3}$	10^{-3} to 3	3 to 200	>200
IV	$\leq 10^{-3}$	10^{-3} to 20	20 to 200	>200
V	$\leq 10^{-3}$	10^{-3} to 20	20 to 5×10^{3}	$>5 \times 10^{3}$
VI	$\leq 10^{-3}$	10^{-3} to 10^{3}	10^{3} to 5×10^{4}	$>5 \times 10^{4}$
VII	≤ 25	25 to 10^{3}	10^{3} to 5×10^{4}	$>5 \times 10^{4}$
Special Form	$\leq 10^{-3}$	10^{-3} to 20	20 to 5×10^{3}	$>5 \times 10^{3}$

*49 CFR 173.391.
**10 CFR 71.4 and 49 CFR 173.389.
Note: The regulations actually prescribe only the upper limits for Limited, Type A, and Type B quantities. The symbol ≤ means "less than or equal to," and > means "greater than."

in a fire, or under severe impact conditions. The complete definition is found in 10 CFR 71.4(o) (Appendix B to this document) and in 49 CFR 173.389, "Radioactive Materials; Definitions." The usefulness of the special-form concept is that more radioactive material may be shipped in a Type A package (one that does not resist severe accidents) because of the greatly reduced dispersibility of special-form material.

Any radioactive material that does not qualify as a special-form material is considered "normal form" and is categorized according to its transport group. While a special-form material could, in the event of a severe accident, present an external radiation exposure hazard, it is apparent from its definition that the chance of any significant amount of the contents being released into the air, groundwater, etc., and being ingested by a human is extremely remote. Examples of special-form materials are sealed radiography and teletherapy sources and, in some cases, unirradiated reactor fuel rods.

2.3.1 TYPE A PACKAGE

To be qualified for transport, any packaging used to contain radioactive material must meet the general requirements of 49 CFR 173.393, "General Packaging and Shipment Requirements" (Appendix B to this document). These requirements state, among other things, that the packaging must be adequate to prevent loss of dispersal of the radioactive contents and maintain the radiation shielding properties for the normal conditions encountered during transport. Tests to simulate normal transport conditions are outlined in 49 CFR 173.398(b), "Standards for Type A Packaging," and in Appendix A, "Normal Conditions of Transport," to 10 CFR 71 (see Appendix B to this document).

The seven transport groupings and the Type A quantity limits have their origin in the IAEA regulations. The Type A limits were determined in the following way (Ref. 2-2): It was recognized that the chance of a rail accident of such severity as to cause loss of the package contents was very small. Experimental work had indicated that a release of 0.1 percent of the package contents would be a reasonable assumption for the vast majority of possible accidents. Furthermore, on the basis of general handling experience, it was assumed that the actual intake of radioactive material into the body by a person coming into contact with air or surfaces contaminated by such a release was unlikely to exceed 0.1 percent of the amount released from the package. Thus, it would be unlikely that any one person would ingest more than one-millionth of the actual package contents in the event of an accidental release. Therefore, the Type A package limits were established on the basis that neither:

1. An intake of 10^{-6} of the maximum allowed package contents would result in a radiation dose to any organ in the body exceeding internationally accepted limits, assuming a 50-year life expectancy after the intake; nor

2. The external radiation from the unshielded contents would exceed 1 rem/hour at 10 feet (3 meters).

In 49 CFR 178 there are descriptions of various DOT-approved containers for Type A packaging, including carboys, fiberboard boxes, steel drums, etc., that may be used without specific regulatory approval. However, in a recent rulemaking (Ref. 2-3) DOT eliminated the various "hardware-oriented" specifications for the Type A package containers listed in 49 CFR 173.394, "Radioactive Material in Special Form," and 49 CFR 173.395, "Radioactive Material in Normal Form," and ruled that each Type A package presented for shipment must be certified according to the Type A "Specification 7A" design with a supporting safety analysis. The requirements for this design are specified in 49 CFR 178.350, "Specification 7A; General Packaging, Type A." The use of existing Specification 55 (as described in the former 49 CFR 178.250) containers is also authorized for Type A shipments, but the construction of additional Specification 55 containers after March 31, 1975, has been prohibited. Foreign-made packagings, properly labeled as "Type A," are also acceptable by DOT for use in domestic transport (see 49 CFR 173.394(a)(4) and 173.395(a)(4)).

2.3.2 TYPE B AND LARGE QUANTITY PACKAGING

Quantities of radioactive material greater than the Type A limits can be transported only in Type B packaging. A Type B packaging is designed to more stringent standards and hence is considerably more accident resistant than a Type A packaging. In addition to meeting the standards for a Type A package, a Type B package must also be able to survive certain hypothetical accident conditions with essentially no loss of containment and limited loss of shielding capability. The NRC packaging standards are given in Subpart C, "Package Standards," of 10 CFR 71, and the tests to simulate accident conditions are found in Appendix B, "Hypothetical Accident Conditions," to 10 CFR 71. A Type B packaging design requires the approval of the NRC before it can be used for shipping radioactive material.

The Type B quantity limits are somewhat artificial in that the regulations permit shipments of quantities greater than these limits as "large quantity" shipments in Type B containers. Like the Type A limits, Type B limits have their origin in the earlier IAEA regulations. In the 1973 revision of the IAEA regulations, the upper Type B limits were discontinued.

The types of packaging acceptable to DOT for Type B quantities, listed in 49 CFR 173.394 and 49 CFR 173.395, are summarized in Table 2-2, which includes the recent HM-111 rule changes (Ref. 2-3).

Certain types of sources, particularly irradiated reactor fuel elements, irradiator and teletherapy sources, and most plutonium shipments contain quantities of radioactive materials in excess of the Type B limits. Packaging for large sources is subject to the requirements for Type B packaging plus additional requirements related primarily to decay heat dissipation (49 CFR 173.393(e)). The DOT packaging requirements for large quantities of normal-form material are stated in the following exerpt from 49 CFR 173.395(c):

> Large quantities of radioactive materials in normal form must be packaged as follows: (1) Specification 6M (§178.104 of this chapter) metal packaging. Authorized only for solid or gaseous radioactive materials which will not decompose at temperatures up to 250°F. Radioactive thermal decay energy must not exceed 10 watts. (2) Any other Type B packaging for large quantities of radioactive materials which meets the pertinent requirements in the regulations of the U.S. Atomic Energy Commission (10 CFR 71) and is approved by the U.S.

TABLE 2-2

TYPE B PACKAGINGS PERMITTED BY DOT
FOR TRANSPORT BY 49 CFR 173.394 AND 49 CFR 173.395

Special Form	Normal Form
1. Spec 55 (300 Ci Max.) (49 CFR 178.250)	1. Spec 6M (for solid or gas only which does not decompose up to 250° F).
2. Spec 6M (49 CFR 178.104)	2. NRC (AEC) approved per 10 CFR 71.
3. NRC (AEC) approved per 10 CFR 71.	3. Type B packaging meeting 1967 IAEA regulations for which foreign competent authority certificate has been revalidated by DOT.
4. Type B packaging meeting 1967 IAEA regulations for which foreign competent authority certificate has been revalidated by DOT.	4. Spec 20WC jacket with snug-fitting inner Spec 2R or existing Spec 55 inner package. For liquid, 173.393(g) must also be met for the inner package.
5. Spec 20WC (49 CFR 178.194) outer jacket with snug-fitting Spec 7A (49 CFR 178.350) or existing Spec 55 inner container.	
6. Spec 21WC overpack with single inner Spec 2R (49 CFR 178.34) or existing Spec 55 inner package securely positioned and centered.	

> Atomic Energy Commission. (3) Any other Type B packaging which meets the pertinent requirements for large quantities of radioactive materials in the 1967 regulations of the International Atomic Energy Agency, and for which the foreign competent authority certificate has been revalidated by the Department.

The packaging requirements for large quantities of special-form material are located in 49 CFR 173.394(c) and are substantially the same as for normal form except that, for special form, provision is also made for the use of existing Specification 55 containers with a 20WC overpack; that is:

> Specification 20WC (§178.194 of this subchapter) wooden outer protective jacket, with a single, snug-fitting specification 55 inner packaging. Only use of existing specification 55 container authorized; construction not authorized after March 31, 1975. Radioactive thermal decay energy must not exceed 100 watts.

2.3.3 RADIOACTIVE DEVICES AND LIMITED QUANTITIES

Certain small quantities of radioactive materials are exempt from specification packaging, marking, and labeling requirements and from the general packaging requirements of 49 CFR 173.393, as are certain manufactured articles, such as clocks and electronic tubes, that contain radioactive materials in a nondispersible form. These exemptions are covered in 49 CFR 173.391, "Limited Quantities of Radioactive Materials and Radioactive Devices" (Appendix B to this document).

The "limited" quantity limits and the maximum allowable radioactivity content for exempt manufactured articles for the seven transport groups and for special form are given in Table 2-3. The limited quantity limits are also given in Table 2-1. These limits were chosen in such a way that the release of up to 100 percent of the contents in an accident would still represent a very low potential radiological hazard (Ref. 2-2).

2.3.4 LOW SPECIFIC ACTIVITY MATERIALS

To meet the need for bulk transportation of radioactive ores, slag, or residues from processing, the DOT regulations in 49 CFR 173.392, "Low Specific Activity Radioactive Material," provide exemptions from the requirements of 49 CFR 173.393(a) through (e) and (g) in the case of "low specific activity" (LSA) materials. However, LSA materials must be packed in accordance with the requirements of 49 CFR 173.395 and must be marked and labeled as required in 49 CFR 172.300, "General Marking Requirements," and 172.400, "General Labeling Requirements." LSA materials are defined in 10 CFR 71.4(g) (Appendix B to this document) and include uranium and thorium ores, ore concentrates, materials not exceeding the specific activity limits in Table 2-3, certain contaminated nonradioactive materials, certain solutions of tritium oxide, unirradiated natural or depleted uranium, and unirradiated natural thorium.

In defining the activity limits for LSA materials, the IAEA introduced the concept that, from a radiotoxicity point of view, LSA materials should be "inherently safe"; i.e., it is inconceivable that, under any circumstances arising in transport, a person could ingest enough

TABLE 2-3

LIMITS FOR LIMITED QUANTITIES, LSA MATERIALS, AND MANUFACTURED ARTICLES

Transport Group	Small or Limited Quantity Limit (mCi)*	LSA Materials Limits (mCi/gm)**	Maximum Radioactivity Content for Manufactured Articles (Curies)*	
			Per Device	Per Package
I	.01	.0001	.0001	.001
II	.1	.005	.001	.05
III	.1	0.3	.01	3
IV	1	0.3	.05	3
V	1		1	1
VI	1		1	1
VII	25000		25	200
Special Form	1		.05	20

* 49 CFR 173.391 - exempt from specification packaging, marking, and labeling requirements and from the general packaging requirements of 49 CFR 173.393.

** 10 CFR 71.4(g) and 49 CFR 173.392 - for material in which activity is uniformly distributed; exempt from 49 CFR 173.393(a) though (e) and (g), but must be packed in accordance with the requirements of 49 CFR 173.395 and must be marked and labeled as required in 49 CFR 173.401 and 173.402. LSA limits are not defined for transport groups V, VI, VII, and special form.

material to give rise to a significant radiation hazard (Ref. 2-2). Thus, for LSA materials, it is the limited activity within each segment of the material itself rather than the packaging that permits shipments to meet the basic safety requirements. Nevertheless, both NRC and DOT place packaging requirements on shipments of LSA materials that are not transported on exclusive-use vehicles. NRC also has packaging requirements for Type B quantities of radioactive material transported on exclusive-use vehicles.

2.4 RADIATION CONTROL -- THE TRANSPORT INDEX

The second safety requirement that must be met when transporting radioactive material is the provision for adequate control of the radiation emitted from the material. This radiation is only partially absorbed by the containment and shielding systems. Some passes through the packaging and exposes freight handlers and others who come into close proximity with the package. In order to meet the radiation control limits, the shipper must provide the necessary shielding to reduce the radiation level outside the package to within the allowable limits. The regulations prescribe limits that are chosen to protect not only persons but also animals and film. In fact, the radiation control surface dose rate limit of 0.5 mrem/hour for packages requiring no control was chosen to prevent fogging of sensitive x-ray film that might be transported over a 24-hour period in close proximity to the package containing the radioactive material (Ref. 2-2).

For purposes of radiation control, packages of radioactive material are placed in one of three categories. Packages designated as "Category I - White" (which display a white label) may be transported with no special handling or segregation from other packages and must be within the 0.5 mrem/hour surface dose rate limit. If a transport worker were to handle such packages close to his body for 30 minutes per week, he would receive an average dose rate of 10 mrem/year, which is a factor of 10 less than the average dose rate (100 mrem/year) received by an individual from natural background radiation (Ref. 2-2). The regulations (in 49 CFR 173.393(c)) also prescribe a minimum package dimension of 10 cm (4 inches) so that a person cannot put the package in his or her pocket. The 0.5 mrem/hour surface dose rate limit also applies to "limited" packages, although the minimum package dimension requirement does not.

Except when carried on exclusive-use vehicles, where packages are handled only by shipper and receiver, packages designated as "Category III - Yellow" can have a surface dose rate no greater than 200 mrem/hour <u>and</u> a dose rate at 3 feet from any external surface no greater than 10 mrem/hour (the latter criterion is controlling for larger packages). This limit was chosen to prevent fogging of undeveloped x-ray film during a 24-hour period with a 5 meters (15 feet) separation, 5 meters being chosen as the U.S. Railway Express Company's 1947 conventional separation distance between parcels containing radium and parcels containing undeveloped x-ray film. A package giving out 10 mrem/hour at 1 meter produces 11.5 mrem in 24 hours at 5 meters (Ref. 2-2).

The 200 mrem/hour surface dose rate limit was chosen on the basis that a transport worker carrying such packages held against his or her body for 30 minutes per day would not receive a dose exceeding 100 mrem per 8-hour working day, which was considered acceptable in 1947. Based on current national radiological exposure guidelines, the 200 mrem/hour surface dose rate limit is acceptable as long as the associated handling time is such that individual doses of handlers not treated as "occupationally exposed" are less than the currently accepted limit of 500 mrem/year (Ref.2-4).

An intermediate package category, "Category II - Yellow," includes packages with a surface dose rate not exceeding 50 mrem/hour and a dose rate at 3 feet from any external surface not exceeding 1.0 mrem/hour. Such packages require special handling but do not present the potential hazard of a Category III package. If a highway or rail vehicle carries a Category III package, it must placarded. A summary of the dose rate limits for each package category is given in Table 2-4.

TABLE 2-4

PACKAGE DOSE RATE LIMITS:
MAXIMUM ALLOWED DOSE RATE (MREM/HR)*

Category	Package Surface	3 Feet from Surface (TI)
I - White	0.5	-
II - Yellow	50	1.0
III - Yellow	200	10

*49 CFR 173.393(i)

Since a number of packages of radioactive material are often loaded onto a single transport vehicle that may also carry passengers (e.g., a passenger aircraft), a simple system had to be devised to enable transport workers to determine quickly how many packages could be loaded and how to segregate the packages from passengers and film. For this purpose, the radiation transport index (TI) was devised. This index was defined as the highest radiation dose rate in mrem/hour at 3 feet from any accessible external surface of the package, rounded up to the next highest tenth (see 49 CFR 173.389(i)(1)). For example, if the highest measured dose rate at 1 meter were 2.61 mrem/hour, the TI for that package would be 2.7. From Table 2-4 it would appear that no package with a TI greater than 10 may be transported.

However, the regulations (see 49 CFR 173.393(j)) do provide for transport of packages with dose rates exceeding those in Table 2-4 in a transport vehicle (except aircraft) that has been consigned as exclusive use, provided the following dose limits are not exceeded:

(1) 1,000 millirem per hour at 3 feet from the external surface of the package (closed transport vehicle only);

(2) 200 millirem per hour at any point on the external surface of the car or vehicle (closed transport vehicle only);

(3) 10 millirem per hour at any point 2 meters (six feet) from the vertical planes projected by the outer lateral surface of the car or vehicle; or if the load is transported in an open transport vehicle, at any point 2 meters (six feet) from the vertical planes projected from the outer edges of the vehicle.

(4) 2 millirem per hour in any normally occupied position in the car or vehicle, except that this provision does not apply to private motor carriers.

When more than one package of radioactive material is loaded onto a transport vehicle, a total index for the shipment is obtained by summing the TIs for each individual package, a process requiring only the simple addition of numbers. The total TI for packages loaded onto a single transport vehicle may not exceed 50 (see 49 CFR 174.700(b), 49 CFR 175.75(a)(3), and 49 CFR 177.842(a)). There are two exceptions to this rule. One is for vehicles (other than aircraft) consigned for exclusive use (49 CFR 173.393(j)). The other is for transport by ship; in this case a total TI of 200 is permitted with the packages in single groups each having a total TI not greater than 50, and each such group located at least 20 feet (6.1 meters) from any other group (49 CFR 176.700). At least two cargo airlines are presently operating under special DOT permit to carry up to 200 TI, but all other aircraft are limited to 50 TI.

The regulations also provide tables of safe separation distances that must be maintained between stowed packages of radioactive material and persons or undeveloped film for various types of transport (see 49 CFR 174.700, "Special Handling Requirements for Radioactive Materials," for rail freight; 49 CFR 175.700, "Special Requirements for Radioactive Materials," for aircraft; 49 CFR 176.700, "General Stowage Requirements," for ships; and 49 CFR 177.842(b) for truck and other common, contract, or private carriers by public highway). It will be noticed from Table 2-4 that these requirements apply only to Categories II- and III-Yellow packages. Category I packages are not assigned a transport index.

All packages are expected to retain their shielding effectiveness during normal transport conditions. The external dose rate, or TI, measured by the shipper and written on the package label must not increase during transport, e.g., as a result of faulty shielding. After being subjected to the hypothetical accident conditions listed in Appendix B to 10 CFR Part 71, any reduction of shielding caused by damage to a Type B package must not increase the external dose rate to more than 1000 mrem per hour at 3 feet from the external surface of the package (see 10 CFR 71.36(a)(1)).

2.5 SPECIAL CONSIDERATION FOR FISSILE MATERIAL

The third basic safety requirement for transporting radioactive materials is the prevention of nuclear criticality for fissile materials. These are defined in 10 CFR 71.4(e) as U-233, U-235, Pu-238, Pu-239, and Pu-241.

The criticality standards for fissile material packages are found in 10 CFR 71.33, which states, in effect, that a package used to ship fissile material is to be so designed and constructed and the contents so limited that the package would be subcritical if water were to leak into the package or if any liquid contents of the package were to leak out. However, a sufficient number of certain types of packages of fissile material, even though each package is subcritical, could conceivably be grouped in such a way that the assembly becomes critical. The number of such packages that may be transported together is limited and depends on the package design and contents.

There are, however, some quantities, forms, or concentrations of fissile nuclides that cannot be made critical under any credible transport conditions. These are specified in 10 CFR

71.9, "Exemption for Fissile Material," and are exempted from the special requirements for fissile material shipments. They include, for example, packages containing natural thorium or natural uranium or less than 15 grams of fissile material.

The regulations prescribe three package classes called Fissile Class I, II, and III for shipments of fissile materials that do not qualify for exemption as defined above. Fissile Class I packages are considered safe from nuclear criticality by virtue of the package design and contents and may therefore be transported in unlimited numbers and in any arrangement so long as the total radiation TI limit is not exceeded. Each such packaging must be so designed that it is a net absorber of neutrons in both normal and accident environments. The specific standards for Fissile Class I packages are given in 10 CFR 71.38.

If a limited number of packages would be subcritical in any arrangement and in any foreseeable transport circumstances, they are in Fissile Class II. For purposes of nuclear criticality safety control, a special fissile transport index is assigned to such packages as follows:

$$\text{fissile TI} = 50/N \qquad (2\text{-}1)$$

where N is the number of similar packages that may be transported together as determined under the limitations of 10 CFR 71.39(a). This transport index cannot be less than 0.1 nor more than 10. Thus, a shipment of N packages would not result in an aggregate fissile transport index greater than 50. The actual transport index assigned to any fissile material package is always the greater of the fissile TI or the previously defined radiation TI (see 49 CFR 173.389(i)). Aside from the limit on the number of packages per shipment, Fissile Class II packages (like Fissile Class I) require no nuclear criticality safety control by the shipper.

Fissile Class III includes all packages of nonlimited fissile material that do not comply with the requirements of either Class I or Class II packages. Fissile Class III packages are those considered to be precluded from criticality under all foreseeable circumstances of transport by reason of special precautions or special administrative or operational controls imposed on the transport of the consignment (Ref. 2-2). Special arrangements between the shipper and the carrier are required to provide nuclear criticality safety. The specific standards for such shipments are given in 10 CFR 71.40. International shipments of Fissile Class III packages require multilateral competent authority approval (Ref. 2-2).

Because of plutonium's toxicity, special additional requirements are imposed on its shipments. There is currently a ban on shipments of plutonium by aircraft (Ref. 2-5). The requirements of 10 CFR 71.42 apply to plutonium shipments after June 17, 1978, and stipulate that plutonium in excess of 20 curies per package must be shipped as a solid and must be packaged in a separate inner container. Exempted from this requirement is solid plutonium in the form of reactor fuel elements, metal, and metal alloy.

DOT packaging requirements for the shipment of fissile materials are given in 49 CFR 173.396, "Fissile Radioactive Material." This section specifies certain existing approved packagings for fissile materials and the authorized contents for each. Any other packaging design that is approved by NRC is accepted by DOT for fissile material shipments (see 49 CFR

173.396(b)(4) and 49 CFR 173.396(c)(3)). Since fissile material quantities are usually given in grams or kilograms, one cannot use Table 2-1 directly to determine which quantity classification applies to a given amount of a particular fissile isotope. The quantity limits in grams for Type A and Type B packages of some of the more important fissile materials are listed in Table 2-5. These were calculated from the data in Table 2-1 and the respective specific activities, taking into account the transport group assigned to each isotope. It is apparent from the table that a package containing, for example, only 2 grams of Pu-238 would be classified as a "large quantity," i.e., greater than the Type B limit, whereas a package containing 100 kg of 3 percent enriched uranium would be classified as a Type A quantity, because of the amount of radioactivity in each case.

2.6 PROCEDURES TO BE FOLLOWED BY THE RECEIVER

The standards discussed so far have been applicable to the shipper of radioisotopes and pertain primarily to packaging of the material in such a way that the transport occurs safely. The NRC standards of 10 CFR 20.205, "Procedures for Picking Up, Receiving, and Opening Packages" (Appendix B to this document), outline the procedures for picking up, receiving, and opening the packages and apply to the licensee who is to receive the package. These standards point out the responsibility of the receiver to:

1. Make arrangements with the carrier to receive the package or to receive notification of the arrival of the package at the carrier's terminal (in the latter case, the receiver is to pick up the package expeditiously from the terminal).

2. Monitor the external surfaces of the package for radioactive contamination caused by possible leakage of the radioactive contents and monitor the radiation levels on and at 3 feet from the external package surfaces. This monitoring must be performed no later than three hours after receipt of the package if received during normal working hours, or in any case, within eighteen hours.

3. Notify, by telephone and telegraph, both the final delivering carrier and the appropriate NRC Inspection and Enforcement Regional Office if the monitoring reveals:

   a. Removable radioactive contamination in excess of 0.01 microcuries per 100 square centimeters of package surface;

   b. Radiation levels on the external package surface in excess of 200 millirems per hour; or

   c. Radiation levels at 3 feet from an external package surface in excess of 10 millirems per hour.

4. Establish and maintain procedures for safely opening packages in which licensed material is received, and ensure that those procedures are followed, giving due consideration to special instructions for the type of package being opened. Exemptions from the requirements for monitoring external surfaces for contamination are provided in 10 CFR 20.205(b) for special-

TABLE 2-5

TYPE A AND TYPE B QUANTITY LIMITS IN GRAMS FOR CERTAIN FISSILE MATERIALS

Element	Specific Activity (Ci/gm) [6]	Transport Group	Maximum Content (grams)* Type A	Type B
U-235	2.1×10^{-6}	III	1.4×10^{6}	9.5×10^{7}
U-238 (or depleted uranium)	3.3×10^{-7}	III	9.1×10^{6}	6.1×10^{8}
Uranium (average enrichment - 3% U-235)	3.86×10^{-7}	III	7.8×10^{6}	5.2×10^{8}
Uranium (natural - .711% U-235)	3.45×10^{-7}	III	8.7×10^{6}	5.8×10^{8}
U-233	9.5×10^{-3}	II	5.3	2100
Pu-238	17.4	I	5.7×10^{-5}	1.1
Pu-239	6.1×10^{-2}	I	1.6×10^{-2}	326
Pu-240	.23	I	4.3×10^{-3}	86
Pu-241 (+ daughters)	112	I	8.9×10^{-6}	0.18
Pu-242	3.9×10^{-3}	I	0.26	5200
Am-241 (+ Np-237)	3.24	I	3.1×10^{-4}	6.2
Am-243 (+ daughters)	.19	I	5.3×10^{-3}	106
Cf-252	536	I	1.9×10^{-6}	.038

*Greater quantities must be shipped in packages approved for large quantities.

form materials and gases, Type A packages containing only radioactive material in other than liquid form, packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries, all packages containing only limited quantities, and packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, C-14, S-35, or I-125.

2.7 LABELING OF PACKAGES

Each package containing more than limited quantities of radioactive material must be labeled on two opposite sides with one of three warning labels as described in 49 CFR 172.436, "Radioactive White - I Label"; 172.438, "Radioactive Yellow - II Labels"; and 172.440, "Radioactive Yellow - III Label." The labeling requirements are given in 49 CFR 172.403, "Radioactive Material."

All three label types contain the distinctive trefoil symbol and either one, two, or three vertical stripes. The one-striped label has a white background and is placed on a Category I - White package. A label with a bright yellow upper half and a white lower half is marked with either two or three vertical stripes and indicates a significant radiation level outside the package. The two-stripe label is placed on a Category II - Yellow package, and the three-stripe label is placed on a Category III - Yellow package. The radioactive White - I label may not be used for Fissile Class II packages (49 CFR 172.403(b)(1)). Each Fissile Class III package, each package containing a "large quantity" of radioactive material, and certain other types of packages must bear a Radioactive - Yellow III label (49 CFR 172.403(d)). The label must show the isotope contained in the package, the number of curies, and the transport index (except for the White - I label). In addition, each package weighing more than 50 kg (110 pounds) must have its gross weight marked on the outside of the package (49 CFR 172.310(a)(1)). Type A or Type B packaging must be plainly marked with the words "Type A" or "Type B," respectively. Packages destined for export shipment must also be marked "USA" (49 CFR 172.310(a)(3)).

2.8 REQUIREMENTS PERTAINING TO THE CARRIER - VEHICLE PLACARDING AND STOWAGE

DOT imposes certain regulations on the carrier for radioactive materials transport. These include vehicle placarding, examination of shipper certification papers and packages for proper marking and labeling, and proper loading and stowage of the packages aboard the transport vehicle. Appropriate placards must be displayed on the front and rear and on each side of rail or highway vehicles carrying packages bearing the Radioactive - Yellow - III label. The regulations regarding placarding are given in 49 CFR 172.504, "General Placarding Requirements."

In addition to placarding his vehicle as required, the carrier has the responsibility of ensuring that the articles offered for transport have been certified by the shipper to be properly classified, described, packaged, marked, labeled, and in proper condition for transportation.

For normal-form materials, the shipping papers must include the transport group or groups of the radionuclides, the names of the radionuclides in the material, and a description of their physical and chemical form. For all radioactive material, the activity of the material in curies and the type of radioactive label applied must also be listed. In addition, for fissile materials, the fissile class must be given with an additional warning statement as described in 49 CFR 172.203(d).

For shipments by aircraft, the operator of the aircraft (e.g., an airline official) must inform the pilot-in-command of the name, classification, and location of the radioactive material on the aircraft per 49 CFR 175.33, "Notification of Pilot-in-Command." In addition, for passenger-carrying aircraft there must be a clear and visible statement accompanying the shipment, signed or stamped by the shipper or his agent, stating that the shipment contains radioactive materials intended for use in, or incident to, research, medical diagnosis, or medical treatment (49 CFR 172.204(c)(4)).

The carrier is also required to make sure that the maximum allowable TI is not exceeded and that the packages are not transported or stored in groups having a total TI greater than 50. He must also ensure that such groups of yellow-labeled packages are separated by the required distances from areas continually occupied by persons, from film, and from shipments of animals. Further, he must ensure that a Fissile Class III shipment is not transported on the same vehicle with other fissile material and is segregated by at least 20 feet (6.1 meters) from other radioactive material packages in storage. The pertinent regulations are found in 49 CFR 174.700(d), 175.710, 176.700(d), and 177.842(f).

There are special requirements for stowage of packages of radioactive material bearing Radioactive - Yellow - II or Yellow - III labels aboard vehicles. For a vehicle loaded with the maximum allowable radioactive package load of 50 TI, a minimum distance of 2.1 meters must be maintained between the package and a space continuously occupied by people. In practice, radioactive packages are usually placed as far to the rear of the aft cargo hold as possible in passenger aircraft.

2.9 REPORTING OF INCIDENTS AND SUSPECTED CONTAMINATION

If death, injury, fire, breakage, spillage, or suspected radioactive contamination occurs as a direct result of hazardous materials transportation, the regulations (49 CFR 171.15, "Immediate Notice of Certain Hazardous Materials Incidents") require immediate notification to DOT and the shipper. The carrier must submit within 15 days of the date of discovery of such an occurrence a "detailed hazardous materials incident report" (49 CFR 171.16, "Detailed Hazardous Materials Incident Reports"). The vehicles, buildings, areas, or equipment in which a spillage of radioactive materials has occurred may not be used again until the radiation dose rate at any accessible surface is less than 0.5 mrem/hour and there is no significant removable surface contamination. The carrier can obtain technical assistance in radiation monitoring following an incident or accident by calling one of the ERDA or NRC Regional Offices for radiological assistance.

The level above which removable radioactive contamination is considered "significant" depends on the contaminating nuclide and is specified in 49 CFR 173.397(a). This section also prescribes a method for assessing the surface contamination of a package. For radioactive material packages consigned for shipment on exclusive-use vehicles (49 CFR 173.389(o)), the "significant" levels of surface contamination are 10 times as great as for packages transported on non-exclusive-use vehicles (49 CFR 173.397(b)). Exclusive-use transport vehicles must be surveyed with appropriate radiation detection instruments after each use and may not be returned to service until the radiation dose rate at any accessible surface is 0.5 mrem/hour or less and there is no significant removable radioactive surface contamination (49 CFR 173.397(c)).

2.10 REQUIREMENTS FOR SAFEGUARDING OF CERTAIN SPECIAL NUCLEAR MATERIAL

Certain strategic quantities and types of special nuclear material (SNM) require physical protection against theft and sabotage both at fixed sites and during transit because of their potential for use in a nuclear explosive device. The NRC standards for physical protection of materials while in transit are found in 10 CFR 73.30 - 10 CFR 73.36, which make up a subchapter entitled, "Physical Protection of Special Nuclear Material in Transit." They apply to any person licensed pursuant to the regulations in 10 CFR 70 who imports, exports, transports, delivers to a carrier for transport in a single shipment, or takes delivery of a single shipment free on board (f.o.b.) at the point where it is delivered to a carrier, any one of the following:

1. 5000 grams or more of U-235 contained in uranium enriched in the U-235 isotope to 20 percent of more,

2. 2000 grams or more of U-233,

3. 2000 grams or more of plutonium, or

4. Any combination of these materials in the amount of 5000 grams or more computed by the formula:

$$\text{grams} = (\text{grams contained U-235}) + 2.5\,(\text{grams U-233} + \text{grams plutonium}).$$

The standards also apply to air shipments of SNM in quantities exceeding:

1. 20 grams or 20 curies (whichever is less) of plutonium or U-233 or

2. 350 grams of U-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope).

Quantities and types of SNM that require safeguarding are often referred to as "strategic special nuclear material," or "SSNM." A licensee is exempt from these requirements for shipments of (see 10 CFR 73.6, "Exemptions for Certain Quantities and Kinds of Special Nuclear Material"):

1. Uranium enriched to less than 20 percent in the U-235 isotope,

2. SNM that is not readily separable from other radioactive material and that has a total external radiation dose rate in excess of 100 rems per hour at a distance of 3 feet from any accessible surface without intervening shielding (e.g., irradiated fuel), and

3. SNM in a quantity not exceeding 350 grams of U-235, U-233, plutonium, or a combination thereof, possessed in any analytical research, quality control, metallurgical, or electronic laboratory.

The general requirements for physical protection of SSNM while in transit are found in 10 CFR 73.30, "General Requirements" (Appendix B to this document), and are concerned with the following:

1. The necessity for the shipper to make prior arrangements with the carrier for physical protection of the SSNM, including exchange of hand-to-hand receipts at origin, destination, and transfer points.

2. The minimizing of transit time and avoidance of areas of natural disaster or civil disorder (does not apply to the air shipments described earlier).

3. The required use of tamper-indicating type seals and locking of containers for specified contents. No container weighing 500 pounds or less can be shipped in open trucks, railroad flat cars, or box cars and ships.

4. The use and qualification of guards.

5. The outlining of procedures to be followed by the licensee.

6. The provision for approval of special procedures not found in the standards.

Specific standards for safeguarding shipments of SSNM by road are given in 10 CFR 73.31, "Shipment by Road." The basic requirements of this paragraph are as follows:

1. No scheduled intermediate stops are allowed.

2. Vehicles used to transport SSNM are to be equipped with radiotelephones, and contact with the licensee or agent is to be made, in most cases, every two hours.

3. Two people are to accompany the shipment in the vehicle containing the shipment. In addition, either an armed escort consisting of at least two guards in a separate vehicle shall accompany the shipment (in this case only one driver is required in the vehicle containing the SSNM for shipments lasting less than one hour) or a specially designed truck or trailer that reduces the vulnerability to diversion shall be used.

4. The vehicles are to be marked on top with identifying letters, to permit identification in daylight and clear weather at 1000 feet above ground level, and also on the sides and rear of the vehicle.

Standards for safeguarding shipments of SSNM by air are discussed in 10 CFR 73.32, "Shipment by Air":

1. Shipments by passenger aircraft* of plutonium or U-233 in quantities exceeding 20 curies or 20 grams (whichever is less) or 350 grams of U-235 contained in uranium enriched to 20 percent or more in the U-235 isotope must be specifically approved by the NRC.

2. Transfers are to be minimized.

3. Export shipments are to be escorted by an unarmed authorized individual from the last terminal in the United States until the shipment is unloaded at a foreign terminal.

The regulations of 10 CFR 73.33, "Shipment by Rail," provide that, for safeguarding shipments by rail, an escort by two guards is required (guards are, by definition, uniformed and armed - see 10 CFR 73.2(c)). The guards ride either in the shipment car or in an escort car from which they can keep the shipment car under observation. Radiotelephone contact with the licensee or his agent is to be made at specific intervals.

The regulations for safeguarding shipments of SSNM by sea, given in 10 CFR 73.34, "Shipment by Sea," provide that:

1. Shipments shall be made on vessels making minimum ports of call and with no scheduled transfers to other ships.

2. The shipment is to be placed in a secure compartment that is locked and sealed.

3. Export shipments shall be escorted by an unarmed authorized individual from the last port in the United States until the shipment is unloaded at a foreign port.

4. Ship-to-shore contact is to be made every 24 hours, and the information regarding position and status of the shipment is to be sent to the licensee or his agent who arranges for the protection of the shipment.

The necessary transfers of SSNM during a shipment must be monitored by a guard. These monitoring procedures are outlined in 10 CFR 73.35, "Transfer of Special Nuclear Material":

1. At a scheduled intermediate stop where the SSNM is not to be unloaded, the guard is to observe the opening of the cargo compartment, maintaining continuous visual surveillance of it until the vehicle departs. Then the guard must immediately notify the licensee or his agent of the latest status.

2. At points where SSNM transfers occur, the guard is to keep the shipment under continuous visual surveillance, observe the opening of the cargo compartment for an incoming vehicle,

*Note that 49 CFR 175 prohibits these shipments unless the materials are intended for medical or research use, and Public Law 94-79 prohibits NRC approval of shipments by air in uncertified packages of any licensed plutonium other than that contained in specified medical devices.

and ensure that the shipment is complete by checking locks and/or seals. Continuous visual surveillance is also to be maintained when the shipment is in the terminal or in storage. Immediately after a vehicle carrying SSNM has departed, the guard must notify the licensee or his agent of the latest status.

3. The guard is to report immediately to the carrier and the licensee who arranged for the protection of the SSNM any deviations or attempted interference.

Finally, 10 CFR 73.36, "Miscellaneous Requirements," contains miscellaneous safeguarding requirements for licensees who ship, receive, export, or import SSNM. The basic features of these requirements are as follows:

1. If a licensee agrees to take delivery of an f.o.b. shipment of SSNM, the licensee, rather than the shipper, arranges for the protection of the shipment while it is in transit.

2. A licensee who imports SSNM must ensure that the shipment is not diverted in transit between the first point of arrival in the United States and delivery to the licensee.

3. The licensee who delivers SSNM to a carrier for transport must, at the time of departure of the shipment, notify the consignee of the methods of transportation, the names of the carriers, and the estimated arrival time. The licensee must also arrange to be notified by the consignee immediately upon arrival of the shipment.

4. The licensee who exports SSNM must comply with this regulation for transport to the first point outside the United States at which the shipment is removed from the vehicle.

5. A licensee who receives a shipment of SSNM is to notify the shipper immediately upon arrival of the shipment at its destination.

6. If a shipment of SSNM is lost or unaccounted for after the estimated arrival time, the licensee who arranged for safeguarding the shipment shall immediately conduct a trace investigation and file a report with the NRC as specified in 10 CFR 73.71, "Reports of Unaccounted For Shipments, Suspected Theft, Unlawful Diversion, or Industrial Sabotage."

The application of the above requirements and additional measures required as license conditions (10 CFR 70.32(b)) are discussed in Chapter 7.

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2-1. International Atomic Energy Agency, A Basic Toxicity Classification of Radionuclides, Technical Report Series No. 15, IAEA, Vienna, 1963.

2-2. A. Fairbairn, The Development of the IAEA Regulations for the Safe Transport of Radioactive Materials, Atomic Energy Review, Vol. 11, No. 4, IAEA, Vienna, 1973.

2-3. Docket No. HM-111, Federal Register, Vol. 39, No. 252, December 31, 1974.

2-4. International Commission on Radiological Protection, "Recommendations of the International Commission on Radiological Protection," ICRP Publication 9, Pergammon Press, Oxford, 1966.

2-5. Public Law 94-79 (S.1716).

CHAPTER 3
RADIOLOGICAL EFFECTS

3.1 RADIATION

Radiation is emitted as a result of radioactive nuclides undergoing spontaneous decay. During the decay process, these nuclides emit characteristic particles or electromagnetic radiation and are thereby transformed into either completely different nuclei or more stable forms of the same nuclei. The nuclide that results from this emission may also be radioactive, depending on the relative stability achieved by the nucleus via decay (Ref. 3-1). From a radiological health viewpoint, three of the most important types of radiation are charged particles, neutrons, and electromagnetic radiation.

3.1.1 CHARGED PARTICLES

Charged particles such as beta and alpha particles undergo strong Coulomb interactions with matter. These interactions rapidly diminish the energy of the charged particles and therefore limit their travel to short distances. An alpha particle with 5 million electron volts (MeV) of energy, for example, will travel about 3.1 cm in dry air and 0.004 cm in tissue (Refs. 3-2 and 3-3).

3.1.2 NEUTRONS

Radiation dose from neutrons is a strong function of particle energy. Fast neutrons interact with matter primarily through scattering collisions with nuclei. About one-half the neutrons with energies near 1 MeV are absorbed after passage through 9.25 cm of water (Ref. 3-3). "Thermal" or low-energy neutrons have a higher probability of absorption by matter. They are captured by some nuclei in a process that is often accompanied by subsequent radiation or fission.

3.1.3 ELECTROMAGNETIC RADIATION

X-rays and gamma rays lose energy as a result of the photoelectric effect, Compton scattering, and pair production. Since these processes are less probable than the Coulomb interactions characteristic of charged particles, the range of electromagnetic radiation is much greater than that of alpha or beta particles of comparable energy. One-MeV gamma radiation will travel about 7 cm in water before half of the initial incident photons are absorbed (Ref. 3-3).

3.2 DOSE

Radiation exposure may be measured in terms of its ionizing effect or in terms of the energy absorbed per unit mass of exposed material. Historically, radiation exposure for x- and gamma radiation was measured in units of roentgens (the amount of radiation required to produce one electrostatic unit (esu) of charge from either part of an ion pair in 1 cm^3 of dry air). It can be shown that 1 roentgen is equivalent to energy deposition of 88 ergs in 1 gram of dry air (Ref. 3-4). A modern and more useful method for quantifying radiation interaction is in terms of the energy absorbed per unit mass. One radiation absorbed dose (rad) unit equals 100 ergs per gram of absorbing material.

Since biological effects of radiation have been found to depend on both the energy deposited and the spatial distribution of the deposition, it was found convenient to define the relative biological effectiveness (RBE) as

$$RBE = \frac{\text{Dose of 220-250 keV x-rays for a given effect}}{\text{Dose of the radiation in question for the same effect}} \qquad (3\text{-}1)$$

where a particular biological effect is considered (Ref. 3-5). In an attempt to devise a unit that would provide a better criterion of biological injury when applied to different radiations, a biological dose unit, the Roentgen Equivalent Man (rem), is defined by

$$\text{Dose equivalent in rem} = \text{RBE} \times \text{absorbed dose in rad} \qquad (3\text{-}2)$$

Since RBE will depend on effect studied, dose, dose rate, physiological condition, and other factors, the quality factor (QF) is defined to be the upper limit for the most important effect due to the radiation in question. The biological effect of 1 rem of radiation will be equivalent for all types and energies of radiations; radiation doses in rem are thus additive, independent of radiation nature. Table 3-1 lists QFs for various types of radiation.

TABLE 3-1

QUALITY FACTORS FOR VARIOUS TYPES OF RADIATION

(Refs. 3-6, 3-7, and 3-8)

Radiation	Range of Quality Factor	Typical Value
x-ray, γ-ray	1.0	1
Beta particles, electrons	1.0 - 1.7	1
Fast neutrons	5.0 - 11.0	10
Slow (thermal) neutrons	2.0 - 5.0	3
Alpha particles	1.0 - 20.0	10
Protons	1.0 - 10.0	10
Heavy ions, fission fragments	20.0	20

Radiation from sources external to the body is usually only harmful to humans when in the form of neutrons, x-rays, or gamma rays, since alpha and beta particles are typically stopped by the skin.* However, any source of radiation incorporated into the body is potentially hazardous. The large QF assigned to alpha particles, for example, indicates that they may be especially

*Extremely energetic beta radiation can penetrate the outer layers of skin and damage the more sensitive inner layers.

hazardous internally where they can deposit a large quantity of energy in a small amount of potentially more sensitive internal body tissue.

The radiosensitivities of different life forms differ considerably. In general, higher life forms are more sensitive to radiation than lower forms, although in some specific cases this is not true (Ref. 3-5). Table 3-2 shows the dose response for a range of life forms. Throughout this report, the radiological impact to man will be the only one quantitatively evaluated. This perspective is taken because of the generally higher sensitivity of man to radiation and because the societal impacts of doses to human beings are generally considered to be more significant than the impact due to irradiation of lower life forms.

3.3 BACKGROUND SOURCES OF EXPOSURE

Natural background radiation, originating primarily from cosmic rays and terrestrial gamma emitters, constitutes the most significant source of radiation exposure to the general population. The dose from background sources will vary with altitude, latitude, and differences in the radioactive material content of the soil, building materials, etc. The variation in cosmic radiation with altitude, for example, is shown in Figure 3-1. At low altitudes, the charged particle component (both solar and galactic) is essentially constant with latitude. However, depending on the altitude of the recipient, the neutron component varies as much as a factor of 3 from 41°N to 90°N (Ref. 3-9). Consequently, the individual dose from these sources will vary considerably with location. For example, a person in Louisiana or Texas will receive about one-half the annual dose received by a person in Colorado or Wyoming (Ref. 3-10).

Both internal and external exposure to all persons results from the presence of naturally occurring radioactive material in the soil, air, water, vegetation, and even the human body. The doses received by various organs from these sources can differ widely depending on the type of soil, house construction material, diet, etc. An average annual individual whole-body equivalent dose* of 102 mrem is received from natural background exposure (cosmic rays and internal and external terrestrial sources) (Ref. 3-10). Since the U.S. population was about 220 x 10^6 persons in 1975, the total annual natural background population dose is 22.4 x 10^6 person-rem.

Radiation exposure to the public also occurs in medical and dental applications of radiation sources. A large component of this dose results from diagnostic use of medical and dental x-rays (15.8 person-rem). A smaller, but increasing, population dose results from the use of radiopharmaceuticals (0.2 person-rem).

Fallout from atmospheric weapon testing by the U.S., U.S.S.R., U.K., China, and France is estimated to result in an average annual individual dose of 4 mrem (Ref. 3-10), contributing 9 x 10^5 person-rem in 1975.

Nuclear power, including fuel reprocessing and power reactor operation, is expected to result in an average annual dose of approximately 0.4 mrem to individuals in the general population in the year 2000 (Ref. 3-11), corresponding to an annual population dose of 9 x 10^4 person-rem.

*Whole-body dose is defined in paragraph 20.101(b)(3) of 10 CFR Part 20, "Standards for Protection Against Radiation," as dose to the whole body, gonads, active blood-forming organs, head and trunk, or lens of the eye.

TABLE 3-2

APPROXIMATE RADIOSENSITIVITY OF VARIOUS LIFE FORMS TO EXTERNAL RADIATION (Ref. 3-5)

Life Form	Biological Effects	Necessary Dose
Plant Life	Growth Impairments	2,000 - 70,000 R
Arthropods	Death	1,000 - 100,000 R
Insect Pupae and Larvae	Death	200 - 2,000 R
Fish, Amphibia, Reptiles	Death	1,000 - 2,000 R
Mammals (general)	Death (LD 50/30)*	300 - 800 R
Hamsters	Death (LD 50/30)*	800 R
Mouse	Death (LD 50/30)*	600 R
Man	Death (LD 50/30)*	300 - 600 R

*Lethal dose to 50 percent of the exposed population within 30 days.

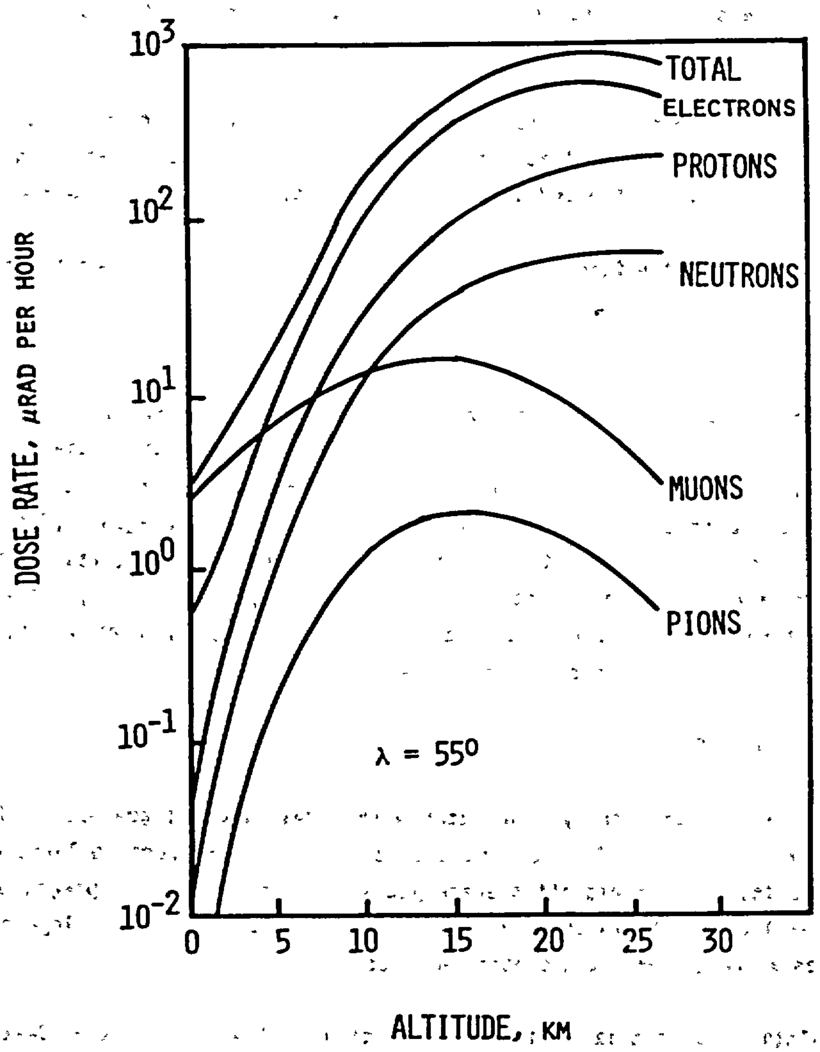


FIGURE 3-1. VARIATION OF GALACTIC RADIATION* DOSE RATES WITH ALTITUDE AT GEOMAGNETIC LATITUDE (λ) OF 55° (Ref. 3-9).

*Galactic radiation is primarily energetic alpha particles, protons, and some heavy nuclei derived from sources other than the sun. Solar radiation consists mainly of protons and heavier nuclei emitted from solar flares and also associated with sunspots (Ref. 3-9).

The occupational dose received by Federal radiation workers, naval nuclear propulsion program personnel, power reactor employees, nuclear fuel cycle service personnel, etc., accounts for an accumulated annual dose of 2×10^5 person-rem, for an average per capita dose of 0.8 mrem (Ref. 3-10).

Additional exposure results from color television sets, commercial air travel, and various consumer products using radium or other radioactive materials. The estimated annual individual dose from these causes is approximately 2 mrem for an accumulated dose of 4×10^5 person-rem.

Background radiation doses and the integrated population doses are summarized in Table 3-3.

3.4 HAZARDS FROM RADIATION

The effects of radiation upon the body are a manifestation of the localized deposition of electromagnetic or kinetic energy in the atoms along the path traveled by the radiation. The ionizations and excitations caused by this deposition can directly or indirectly alter both the chemical composition and the chemical equilibrium within the cells along the path (Ref. 3-5). The effects of the radiation may be undetectable, or they may manifest themselves as acute physiological changes, carcinogenesis, or genetic effects, depending on the amount and type of incident radiation, the type of cells irradiated, and the time span over which irradiation occurs. Each of these effects will be discussed briefly below.

3.4.1 ACUTE PHYSIOLOGICAL CHANGES

Acute physiological changes are normally associated with relatively large absorbed doses received over a short period of time. Data on these effects in man are derived largely from Japanese atomic bomb casualties, some radiation therapy patients, and a few recipients of high acute doses from industrial accidents in the early days of the nuclear weapon development programs. Table 3-4 summarizes acute whole-body radiation effects in man.

If the acute irradiation is localized in a specific region of the body, the effects can vary widely because of variations in cell sensitivity to radiation. The reproductive organs are among the more sensitive. Radiation doses to males beginning above 10 rads and extending to 600 rads produce a decrease in, or absence of, sperm beginning 6 to 7 weeks after exposure and continuing for a few months to several years, after which time there is full recovery. The extent of sperm count decrease and the rate of recovery are related to the magnitude of the dose (Ref. 3-13). On the other hand, organs such as kidneys, lungs, stomach, bladder, and rectum may be able to withstand acute doses of several thousand rads before substantial damage occurs (Ref. 3-7).

3.4.2 CARCINOGENESIS

Fatal cancers account for approximately 20 percent of all deaths in the U.S. (Ref. 3-14). These cancers are divided into three broad groups: carcinomas, sarcomas, and leukemias or lymphomas. Within these groups, there are 100 or so distinct varieties of disease based on the

TABLE 3-3

ESTIMATES OF ANNUAL WHOLE-BODY DOSES
IN THE UNITED STATES
(Refs. 3-10, 3-11, and 3-12)

Source	Average Annual Dose* (mrem)	Integrated Annual Population Dose** (10^6 person-rem)
Cosmic rays	44	9.7
Terrestrial Radiation		
External	40	8.8
Internal	18	4.0
Fallout	4	0.9
Nuclear Power	0.4***	.09
Medical/Dental		
Diagnostic x-rays	72†	15.8
Radiopharmaceuticals	1	0.2
Occupational	0.8	0.2
Miscellaneous	2	0.4
Total		40

*The numbers shown are average values only. For given segments of the population, doses considerably greater than these may be experienced.

**Based on U.S. population of 220×10^6.

***Estimate for the year 2000.

†Based on the abdominal dose.

TABLE 3-4

DOSE-EFFECT RELATIONSHIPS IN MAN FOR ACUTE WHOLE-BODY GAMMA IRRADIATION

(Refs. 3-7 and 3-13)

Dose (rads)	Nature of Effect
5-25	Minimum detectable dose by chromosome analysis or other specialized tests.
50-75	Minimum acute dose readily detectable in a specific individual.
75-125	Minimum acute dose likely to produce vomiting in about 10 percent of people so exposed.
150-200	Acute dose likely to produce transient disability and obvious blood changes in a majority of people exposed.
~340	Median lethal dose for single short exposure with no medical treatment (Ref. 3-13).
~510	Median lethal dose for single short exposure with supportive medical treatment (barrier nursing, antibiotics, transfusions) (Ref. 3-13).
~1050	Median lethal dose for single short exposure with heroic medical treatment (bone marrow transplants, etc.) (Ref. 3-13).

original site of the malignancy. The specific fatality and man-year losses in the United States due to the principal types of cancer are shown in Table 3-5.

There are many theories of carcinogenesis, but most researchers acknowledge that a statistical correlation can be established between certain environmental factors and cancer induction. Examples of these correlations include the correlation of smoking to lung cancer and that of radiation dose to leukemia among atomic bomb survivors. The correlation between exposure to radiation and cancer induction has been qualitatively established for animal exposures and is widely accepted for human exposures (Ref. 3-15), although the physiological mechanisms involved are not well understood. Statistical analysis of large numbers of exposed persons such as Japanese atomic bomb survivors, uranium miners, fluorspar miners, radium dial painters (Ref. 3-11) permits rough predictions of latent cancer fatalities per million person-rem of population dose. These values, modified to account for the distribution of ages within the general population (Ref. 3-13), are used in the health-effects model for this assessment (discussed in Section 3.7 of this chapter).

3.4.3 GENETIC EFFECTS

The genetic material (DNA) is organized into linear sequences (chromosomes) of large numbers of protein groupings (genes). Changing the chemical nature or location of one or more of the protein molecules within a gene will change the genetic information carried by the chromosome and, hence, the genetic information used to "construct" cells in any offspring. Changes that result from such modifications of the genetic coding are called gene mutations. In extreme cases where there are gross changes in the number or overall composition of entire chromosomes, the mutations are called chromosomal aberrations (Ref. 3-13).

Whatever their origin, mutations are frequently detrimental, and every individual appears to carry a "load" of defective genes which collectively tends to reduce his overall fitness to some degree (Ref. 3-7). During the evolutionary past, an equilibrium between mutation rates and natural selection against detrimental genes and in favor of favorable genes has been established for each species (Ref. 3-7). Concern has arisen because of the laboratory work that has shown radiation to be mutagenic in lower life forms such as Drosophila (fruit flies) and various species of mice. These data have been extrapolated to dose-effect relationships (Refs. 3-3, 3-7, and 3-11) in man, although this extrapolation is a tenuous and possibly inaccurate procedure. There is positive evidence of induction of chromosomal aberrations by radiation in human lymphocytes. However, several detailed investigations of children of Japanese atomic bomb survivors have not shown significant increase in mutation incidence (Ref. 3-17).

3.5 RADIATION STANDARDS

As a result of early injuries and deaths from exposure to various sources of radiation, international efforts were organized during the early 1920's to establish standards for radiation protection. In 1928, the International Committee (now Commission) on Radiation Protection (ICRP) was created. In the United States, the Advisory Committee on X-ray and Radium Protection, later to become the National Council on Radiation Protection and Measurements (NCRP), was organized in 1929. More recently the Federal Government entered the field of radiation protection

TABLE 3-5

EFFECTS OF CANCERS IN THE UNITED STATES

(Refs. 3-14 and 3-16)

Type of Cancer	Annual Deaths	(%)	Annual Man-years of working life lost	(%)
lung	65,000	19	287,000	16
large intestine	46,000	14	141,000	8
breast	30,000	9	208,000	12
pancreas	18,000	5	unknown	–
prostate	17,000	5	unknown	–
stomach	16,000	5	unknown	–
leukemia	14,000	4	176,000	10
brain	6,000	2	117,000	7
lymphoma	11,000	3	114,000	7
other cancers	113,000	34	701,000	40
TOTAL	336,000	100	1,744,000	100

through the Federal Radiation Council (FRC), whose functions were transferred to the Environmental Protection Agency (EPA) in 1970. The dose limits proposed by NCRP, recommended as guidance for Federal agencies by FRC, and adopted for that purpose by the President of the United States on May 13, 1960, are tabulated in Table 3-6. It can be noted from this table that the recommended population dose limitation, for example, is 0.17 rem average whole-body dose per person per year. This value represents exposure from all sources except natural background radiation and medical procedures. In addition, the EPA in the Federal Register has proposed standards for exposure during normal uranium fuel cycle operations (see 40 FR 23420).

A maximum permissible concentration (MPC) in air or water may often be stated for a given radionuclide. This is the maximum concentration in air or drinking water to which a person might be chronically exposed internally without exceeding the recommended dose limitations to a specified critical organ. It should be noted that the levels in Table 3-6 were suggested as upper limits, with the understanding that radiation exposure is to be kept as low as is reasonably achievable. The recommended limiting levels (given in 10 CFR Part 20 and 40 FR 23420) are substantially below the level where harmful effects have been observed in humans.

3.6 COST-BENEFIT

There is a certain amount of statistical risk involved with any level of exposure to radiation. In line with other activities and needs of society, one must compare the benefits gained from the use of radioactive substances with the possible risks entailed. For example, people continue to use medical x-rays and radiopharmaceuticals that may help discover a developing tumor in spite of the potential for other cell damage produced by the radiation (Ref. 3-18). Similarly, few people are likely to change their location to reduce background dose, although this background can differ between certain states by as much as 100 mrem per year. In short, benefits outweighing the prospective costs are usually expected from certain uses of radioactive substances, just as from many other hazardous materials. In Table 3-7, the risk of fatal cancer or life-span shortening from radiation is compared to estimates of other risks commonly accepted in our society.

3.7 HEALTH-EFFECTS MODEL

The health-effects model used in this assessment is based on the more detailed model developed in Appendix VI to WASH-1400 (Ref. 3-13), although the complete methodology was not used. The simplifications discussed below were used to make the more detailed reactor accident analysis applicable to the transportation situation.

Potential dosage sources were first subdivided into external penetrating radiation sources (principally from normal transport as discussed in Chapter 4) and internal radiation sources (principally from inhalation following accidents as discussed in Chapter 5).

External penetrating radiation presents a whole-body exposure problem from photons and neutrons with each organ receiving similar dosages. Internal dose effects are dependent on the biological pathway taken by the specific radionuclide in the body. In order to specify this pathway, the chemical nature of the material, in particular whether it is soluble or insoluble,

TABLE 3-6

NCRP DOSE-LIMITING RECOMMENDATIONS

(Ref. 3-7)

Combined Whole-Body Occupational Exposure	
Prospective annual limit	5 rem in any one year (3/quarter)
Retrospective annual limit	10-15 rem in any one year
Long-term accumulation to age N years	(N-18) x 5 rem
Skin	15 rem in any one year
Forearms	30 rem in any one year (10/quarter)
Other organs, tissues, and organ systems	15 rem in any one year (5/quarter)
Pregnant women (with respect to fetus)	0.5 rem in gestation period
Dose Limits for the Public or Occasionally Exposed Individuals	0.5 rem in any one year
Population Dose Limits	
Genetic	0.17 rem average/year
Somatic	0.17 rem average/year
Emergency Dose Limits - Life Saving	
Individual (older than 45 yrs., if possible)	100 rem
Hands and forearms	200 rem, additional (300 rem, total)
Emergency Dose Limits - Less Urgent	
Individual	25 rem
Hands and forearms	100 rem, total

TABLE 3-7

COST IN DAYS OF LIFE ASSOCIATED WITH VARIOUS ACTIVITIES (Ref. 3-19)

Activity	Cost in Days of Life
Living in city (rather than in country)	1800
Remaining unmarried	1800
Smoking 1 pack of cigarettes per day	3000
Being 4.5 kg overweight	500
Using automobiles	240
170 mrem/year of radiation dose	10
Transportation of radioactive material*	0.030

*Calculation based on an average of 0.5 mrem per year to an average exposed individual (see Chapter 4).

must be specified. Additionally, for insoluble materials, the mechanism by which the material enters the body (i.e., ingestion or inhalation) must be specified. Ingestion is considered a pathway only for long-term low-level activity present in the diet (Ref. 3-13). An examination of the materials in the transportation analysis eliminates this pathway because the types and amounts of materials involved in accidents preclude significant food-chain buildup. Inhalation is therefore left as the only significant internal dose mechanism. Solubility or insolubility is determined from chemical forms suggested in Reference 3-13. Dosimetric parameters for each of the standard shipments evaluated are discussed in Appendix A.

In order to compare annual risk resulting from exposure during accidents involving various materials with annual risk from exposure to external penetrating radiation resulting from normal transportation of radioactive materials, a common basis for comparison must be established. For the purpose of this assessment, the expected number of additional latent cancer fatalities (LCFs) occurring during the lifetime of exposed individuals was chosen. Values for LCFs reflecting the consequences of exposure to various organs are tabulated in Table 3-8, which assumes a linear dose-effect relationship. Also from Table 3-8, the LCF coefficient of 121.6 deaths per million person-rem (less thyroid), for whole-body exposures, is used in the model. Neither of these values reflects the possible mitigation of effect due to low dose rates, as reflected in the calculations performed in Reference 3-13.

In addition to LCFs, the question of early fatalities due to large acute doses must be addressed. The two organs of particular interest for early fatalities in this analysis are the bone marrow (the fatality probability versus dose curve used is shown in Figure 3-2, curve B) and the lungs (the fatality probability versus dose curve is shown in Figure 3-3). The only incidences of early bone marrow fatalities (within the constraints of this model) would occur from large dosages from external penetrating radiation sources. Isotopes capable of causing early lung fatalities would include any inhaled material providing a sufficient dose to the lungs such as plutonium dioxide. The LD 50/365 (lethal dose to 50 percent of exposed people

TABLE 3-8

EXPECTED LATENT CANCER FATALITIES PER 10^6 PERSON-REM DOSE TO THE POPULATION* (Ref. 3-13)

Organ Exposed	Expected Deaths** per 10^6 Person-Rem
Blood Forming Organs (leukemia)	28.4
Lung	22.2
Stomach	10.2
Alimentary Canal	3.4
Pancreas	3.4
Breast	25.6
Bone	6.9
All Others	21.6
Whole Body	121.6
Thyroid***	13.4

*Adjusted for age distribution within the population.

**BEIR coefficients (Ref. 3-13) for a 75-year lifetime of potential cancer development are used.

***For assumed average individual doses of greater than 1500 rem.

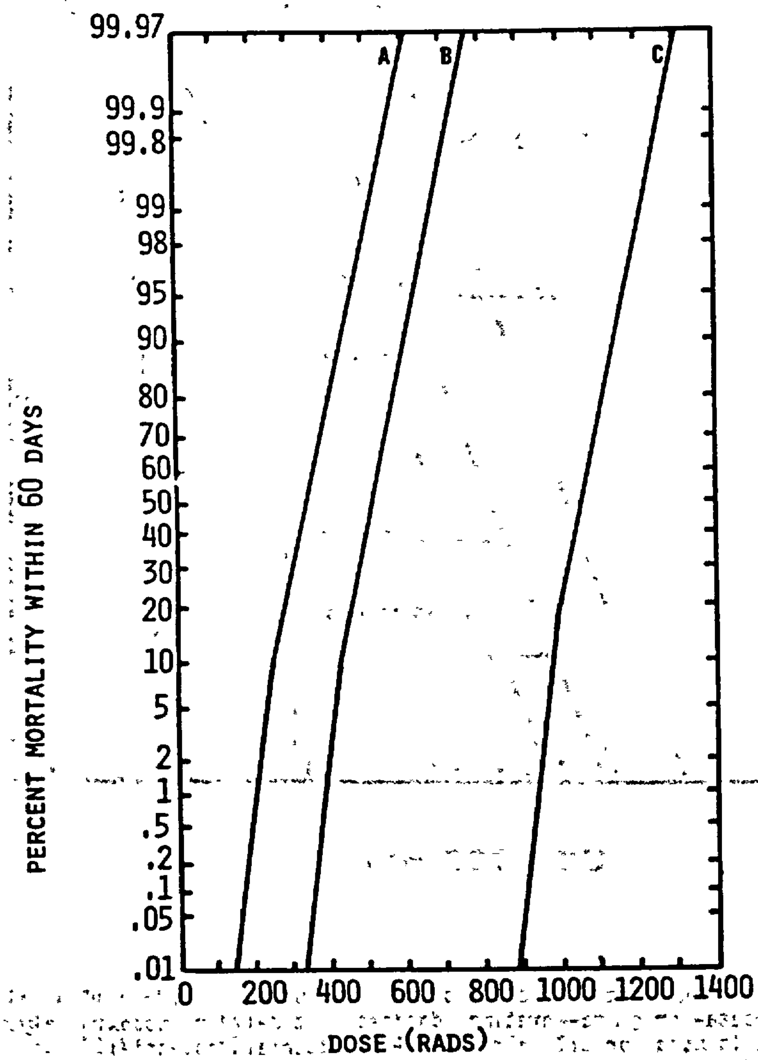
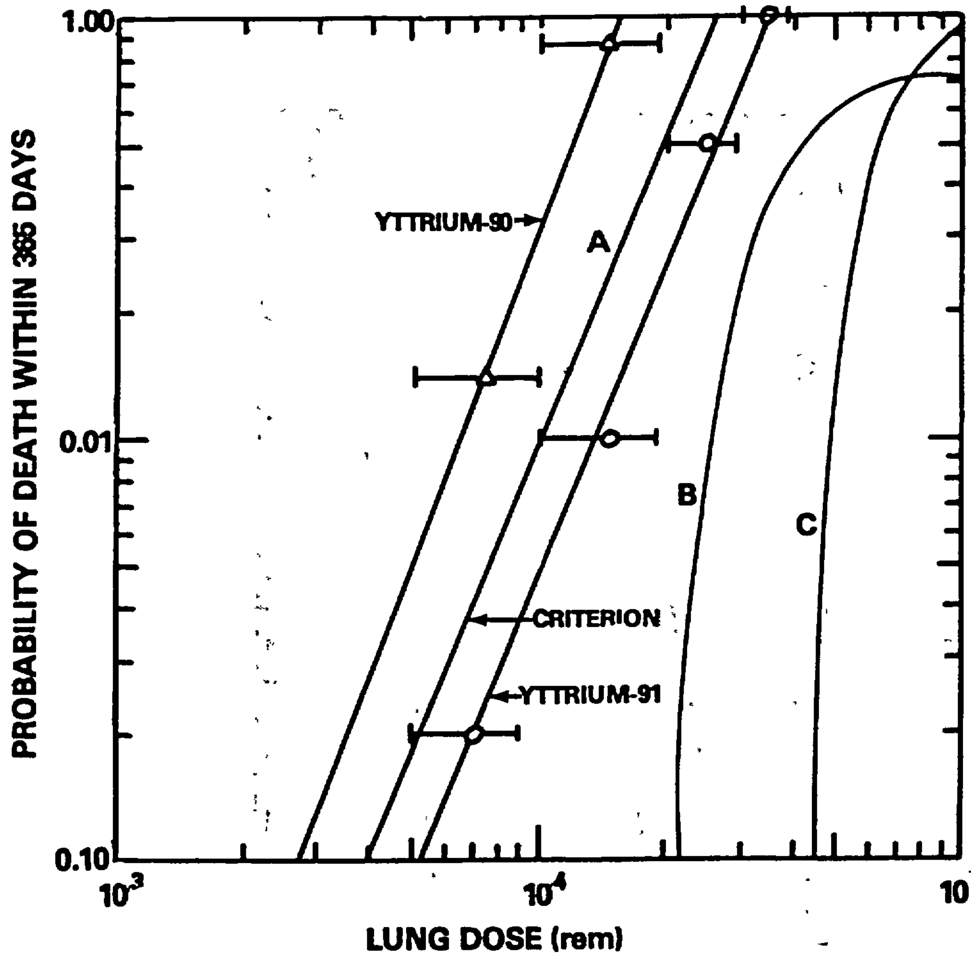


FIGURE 3-2. ESTIMATED DOSE-RESPONSE CURVES FOR MORTALITY WITHIN 60 DAYS FROM WHOLE-BODY EXPOSURE TO EXTERNAL PENETRATING RADIATION: WITH MINIMAL TREATMENT (CURVE A), SUPPORTIVE TREATMENT (CURVE B), AND HEROIC TREATMENT (CURVE C). CURVE B REPRESENTS THE MOST LIKELY LEVEL OF TREATMENT AVAILABLE FOR MOST ACCIDENT VICTIMS (Ref. 3-13); IT IS THEREFORE USED IN THIS ASSESSMENT TO ESTIMATE EARLY FATALITIES FROM WHOLE-BODY EXPOSURE TO EXTERNAL PENETRATING RADIATION.



A - Yttrium-90 and -91 were the isotopes used to obtain this curve. It is equally valid for other short-half-life beta- or gamma-emitting isotopes that deliver approximately the same dose rate. This curve is used for all short-half-life materials potentially encountered in transportation accidents (Source: Ref. 3-13).

B - This curve is based on data from Sr-90/Y-90 inhalation by beagles and is used for long-half-life, low-linear-energy-transfer radiation (Source: Ref. 3-20).

C - This curve is based on data from Pu-239 inhalation by beagles and is used for long-half-life, high-linear-energy-transfer radiation (Source: Ref. 3-20).

FIGURE 3-3. DOSE-RESPONSE CURVES FOR MORTALITY DUE TO ACUTE PULMONARY EFFECTS FROM RADIATION.

within 365 days) for long-lived alpha emitters is the basis for the curve identified as line C plotted on Figure 3-3 (Ref. 3-20). This aspect of the radioactive material shipment hazard is addressed in Chapter 5 of this assessment.

The number of genetic effects is based on the radiation dose received by the gonads. If the integrated gonadal dose is known, estimates can be made of the number of various types of genetic effects that might be expected to occur in all subsequent generations as a result of that dose. Values for the four types of genetic effects considered are shown on Table 3-9 (Ref. 3-13).

For the most part, the radioactive materials transported are relatively short half-life species. However, there are a few exceptions such as Pu-239 (discussed in Appendix C), Cs-137, and Co-60. Because these isotopes have the potential for a long residence time in the body, two doses must be considered. The early dose is based on the rem/curie value for a 60-day exposure for bone marrow or a 1-year period for lung. This early dose is used to compute early fatalities by using probabilities from Figures 3-2 and 3-3. The long-lived dose is based on the rem/curie value for a 50-year period. This long-term dose is used to predict LCFs for long half-life species.

TABLE 3-9

GENETIC EFFECTS COEFFICIENTS PER 10^6 PERSON-REM GONADAL DOSE

(Ref. 3-13)

Genetic Effect	Expected Genetic Effects Per 10^6 Person-Rem
Single-gene disorders	42
Multifactorial disorders	84*
Congenital disorders	6.4
Spontaneous abortions	42
Total Genetic Effects	174.4

*Upper range of 8.4-84.

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CHAPTER 4
TRANSPORT IMPACTS UNDER NORMAL CONDITIONS

4.1 INTRODUCTION

Normal transport of a radioactive material involves a wide range of events that can have environmental consequences. To make the source of these consequences clear, the sequence of events in a radioactive material shipment must be considered. First, for most shipments, the material is placed in a package meeting regulatory standards, the radiation exposure levels are noted, the package is labeled with the appropriate information, a shipping bill is prepared, and the package is put aside until the transportation process begins. Once the package begins moving toward its destination, it becomes a part of the subject of this assessment.

As shown schematically in Figure 4-1, the transportation process may take one of several paths. The package might be loaded onto a vehicle that will take it directly to its ultimate destination. However, most packages undergo a secondary mode of transport, e.g., a truck or light duty vehicle, which takes the package to a terminal where it is assigned to a primary vehicle along with other parcels. The primary vehicle takes it to a terminal near its destination where it is again loaded onto a secondary-mode vehicle that takes it to its ultimate destination.

In some other instances packages are picked up by or delivered to a freight forwarder and are consolidated with other packages into a single shipment. This shipment may consist of a large number of packages obtained from a number of different shippers. When the shipment arrives at its destination, it is separated into individual packages that are delivered to the consignees.

When transport occurs without unusual delay, loss of or damage to the package, or an accident involving the transporting vehicle, it is called "normal" transport. Radiological impacts occurring during this phase of transport are considered in Sections 4.2, 4.3, and 4.4 of this chapter. Cases do occur, although infrequently, in which the shipment is not timely, the package is damaged, or the contents are lost or destroyed without being involved in a vehicular accident. These abnormal occurrences are considered in Section 4.6.

4.2 RADIOLOGICAL IMPACTS OTHER THAN THOSE DIRECTLY ON MAN

The principal emphasis of this study is the direct impact on man and his environment from the transport of radioactive material. However, there are impacts on flora and fauna and on inanimate objects, as well as indirect impacts on man that also must be considered. As concluded in Chapter 3, these effects are judged to be very small in comparison to the direct radiological impact to man in the normal transport case. Indirect radiological impacts on man are negligible by comparison to the direct radiological impacts, since no credible mechanism

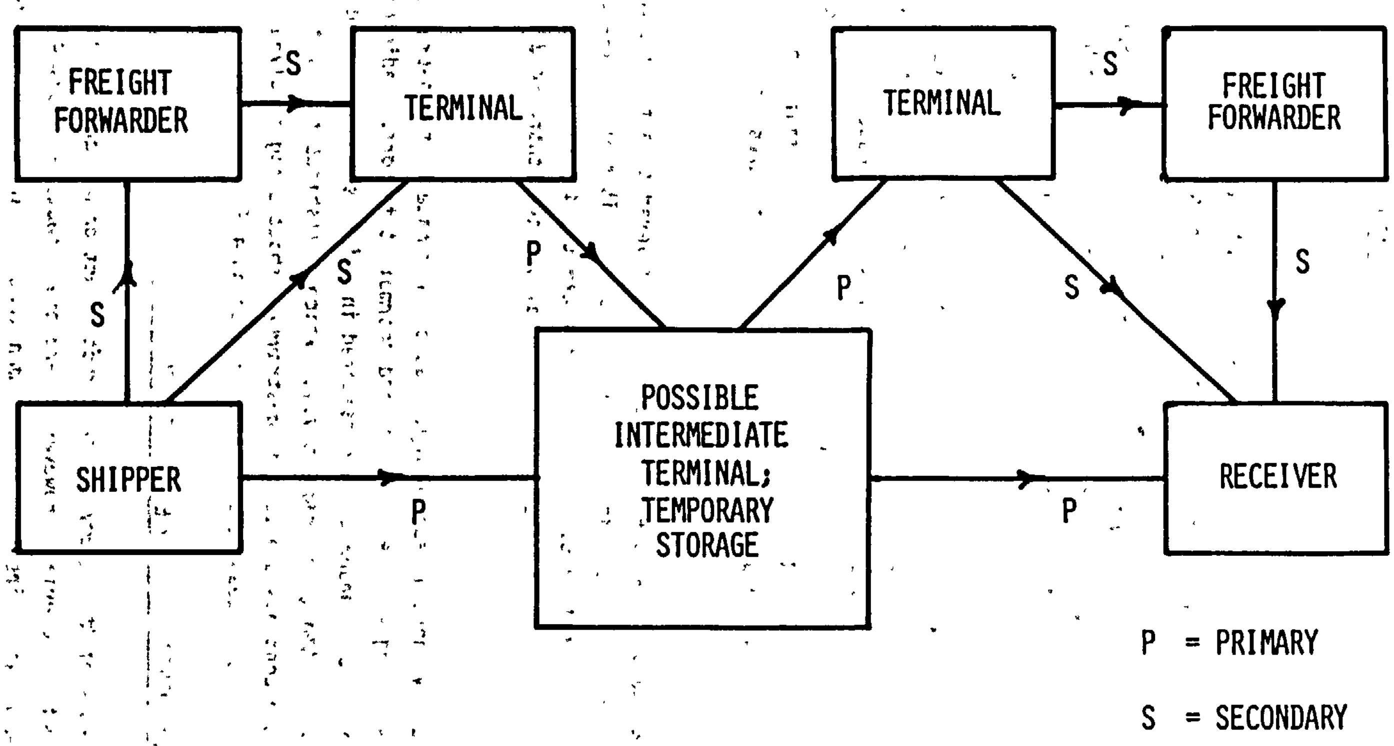

FIGURE 4-1. POSSIBLE TRANSPORT PATHS

exists for an indirect radiological effect, except through the food chain and by activation mechanisms. However, the food chain avenue is foreclosed in the normal case by package containment, and radiation outside packages is sufficiently low and of such type that activation of structures surrounding man is negligible. Exposures to casually exposed life forms are equal to or less than those to man and therefore present no significant impact. In addition, packaging and transport regulations are, in part, designed to minimize dosage to animals shipped in the same vehicle as radioactive material packages (see Chapter 2).

The principal radiological impact on objects is to undeveloped photographic film. The regulations for spacing between radioactive material packages and film are designed to minimize this problem (see Chapter 2).

4.3 DIRECT RADIOLOGICAL IMPACT ON MAN

The principal environmental impact during normal transport is direct radiation exposure to nearby persons from the radioactive material in the package. The impact is quantified in terms of annual population dose in person-rem and in terms of the annual latent cancer fatalities expected from this population dose. The radiological effects from normal transport result from radiation that escapes from the unbreached package. Shielding from buildings, terrain, or vehicles is not considered in this report. However, the maximum distance over which the average population dose is computed is limited as discussed in Appendix D.

Radiation dose rates decrease rapidly with distance from the package. Thus people who handle the package directly (such as loaders, dock workers, and baggage handlers) are exposed to the highest dose rates, although these exposures are usually for very short periods of time. The dose to handlers in all transport modes is addressed in Section 4.4 of this chapter.

Those who work in the vicinity of the package (but do not actually handle it) or who are transported with it (e.g., aircraft passengers) are subjected to lower dose rates than handlers but generally for longer periods of time. Bystanders and persons living along a travel route generally are subjected to even lower dose rates, but the small doses delivered to so many people make the total population dose comparable to other group population doses.

For the purposes of computing the direct radiological impact in the normal case, the most important characteristic of a package containing radioactive material is the transport index (TI), defined in Chapter 2 as the radiation dose rate in mrem per hour at a distance of one meter from the package surface. The radionuclide and the characteristics of the packaging are of little importance in evaluating the impact in the normal case. However, these factors may govern whether the material can be shipped by a given transport mode and may limit the total number of packages on a given vehicle.

The evaluation of the radiological impact of normal transport makes use of the standard shipments model developed in Appendix A. Various tables in that appendix list the package type, average TI per package, primary and secondary transport modes, and average distances for each standard shipment. The methodology for the normal transport annual population dose calculation is presented in detail in Appendix D. This appendix shows the factors considered in each calculation and the specific relationships used to compute the population dose.

Different transport modes have different characteristics such as mean velocity, location of bystanders, and carriage of passengers, all of which affect population dose. For that reason, each primary mode is considered separately when assessing environmental impact. As previously mentioned, a secondary transport mode is frequently used to transport the package from the shipper to the primary mode terminal and from the end point terminal to the receiver. The radiological impacts associated with secondary mode transport are considered explicitly in Section 4.3.2.2. For each primary and secondary mode analyzed, both the accumulated annual person-rem and the maximum individual dose received by persons as a result of transport by that mode are evaluated. These results are summarized in the tables at the end of the chapter.

4.3.1 TRANSPORT BY AIR

The radiological impacts of normal transport of radioactive materials by aircraft are the direct radiation doses to passengers, attendants, crew, cargo handlers, and persons in the vicinity of the aircraft while it is stopped. Doses to persons on the ground below the flight path are considered negligible because of the large separation distances and high velocities. The discussion of the environmental impact of transport of radioactive material by air is divided into three sections according to the principal transport mode: commercial air passenger service, commercial air cargo service, and other air modes (including air taxi and corporate aircraft, helicopter, and lighter-than-air craft).

4.3.1.1 Transport by Passenger Aircraft

4.3.1.1.1 Passenger Dose

The materials shipped by passenger aircraft are included in Appendix A. Other shipment parameters used in the calculation of passenger dose are shown in Table 4-1. The annual population dose received by passengers aboard aircraft carrying radioactive material is computed as follows:

$$\begin{pmatrix}\text{Annual}\\ \text{Population}\\ \text{Dose}\end{pmatrix} = \begin{pmatrix}\text{Total Passenger}\\ \text{Aircraft Flights per}\\ \text{Year Carrying RAM}\end{pmatrix}\begin{pmatrix}\text{Average}\\ \text{Dose}\\ \text{Rate}\end{pmatrix}\begin{pmatrix}\text{Average}\\ \text{Flight}\\ \text{Duration}\end{pmatrix}\begin{pmatrix}\text{Average Number}\\ \text{of Passengers}\\ \text{per Flight}\end{pmatrix} \quad (4\text{-}1)$$

The average dose rate is given by the average TI per flight (TI per package x number of packages per flight) times the TI-dose rate conversion factor $K_{D/TI}$ (for passengers, $K_{D/TI}$ = 0.03 mrem/hour/TI, Ref. 4-3). The average flight duration is the average distance per flight divided by the mean speed. This calculation is performed for each standard shipment. The sum of the doses computed for each standard shipment results in a total annual population dose to passengers of 2330 person-rem.

The average annual dose received by an individual airline passenger depends on the number of flights taken, the fraction of those flights carrying radioactive material (radioactive

TABLE 4-1

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION AND INDIVIDUAL DOSE FOR THE PASSENGER AIR SHIPMENT MODE

Transport Parameters:			
Mean Speed (km/hr)		682	(Ref. 4-1)
Passengers/Flight		78	(Ref. 4-2)
Cabin Attendants/Flight		4	
Crew/Flight		3	
$K_{D/TI}$ (mrem/hr/TI) (passengers)	=	0.030	(Ref. 4-3)
$K_{D/TI}$ (mrem/hr/TI) (cabin attendants)	=	0.028	(Ref. 4-3)
Average Flight Duration (hours)	=	2	
Average Distance from Cockpit to Radiation Source (m)	=	15.2	
Stop Time (hr)	=	1	
Population Density at Stops (people/km^2)	=	720	
Passenger Flights per Year	=	2.68×10^6	(Ref. 4-2)
Passenger Flights per Year that Carry Radioactive Material (RTF = 1/30)	=	8.95×10^4	

Total TI shipped/year = 4.33×10^5

Average TI per radioactive material (RAM) flight = 4.8

(4.33×10^5 TI/8.95×10^4 RAM flights/year) traffic factor - RTF), the number of TI on the flight, and the duration of those flights. According to the Civil Aeronautics Board there were about 210 million revenue passengers enplaned on scheduled domestic and international flights between March 1975 and March 1976. Using an average RTF of 1/30, the total number of passengers enplaned on flights carrying radioactive material should have been about 7 million. Each passenger makes, on the average, about 5 flights per year (Refs. 4-3, 4-4), but it is unlikely that any individual would fly on more than one radioactive material flight per year. Distributing the 2330 person-rem among 7 million exposed passengers results in an annual average individual dose of 0.34 mrem. The cosmic radiation background dose rate to which these same passengers are exposed is 0.23 mrem/ per hour at an altitude of 9 km.

Assuming that 75 percent of the flight time is spent at 9 km, for 5 flights per year and an average of 2 hours per flight, the annual average cosmic radiation background dose per individual was 1.7 mrem (Refs. 4-5, 4-6). Multiplying this average individual dose by 7×10^6 passengers results in an annual population dose of 1.2×10^4 person-rem to these passengers from cosmic radiation. Thus the average individual dose from radioactive materials on board is considerably less than the cosmic-ray background dose received by the same individuals. Passengers who receive a greater radiation dose from the cargo because they travel more than the average also receive a proportionally higher cosmic radiation dose.

It has been pointed out in another study (Ref. 4-4) that a select group of individuals flying 500 hours per year between airports with RTF's of 1/4 and 1/10 (e.g., Knoxville, Tennessee, and St. Louis, Missouri) would each receive, on the average, 108 mrem per year, assuming an average dose rate at seat level of 1.3 mrem/per hour (fully loaded conditions). These same individuals would receive 86 mrem per year from cosmic radiation (500 hours per year x 0.23 mrem per hour x 0.75).

4.3.1.1.2 Dose to Cabin Attendants

The dose to cabin attendants was calculated in the same manner as the dose to passengers. The average number of attendants per flight was estimated to be four, and the dose conversion factor used was 0.028 mrem per hour per TI (Ref. 4-3). The latter factor is an average over the cabin length and acknowledges the fact that the attendant moves throughout the cabin during the flight. The total population dose to attendants in 1975 was calculated to be 112 person-rem. Assuming that this dose was delivered to 20,000 attendants [one-half of the total attendant population (Ref. 4-4)], the average dose received by each would have been about 6 mrem.

Experiments in Oklahoma City and Boston indicate that the maximum dose rate to an attendant in the tourist section of an aircraft carrying the maximum allowable load of radioactive material is between 0.6 and 0.8 mrem per hour (Refs. 4-3, 4-4), while the dose to an attendant in the first class section is essentially zero (under current practice, radioactive packages are usually carried in the aft cargo hold). If 1000 hours per year of flight time is assumed with an RTF of 1/10 (corresponding to an attendant who works only out of airports serving major radiopharmaceutical centers) and the average load is assumed to be 4.8 TI, the tourist class attendant may receive up to 13 mrem per year (1000 hours per year x 1/10 x 0.028 mrem per hour per TI x 4.8 TI). This compares with a dose of 173 mrem per year (1000 hours per year x 0.23 mrem per hour x 0.75) from cosmic radiation assuming that three quarters of the flying time is spent at 9 km altitude. Multiplying this average individual dose by the 20,000 attendants results in an annual population dose to these attendants of 3500 person-rem.

4.3.1.1.3 Dose to Crew

Crew members on passenger aircraft are usually located away from radioactive materials packages. The common practice of storing packages in the rear baggage holds results in a cockpit dose rate that is very small. The positive effects of this practice are pointed out by Barker, et al. (Ref. 4-3) based on measurements of radiation exposure to flight crews. In most cases radiation was undetectable in the cockpit when radioactive materials were stowed in the aft baggage compartment some 15 meters away.

The annual population dose to crew members is computed in the same way as the doses to passengers and attendants just discussed except that, instead of determining the dose rate by an empirical TI-Dose rate conversion factor, the dose rate is computed analytically using the dose-rate formula given in Appendix D, Equation (D-1). The dose-rate factor K is proportional to the TI, as discussed in Section D.1 of Appendix D. Using an average source-to-cockpit distance of 15 meters together with the assumption of three crew members per flight, an estimate of 16 person-rem to the crew is obtained by summing the contributions of all standard shipments. Distributed over approximately 30,000 flight crew members, this amounts to an annual average individual dose of 0.53 mrem.

In a survey at Boston's Logan Airport (Refs. 4-3, 4-4), only 2 of 42 flights known to be carrying radioactive material had detectable radiation levels in the cockpit area and in both cases the level was only 0.1 mrem per hour. A similar survey in Chicago found none of the 100 flights surveyed had detectable radiation levels in the cockpit. Assuming an RTF of 1/10, the maximum annual dose received by a flight crew member flying 1000 hours per year would be 2.5 mrem, for an average load of 4.8 TI. These same crew members would receive about 173 mrem per year from cosmic radiation, assuming that three-quarters of their 1000 hours per year are spent at an altitude of 9 km, for a total annual population dose from cosmic radiation of 5200 person-rem.

4.3.1.1.4 Dose to Bystanders During Stops

During aircraft stops, the population surrounding the aircraft both within and outside the terminal building is exposed to radiation from any radioactive cargo carried by the aircraft. A general expression for the integrated population dose received during shipment stops is derived in Section D.2 of Appendix D. All stops are assumed to occur in areas with an average population density of about 720 per km^2. A total stop time of 1 hour is assumed for each shipment. The total annual population dose to bystanders during stops, summing over all standard shipments, is 11 person-rem.

The maximum annual dose to an individual during aircraft stops is likely to be received by a member of the ground crew who is refueling, loading, or unloading the plane. If this individual spends 10 minutes per flight 4 times an hour at a distance of 3 meters from an average cargo, his annual dose is estimated to be 85 mrem, using the dose rate formula given in Appendix D, Equation (D-1), and assuming the RTF = 1/10, the average TI = 4.8 (Type A packages), a 40-hour work week, and 50 work weeks per year.

4.3.1.1.5 Summary

The radiation doses resulting from passenger aircraft transport of radioactive materials in 1975 (exclusive of secondary-mode contributions and doses received by freight handlers) are summarized in Table 4-2. The total annual population dose of 2470 person-rem resulting from radioactive material on board passenger aircraft is considerably less than that received by the same individuals from cosmic radiation.

4.3.1.2 Transport by All-Cargo Aircraft

There were 31,400 all-cargo aircraft departures in 1975 (Ref. 4-7). Because of the relatively small number of all-cargo flights and because of the limited number of airports served by all-cargo aircraft, most of the radioactive materials transported by air go by passenger aircraft.

The principal radiological impact from normal transport of radioactive materials by all-cargo aircraft is the dose to the crew and to bystanders. Radioactive materials in cargo aircraft are usually stowed as far from the crew compartment as possible. A 6-meter distance between crew and radioactive cargo was assumed for this assessment.

At the time of this report, two cargo carriers were operating under a Federal Aviation Administration (FAA) waiver that permitted carriage of up to 200 TI per aircraft on specific routes and for a specific time period. This increase in the allowable TI has the potential for increasing the radiation exposure to individual members of the crew, but precautions are required by the FAA to minimize these exposures.

4.3.1.2.1 Dose to Crew

Table 4-3 lists the shipment parameters for the air cargo mode used to compute the doses. The crew dose was computed in the same way as the dose to passenger aircraft crew using Equation (D-1) in Appendix D. An average of three crew members per flight was assumed. The annual dose obtained by summing over all shipments by all-cargo aircraft is 4.1 person-rem. The total crew population exposed to this population dose is estimated to be approximately 350 by applying the ratio of the cargo to passenger air flights to the total number of passenger aircraft crew. As a result, the average annual individual dose is estimated to be 12 mrem. The average annual individual cosmic ray dose would be similar to that for crews on passenger aircraft (173 mrem), for an annual population dose of 60 person-rem.

TABLE 4-2

ANNUAL DOSES FROM TRANSPORT OF RADIOACTIVE MATERIAL (RAM) IN PASSENGER AIRCRAFT AND CORRESPONDING COSMIC RADIATION DOSES - 1975

Population Subgroup	Total Exposed Persons	Annual Population Dose (person-rem)		Annual Individual Dose (mrem)	
		RAM	Cosmic Radiation	RAM	Cosmic Radiation[a]
Passengers	7×10^6	2330	1.2×10^4	0.34 (avg) 108 (max)	1.7 (avg) 86 (max)
Attendants	2×10^4	112	3500	6 (avg) 13 (max)	173
Crew	3×10^4	16	5200	0.53 (avg) 2.5 (max)	173
Ground Crew (including bystanders)	($720/km^2$)	11	not evaluated	85 (max)[b]	44[c]
TOTALS		2470	2.1×10^4		

[a]Dose is in addition to an average annual individual dose of 102 mrem received by persons on the ground from natural background exposure.

[b]Applies only to the most exposed member of ground crew.

[c]See Table 3-3.

TABLE 4-3

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION DOSE FOR THE AIR CARGO SHIPMENT MODE

Transport Parameters:

Mean speed (km/hr)	682	
Crew per flight	3	
Average distance from cockpit to radiation source (m)	6	
Stop time (hr)	1	
Population density at stops (people/km^2)	720	
Estimated total all-cargo flights per year	31,400	(Ref. 4-7)
All-cargo flights per year carrying radioactive material (RTF = .042 (Ref. 4-8)	1,320	
Flight duration (hr)	2	

Total TI shipped/yr = 1.61×10^4

Average TI per RAM flight = 12

The maximum annual dose likely to be received by an individual crew member was estimated by assuming 1000 hours total flight time, with one-eighth of the time spent on flights carrying radioactive material. If each of those flights carried the average (12 TI) amount of radioactive material at a separation distance of 6 meters, the annual individual dose received, computed by using the dose-rate formula in Appendix D, Equation (D-1), would be 61 mrem.

Measurements conducted on typical flights of the two carriers licensed for up to 200 TI per flight indicated that the crew received an average of 0.41 mrem per TI carried with an average load of 44.7 TI and an average annual dose of 364 mrem (Ref. 4-9). Crew exposure for these flights are monitored carefully according to restrictions in the FAA waiver which requires, among other things, that a health physicist supervise the handling and stowage of radioactive material to ensure that radiation exposures are as low as reasonably achievable.

4.3.1.2.2 Dose to Bystanders During Stops

Bystanders are exposed to radioactive material packages during the time required to unload or add cargo to the freighter aircraft. Because freight operations usually occur in areas away from the main terminals the population density may be lower than that for the passenger air case; nevertheless, the same population density (720 persons per km^2) was assumed. Using the same computational technique, the annual dose to bystanders was estimated to be 0.4 person-rem.

The maximum dose delivered to a ground crew member is estimated using the same values as for passenger aircraft, except that the average RTF is 1/24 and the average TI is 12. This gives a maximum anticipated annual individual dose of 106 mrem.

4.3.1.2.3 Summary

The annual population doses resulting from all-cargo aircraft transport of radioactive material in 1975 are summarized in Table 4-4. The total annual population dose is about 5 person-rem.

4.3.1.3 Transport by Other Air Modes

4.3.1.3.1 Transport by Other Fixed-Wing Modes

The assessment of radiological impact from transport of radioactive materials by other fixed-wing modes such as corporate aircraft was performed in a way similar to that for all-cargo aircraft. An informal survey suggests that some radioactive materials are transported by this mode, particularly in the oil-well logging industry. The radiological impacts are determined in essentially the same way as in the all-cargo mode except that the aircraft are usually physically smaller than the typical cargo aircraft and therefore do not permit as much spacing between the crew and radioactive packages.

The total TI transported by other fixed-wing modes is estimated to be no more than one percent of that transported by all-cargo aircraft, i.e., 160 TI per year maximum. The dose rates experienced by the two crew members are estimated using Equation (D-1) in Appendix D,

TABLE 4-4

ANNUAL DOSES FROM TRANSPORT OF RADIOACTIVE MATERIAL IN CARGO AIRCRAFT AND CORRESPONDING COSMIC RADIATION DOSES - 1975

Population Subgroup	Total Exposed Persons	Annual Population Dose (person-rem)		Annual Individual Dose (mrem)	
		RAM	Cosmic Radiation	RAM	Cosmic Radiation
Crew	350	4.1	61	12 (avg) 61 (max)	173
Bystanders/ Ground Crew	$720/km^2$	0.4	not evaluated	106 (max)	44[a]

[a]See Table 3-3.

assuming a separation distance of 3 meters. The estimated total annual population dose from this mode is 0.04 person-rem, assuming an average flight time of 1 hour. This dose is negligible by comparison to the values calculated for transport by passenger and all-cargo aircraft.

4.3.1.3.2 Transport by Helicopters

Helicopters are not widely used for transporting radioactive material. They are used to transfer well-logging sources to off-shore drilling rigs. The actual extent of such transfers is not known, but a thousand such transfers per year is estimated. For a two-man crew, a 1-hour flight time, a separation distance of 3 meters, and a load of 2 TI, the possible dose is about 0.5 person-rem. This result is obtained using Equation (D-1) in Appendix D for the dose rate with d = 3 meters and taking K_0 typical of Type-A packages. A population exposure of 0.5 person-rem is a negligible fraction of the total population dose for air transport.

4.3.1.3.3 Transport by Lighter-Than-Air Vehicles

There is no known current use of lighter-than-air vehicles (LTAV) in radioactive material transport. But contemplated use for special nuclear material shipments with a flight crew of three and a separation distance of 15 meters would result in a population dose of 0.04 person-rem, assuming 1000 such shipments per year of plutonium in Type-B packages, and an average of 2 hours per flight. The average dose rate was determined using Equation (D-1) in Appendix D, with d = 15 meters.

4.3.1.3.4 Bystander Doses from Other Air Modes

The total annual TI transported by air modes other than passenger and cargo aircraft considered in the preceeding calculations is 3140 TI per year. A total of 16,000 TI per year was transported by all-cargo aircraft. Since the doses received by persons while stopped is proportional to the total TI, the doses while stopped for all air modes other than passenger and all-cargo aircraft should be that for all-cargo aircraft times 3140 TI per 16,000 TI or 0.08 person-rem.

Individual doses to ground crew (including bystanders) were computed assuming that a single individual will service a maximum of one-third of the flights per year at a distance of 1.5 meters for a helicopter or corporate aircraft. The exposure time was estimated to be 10 minutes per flight for the individual. The results are presented in Table 4-5.

4.3.1.3.5 Summary

The integrated and individual doses estimated for shipments by other air modes are summarized in Table 4-5. Because flight altitudes for these air modes are generally lower than for commercial air modes, the cosmic ray dose rate is substantially lower (approximately 0.01 mrem per hour at 3 km). Based on the numbers of crewmen listed, the cosmic ray dose rate is estimated to be 0.05 person-rem. This was computed by summing the contributions of each "other-air" mode, assuming 0.75 of the flight time is spent at an altitude of 3 km using the appropriate flight time, numbers of crewmen, and flights per year.

TABLE 4-5

DOSE RESULTING FROM RADIOACTIVE MATERIAL SHIPMENT BY HELICOPTERS AND CORPORATE AIRCRAFT - 1975

Mode	Population Subgroup	Annual Individual Dose (mrem)*	Annual Population Dose (person-rem)
Helicopter	Flight crew	5	5
	Bystanders/ Ground crew	60	see all-modes dose
Corporate Aircraft	Flight crew	4	0.04
	Bystanders/ Ground crew	0.6	see all-modes dose
All Modes Shown Above	Bystanders/ Ground crew		0.08
TOTAL			0.62

*Flight crew doses are computed assuming 20 one-hour flights per year by the same individual. 2 TI per flight is assumed for helicopter and 1.6 TI per flight is assumed for corporate aircraft.

4.3.1.4 Storage Associated with the Air Transport Mode

The radioactive material package may be considered to be in storage between the time it is offered for shipment and the time it is placed aboard an aircraft and again after removal from the aircraft but before transfer to a secondary-mode vehicle for delivery to its final destination. Storage areas are typically on or near the airport grounds and are part of the airline freight handling facilities. Terminals visited during the course of this study had a specific location set aside for radioactive material packages, but the area was not isolated from the general work area. If a storage area occupies approximately 11,000 m^2 (120,000 ft^2) and has 10 employees per shift, the average population density is approximately 900 persons per km^2. In the case of aircraft transport, this dose is charged to the secondary mode vehicles and hence is discussed in Section 4.3.2.2.

4.3.2 SURFACE TRANSPORT BY MOTOR VEHICLE

An estimated 1.2 million radioactive material shipments are transported each year by truck. In addition, most land and air shipments involve a secondary ground link that is also by truck or light duty vehicle. While a number of truck shipments are radiopharmaceuticals, a substantial fraction of those radioactive materials requiring massive shielding are also shipped by truck because of the capability to carry heavy cargo. These latter shipments are relatively few in number and are associated with large fuel-cycle shipments, irradiator sources, and other large-quantity sources.

4.3.2.1 Transport in Trucks

The principal radiological impacts from truck transport of radioactive materials are the direct radiation dose to handlers, crew, and bystanders. In contrast to the passenger aircraft case, there are no passengers exposed to radiation; however, persons along the transport route are exposed during passage of the vehicle. In most cases, exposures are for a relatively short duration, but the number of persons who can be exposed may become very large during a trip of considerable distance. Additional doses result from stops for meals, crew rest, repair, and refueling. Because access to the area around the vehicle during stops is not limited as in the case of air shipment, the potential for exposure is higher. The parameters used to evaluate the normal dose resulting from truck transport are summarized in Table 4-6.

4.3.2.1.1 Dose to Truck Crew

The calculation of the annual population dose received by truck crew is similar to that for the dose to aircraft crew. The average dose rate in the cab is computed using Equation (D-1) in Appendix D with d = 3 meters and with $K = K_0 \times TI$. If the computed dose rate exceeds 2.0 mrem per hour, it is assumed that shielding is introduced to limit the dose to 2 mrem per hour as required by the regulations for exclusive-use vehicles and as a practical limit for all shipments. Two crew members per vehicle are assumed. The crew is assumed to be in the cab only during periods of actual travel. Thus, the duration of exposure to the crew is approximately the same as the distance traveled divided by the average speed while moving. The total annual crew dose summed over all standard shipments is computed to be about 2580 person-rem.

TABLE 4-6

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION DOSE FOR THE TRUCK TRANSPORT MODE

Transport Parameters	High-Population Areas	Medium-Population Areas	Low-Population Areas
Average Speed (km/hr)	24	40	88
Fraction of Travel Distance	0.05	0.05	0.9
Population Density (persons/km^2)	3,861	719	6
Duration of Stops (hr)	1	5	2
Traffic Distribution			
Fraction in Rush Hour	0.08	0	0
Fraction in Non-Rush Hour	0.92	1	1
Truck Traffic Distribution			
Fraction on City Streets	0.05	0	0
Fraction on 4 Lane	0.10	0	0
Fraction on Freeway	0.85	1	1
One-Way Traffic Count per Hour (normal traffic)*	2,800	780	470

Total TI shipped = 3.8×10^6 (3.36×10^6 in exclusive-use trucks)

*Based upon a recent traffic survey in Albuquerque, New Mexico.

The maximum individual dose is likely to be received by a crew member transporting irradiated fuel. Although the maximum allowable radiation dose rate in the cab of an exclusive-use truck carrying radioactive material is 2 mrem per hour, experience indicates that dose rates are usually less than 0.2 mrem per hour (Ref. 4-10) because of the distance from the cask and shielding by intervening material. Dose rates at 2 meters from an irradiated fuel cask are at most 10 mrem per hour (about 33 mrem per hour at 1 meter) but are more likely to be about 25 mrem/hour at 1 meter from the vehicle surface (Ref. 4-10). Assuming that a crew member spends 20 hours per trip in the cab and a total of one hour at a distance of 1 meter from the cask, his maximum possible dose per trip is 73 mrem (2 mrem per hour x 20 hours + 33 mrem per hour x 1 hour). If the same crew member made 30 such trips a year, his annual dose would be 2.2 rem. In practice, however, a 0.2-mrem-per-hour radiation level in the cab and a 25-mrem-per-hour level at 1 meter are more likely, and the accumulated dose is about 29 mrem per trip for a maximum annual individual dose of about 870 mrem.

4.3.2.1.1 Dose to Population Surrounding the Moving Vehicle

The population dose received while the vehicle is in motion is composed of two principal components: that resulting from the exposure of persons in other vehicles occupying the transport link (on-link) and that received by persons along the transport link (off-link).

The off-link population dose calculation is discussed in detail in Section D.1 of Appendix D. Equation (D-1) in Appendix D was used to compute this dose for each standard shipment involving truck transport, and the results were summed to obtain the total annual off-link dose. The transport parameters used in the calculation are listed in Table 4-6. The resulting total annual off-link population dose is 348 person-rem.

The on-link population dose calculation is discussed in Appendix D, Section D.5 and is composed of two components:

1. The dose to persons traveling in the direction opposite to the shipment and

2. The dose to persons traveling in the same direction as the shipment.

The "opposite direction" dose is obtained using Equation (D-17) of Appendix D; the "same direction" dose, Equation (D-22). Both calculations are made for each standard shipment using the transport parameters listed in Table 4-6, and the results are summed over all standard shipments. The resulting total annual on-link population dose is about 172 person-rem.

The maximum dose to an individual sharing the transport link with the vehicle would probably be received by a person in a vehicle following the shipment from its point of origin to its destination. If a truck driver followed an irradiated fuel shipment at a distance of 30 meters during a 20-hour trip once per week, 50 weeks per year, he would receive 94 mrem per year (Equation (D-1), Appendix D, with d = 30 meters). However, it is highly unlikely that this particular set of circumstances would occur for the same driver each week. A more reasonable assumption might be that a specific driver's annual accumulated time at 30 meters behind irradiated fuel shipments might be equivalent to one 20-hour trip. Under these circumstances, that driver would receive an annual dose of 1.9 mrem.

The maximum dose received by a person living along a transport route would probably be received by an individual living adjacent to a highway where radioactive material was frequently shipped. Using Equation (D-2) in Appendix D, the annual dose received by a person living 30 meters from a roadway on which standard irradiated fuel shipments (K = 1000 mrem-ft^2 per hour) pass 250 times per year at an average speed of 48 km per hour is 0.009 mrem.

Neither the off-link nor the on-link calculations explicitly take into account the effects of shielding outside the packaging that might act to absorb radiation and therefore mitigate the population dose. This is likely to be most effective in cities where buildings are constructed from relatively good radiation absorbers such as concrete and steel and in hilly terrain where topographic features may provide shielding.

4.3.2.1.3 Dose to Population While Vehicle is Stopped

The computation of the population dose that occurs as a result of shipment stops is discussed in Section D.2 of Appendix D. Equation (D-10) in Appendix D was used to compute this dose for each standard shipment using the stop duration and population density values listed in Table 4-6. The assumptions shown in Table 4-6 regarding the length of stops in each of the three population zones were made from the observation that fuel stops and rest areas are more often located in suburban areas or in areas that have population densities higher than the rural average. When the results are summed over all standard shipments involving truck transport, a total annual dose of 1000 person-rem is obtained. Again, the effects of shielding by buildings and terrain would probably reduce this value.

Although vehicles carrying large amounts of radioactive material are placarded, bystanders may get close enough to receive a small dose from a shipment. If a bystander spends 3 minutes in an area 1 meter from an irradiated fuel cask, he would receive a dose of 1.3 mrem, assuming a 25 mrem per hour radiation level at that distance (Ref. 4-10). Unless the same person "investigated" several such shipments per year, this is expected to be the maximum annual dose received by an individual while the shipment is stopped.

4.3.2.1.4 Dose Resulting from Intransit Storage

At the beginning and end of the transport cycle and at intermediate terminals, radioactive material packages may be stored temporarily while awaiting a truck that is proceeding to the final destination. The potential therefore exists for irradiation of truck terminal employees and surrounding population during these periods of temporary storage. The calculation is identical to that for storage involved with air transport, and the same average population density (900 persons per km^2) in the warehouse is assumed. The resulting annual population dose for an average intransit storage time of 2 hours per shipment is computed to be 261 person-rem.

4.3.2.2 Truck, Light Truck, and Delivery Vehicles

This transport mode includes all secondary transport. All radioactive materials that are shipped by air and almost all that are transported by truck, rail, ship, or barge are taken from the shipper to the shipping terminal and from the receiving terminal to the receiver by trucks, vans, or automobiles. Freight terminals are usually located in or near cities; thus the population densities are relatively high, and the speeds are relatively low.

Using the same calculation procedure as used for the truck mode with the material and transport parameters shown in Table 4-7, the following estimates of population dose to the indicated groups are predicted:

1. Annual dose to crew (1 person per shipment) = 53 person-rem.

2. Annual dose to surrounding population (on-link) = 216 person-rem.

3. Annual dose to surrounding population (off-link) = 51 person-rem.

4. Annual dose to surrounding population (stopped) = 79 person-rem.

5. Annual dose to surrounding population (intransit storage) = 310 person-rem.

The annual total population dose from secondary modes is 709 person-rem.

Assuming that a van driver carries a shipment with the maximum TI carried by van noted in the standard shipments (3.8 TI - "mixed" - Type B) once per working day (250 working days per year) over a distance of 40 km at a speed of 40 km per hour, he would receive 352 mrem per year (using the same computational procedure as in other crew dose calculations and a separation distance of 2 meters). Recent studies by a number of State health agencies in cooperation with NRC and DOT revealed few instances where these assumptions might be valid. A more likely scenario would be a courier-service driver who makes a single radiopharmaceutical pickup and delivery per week (50 weeks per year). Assuming a total of 3.8 TI (2 Mo-99 generators), the driver would receive 70 mrem per year (1/5 x 352).

The likelihood of the same person following or investigating a van loaded with radioactive material in a city on a regular basis is considered remote. Hence, the maximum annual on-link and bystanders doses are considered negligible. The annual maximum off-link dose is assumed to be the same as that for truck, namely 0.009 mrem.

4.3.2.3 Summary of Truck Transport

The annual doses resulting from truck and van transportation of radioactive material (exclusive of freight handler dose) are summarized in Table 4-8; the total is 5070 person-rem.

TABLE 4-7

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION DOSE FOR THE DELIVERY VEHICLE TRANSPORT MODE

	High-Population Areas	Medium-Population Areas
Transport Parameters		
Average Speed (km/hr)	24	40
Distribution of Travel Distance	0.4	0.6
Population Density (persons/km^2)	3,861	719
Stop Duration (hr)	0.5	0
Traffic Distribution		
Fraction in Non-Rush Hour	0.92	0.92
Fraction in Rush Hour	0.08	0.08
Roadway Distribution		
Fraction on City Streets	0.65	0.65
Fraction on 2-Lane	0.05	0.05
Fraction on 4-Lane	0.05	0.05
Fraction on Freeway	0.25	0.25

Total TI Shipped = 1.18×10^6

TABLE 4-8

DOSES RESULTING FROM TRUCK AND VAN TRANSPORT OF RADIOACTIVE MATERIALS - 1975 (EXCLUSIVE OF FREIGHT HANDLERS)*

Mode	Population Subgroup	Annual Population Dose (person-rem)	Maximum Annual Individual Dose (mrem)
Truck	Crew	2580	870
	On-link	172	1.9
	Off-link	348	0.009
	While stopped	1000	1.3
	Storage	261	500*
Van	Crew	53	70
	On-link	216	negligible
	Off-link	51	0.009
	While stopped	79	negligible
	Storage	310	500*
	TOTAL	5070	

*See discussion of freight handlers in Section 4.4.

4.3.3 RAIL TRANSPORT

The methods used for calculating the impact of transport by rail are similar to those used for truck transport because of similarities in route structure and service areas. The major differences between truck and train are in the speed of transport (train is generally slower) and the proximity of population exposed on the rail link. Although the speed of a freight train while moving through the countryside is reasonably fast, the need to enter sidings occasionally to allow faster trains to pass and to pick up and drop off cars reduces the mean speed considerably. This results in a longer time for exposure of the public to radiation. Where passenger trains pass or are passed, a population dose is incurred in a manner analogous to that received by other vehicles using the highway in the truck mode. Shipment parameters used to compute population dose for rail transport are shown in Table 4-9.

4.3.3.1 Transport by Freight Trains

Because of the length of time required for a shipment and special capability for handling massive loads, the principal radioactive materials shipped by rail are those with long half-lives or those that require special shielding. An example of a shipment of this sort would be a large irradiated fuel cask. The only material shipped by passenger train is a negligible amount of "limited" postal shipments.

4.3.3.1.1 Exposure of Train Crew

An average freight train is composed of approximately 70 cars. As a result, the proximity of the train crew to a car carrying radioactive material is difficult to quantify except on a statistical basis. While the train is in motion, the brakeman or conductor in the caboose may be as close as 3 meters or as far as a few thousand meters from a radioactive shipment. If the latter condition occurs, a great deal of intervening cargo acts to shield the crew car. Similar arguments can be made for the engine crew so long as there is only one shipment per train. If there is only a single cargo car making up the train, the engine crew and caboose crew experience similar dose rates.

The dose received by the crew is calculated in a manner similar to that for trucks. The dose-rate formula (Equation (D-1), Appendix D) is used with $d = 152$ meters, and the average exposure time is given by the average shipment distance divided by the average speed. A total of five crew members is assumed. The computation is performed for each standard shipment involving rail transport, and the results are summed to obtain an annual population dose to crew members of 0.9 person-rem.

The maximum annual individual dose to a member of a train crew is estimated for 50 irradiated fuel shipments per year, an average separation distance of 152 meters, and an average crew time of 8 hours. This combination gives a maximum annual dose of 1.2 mrem.

4.3.3.1.2 Exposure of On-link and Off-link Population

Those persons exposed on the transport link are passengers on trains or freight train crews who pass or who are passed by a train carrying radioactive materials. This calculation

TABLE 4-9

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION DOSE FOR THE RAIL MODE

Transport Parameters	High-Population Areas	Medium-Population Areas	Low-Population Areas
Average Speed (km/hr)	24	40	64
Distribution of Travel Distance	0.05	0.05	0.9
Population Density (people/km^2)	3,861	719	6
Stop Duration (hr)	0	0	24
Passenger Trains (trains/day)	5	5	1
Number of Crew (engineer, fireman, conductor, and 2 brakemen)	5	5	5
Average Separation Distance Between Crew and Radioactive Material (m)	152	152	152

Total TI shipped = 1.8×10^5*

*A TI of 111 is assigned to spent fuel shipments to correspond to the regulatory limit of 10 mrem/hr at a distance of 6 feet from the surface of the vehicle.

is similar to that for truck transport, assuming one freight train per hour and a 10-foot mimimum separation between passing trains. Because of the very small number of passenger trains and the small number of freight train crew members, the on-link annual dose is only 0.012 person-rem. The maximum annual individual on-link dose is negligible owing to the small number of passing trains.

Using the data given in Table 4-9, and summing over the population zones, an annual value of 23 person-rem to the surrounding off-link population is obtained. The maximum off-link dose is similar to that received by a railway station employee who works at a railway station near a spent fuel reprocessing site. If 17 trains per year carrying irradiated fuel pass that station at an average distance of 30 meters and an average speed of 8 km per hour, and if that same station employee is working when each of them pass, he will receive 0.017 mrem according to Equation (D-2) in Appendix D, with K = 1000 mrem-ft^2 per hour.

4.3.3.1.3 Exposure to Population During Stops

As indicated earlier, freight trains frequently stop at rail sidings in order to let other trains pass or to pick up additional cars. In addition, crew change and fuel stops occur at 4-to-6-hour intervals throughout the trip. If it is assumed that the train is stopped a total of 24 hours per trip and those stops occur predominately in low population density zones, a total annual population dose while stopped of 0.9 person-rem is computed using the general expression for population dose during shipment stops derived in Section D.2 of Appendix D for each standard shipment and summing the results.

An example of the maximum dose to an individual while the train is stopped is that received by a railroad employee who serviced the train while it was stopped. If it is postulated that the employee works at a station near an irradiated fuel reprocessing center that handles 100 percent of the annual rail shipments and that this employee spends an average of 15 minutes at an average distance of 15 meters from each shipment, his annual dose would be 1.65 mrem. This value was obtained using the dose-rate formula in Appendix D, Equation (D-1) with d = 15 meters and assuming 17 shipments per year and a K of 1000 mrem-ft^2 per hour.

4.3.3.2 Storage Associated with Rail Transport

Very little storage is likely to be associated with rail transport of radioactive materials. A spent fuel shipment that occupies a single car might spend 24 hours in rail yards waiting to be included in a train to take it toward its destination. In such a location, the average exposable population density is estimated to be 25 people per km^2, corresponding to 20 employees in a railyard 1.6 kilometers long and 0.5 kilometer wide. Again, using the formula for dose while stopped, given in Section D.2 of Appendix D, an annual population dose of 0.7 person-rem is obtained.

An example of the maximum individual dose during rail shipment storage is that delivered to a railroad employee assigned to service or check the railcars carrying irradiated fuel in the yard prior to final coupling to the parent train. If such a person checks 17 such trains per year at an average distance of 8 meters, and if such a check takes 1 hour, he would receive an annual dose of 25 mrem. This number was obtained by using Equation (D-1) of Appendix D for the dose rate and assuming a K value of 1000 mrem-ft^2 per hour for each shipment, as in the standard shipment model.

4.3.3.3 Summary

The annual doses resulting from rail transport of radioactive material are summarized in Table 4-10; the total is 26 person-rem (exclusive of freight handler dosage).

4.3.4 TRANSPORT BY WATER

Historically, water transport modes have been used for shipments of material that are massive or bulky or that do not require exceptionally fast travel. Shipments of irradiated fuel and fresh fuel would therefore qualify for water transport. A considerable number of export shipments of enriched uranium and long-half-life isotopes by ship were reported to have occurred in 1975 (see Appendix A).

4.3.4.1 Transport by Barge

It is anticipated that barge may be a feasible method for transporting fresh fuel to reactors and irradiated fuel to reprocessors located on appropriate waterways. No such shipments were reported in the 1975 shipper survey. However, at least one shipment occurred in early 1976. With relatively few people exposed during movement and a few exposed at each terminal, population exposure is expected to be negligible. The transport of irradiated fuel by barge is considered as an alternative in Chapter 6 of this report.

4.3.4.2 Transport by Ship

For the overseas export-import trade in radioactive materials, there are only two transport modes available: air and ship. Generally, relatively light-weight packages (less than a few tonnes) of short-half-life materials are transported by aircraft. The 1975 survey revealed a total of 3747 TI transported by ship, principally enriched uranium, fresh reactor fuel, and Kr-85. The total annual population dose from these shipments was calculated to be 8.1 person-rem using the transport parameters in Table 4-11 and the same computational techniques as used for other transport modes. The results are summarized in Table 4-12.

An example of the maximum dose is that received by a crewman whose assigned watch station includes the cargo area in which an enriched uranium shipment is stowed. If that person stands 8 hours of watch every day and makes normal hourly rounds, he probably spends 5 minutes per hour at an average distance of 3 meters from the shipment. If his vessel carries a single shipment per year and the trip lasts 10 days, his annual dose would be 3.7 mrem. Individual exposures of the other population subgroups were not evaluated because the actual numbers of people and their yearly exposures were not known.

TABLE 4-10

DOSES FROM RAIL TRANSPORT OF RADIOACTIVE MATERIAL - 1975

Population Subgroup	Annual Population Dose (person-rem)	Maximum Annual Individual Dose (mrem)
Crew	0.9	1.2
Surrounding population		
On-link	0.012	not evaluated
Off-link	23	0.017
Bystanders/Railway Workers	0.9	1.65
Storage	0.7	25
TOTAL	26	

TABLE 4-11

SHIPMENT PARAMETERS FOR CALCULATION OF POPULATION DOSE FOR WATERBORNE TRANSPORT MODES

	Ship	Barge
Number of Crewmen	10	5
Mean Velocity (km/hr)	14	5
Distance from Source to Crew (m)	61	46
Fraction of Travel		
High population zones	0.001	0.01
Medium population zones	0.009	0.09
Low population zones	0.99	0.90
Total Stop Time (hr)		
(Medium population zone)	10	10

Total TI Shipped = 3747

TABLE 4-12

DOSE RESULTING FROM SHIP TRANSPORT OF RADIOACTIVE MATERIAL - 1975

Population Subgroup	Annual Population Dose (person-rem)	Maximum Annual Individual Dose (mrem)
Crew	5.7	3.7
Bystanders/stevedores during stops	1.1	not evaluated
Persons in port area (off-link)	0.9	not evaluated
Persons in vicinity of storage area	0.4	not evaluated
TOTAL	8.1	

4.4 EXPOSURE OF HANDLERS

Handlers of radioactive material packages are generally exposed to the highest dose rates of any population group; however, because they handle the packages for relatively short times, relatively small doses are received. Handling, as defined in this report, occurs whenever a package is transferred from one mode to another, irrespective of the number of people and physical movements that take place. A recent study (Ref. 4-11) indicated that the average population dose received by handlers at airports was 2.5 x 10^{-4} person-rem per TI for small packages. This population dose conversion factor was used for each handling considered in this report. Thus the dose computed for handlers is likely to be conservative because the number of people involved in airport handling is likely to be the largest and the time spent in handling the most prolonged throughout the shipping industry.

In this document, the handler dose is computed by multiplying this average dose conversion factor by the average TI per package, the number of packages per shipment, the number of shipments per year, and an estimated number of handlings per package. This calculation is repeated for each standard shipment, and the total handler dose is obtained by summing all standard shipments. The total annual handler dose was calculated to be 1740 person-rem.

Irradiated fuel casks and irradiator sources, because of their large sizes, are not handled in the same ways as smaller packages. Two handlers are assumed to spend 15 minutes at both the shipping end and the receiving end attaching and detaching rigging equipment for loading and unloading the cask in an average radiation field of 200 mrem per hour (1 meter from the cask) (Ref. 4-10). This results in a population dose of 0.1 person-rem (2 persons x 200 mrem per hour x 1/4 hour) at each end, for a total of 0.2 person-rem per shipment. Multiplication by the number of shipments per year gives the annual population dose in person-rem. A total of 54 person-rem to handlers may result from the handling of large casks. Much of this exposure is not expected to be within the transport industry but rather to employees of the shippers and consignees.

Individual doses to handlers have been evaluated for those employed in airport terminals (Ref. 4-11). Results of those studies indicate that no workers would receive annual doses in excess of 500 mrem and most workers who participated in the survey would have received annual doses smaller than 100 mrem as a result of handling radioactive material shipments. It is expected that the individual doses to airport handlers are the largest of any similar group.

4.5 NONRADIOLOGICAL IMPACTS ON THE ENVIRONMENT

The two principal nonradiological impacts that may arise from the normal transport of radioactive material are area denial and resource use.

4.5.1 AREA DENIAL

There is no significant area denial resulting from normal transport of radioactive material packages. Most packages are shipped along with other freight and are stored in the same terminals as other freight awaiting shipment. Although radioactive material packages are usually isolated in designated areas of freight terminals, it is doubtful that significantly smaller total floor areas would be required if there were no transport of radioactive materials. Exclusive-use shipments require no storage, since they proceed directly from shipper to consignee.

4.5.2 RESOURCE USE

The primary resource uses associated with radioactive material transport include the commitment of shielding material for construction of packages and the use of energy to move the transport vehicles. The shipment of radioactive material requires shielding of individual packages to reduce exposure to people and photographic materials during transport. Construction of these packages requires commitment of natural resources in a manner that may or may not permit recycling and reuse. The principal materials used for shielding are lead and depleted uranium. Quantities committed at any one time to use as shielding in transportation packaging are only a small percentage of the total amounts of these materials used for all other purposes.

Reuse of lead shielding material by return of used packages to the shipper is accomplished (according to an interview with a major radiopharmaceutical shipper) about 50 percent of the time. In the remaining cases, the disposition of the material is unknown, but it is assumed that a significant recycling effort takes place. This assumption is based largely on the fact that the radioactive material packages are received by people who are licensed to possess radioactive materials and who appreciate the value of reusing the shielding material either directly or by recasting it into a usable form. In addition, industrial and commercial users often have an active salvage operation for metals of all kinds. Thus, one might well expect no more than 20 percent loss in lead shielding material per year. A significant fraction of this material is sent to refuse disposal areas. The environmental impacts of this loss are the energy and resources necessary to replace the unreturned material and the presence of lead in an uncontrolled environment.

Depleted uranium is typically used as shielding in large casks such as those used to ship irradiated fuel or large irradiator sources. Since these casks are quite costly, the uranium resources involved are carefully controlled and fully recycled. Depleted uranium used to construct shields is obtained from enrichment tailings and, at present, has few alternative uses.

Other materials such as wood, steel, fiberboard, and plastic are also used in the construction of packaging used to transport radioactive materials. Since radioactive materials constitute only a very small percentage of the total amount of goods transported in similar packages, the use of these resources for their transport is considered negligible.

The second area of resource use is in the operation of the transportation industry itself. The transport of material requires the commitment of personnel, money, and resources. Since radioactive material packages account for only 2×10^6 of the 500×10^9 packages transported annually, and since, for the most part, they are transported incidentally to other freight, virtually no savings in resources would be realized if they were removed from the transport process.

Certain radioactive material shipments, however, cannot be handled routinely along with other freight. Because of excessive bulk, radioactivity, or massive shielding, certain shipments are handled as the exclusive cargo for transport between two locations. Examples of these kinds of shipments are irradiated fuel from military and civilian reactors and large irradiator sources. Natural and enriched uranium are usually carried on exclusive-use vehicles because of their bulk rather than their radioactive properties. The resource use and environmental impact committed to such shipments can be identified with and charged to the transportation of radioactive materials. Such environmental impact items as fuel use, noise, pollution, and accidental injuries and deaths can be associated with such activities. A considerable amount of material is transported by exclusive-use vehicles, but only about 7,500 such shipments consisting of nuclear fuel, waste, large quantity source, and some radiopharmaceuticals are made per year. These shipments are a negligible fraction of the total number of shipments of all materials and therefore account for only a small fraction of these nonradiological transportation impacts.

4.6 ABNORMAL TRANSPORT OCCURRENCES

In each mode of transport there is a class of incidents that occur infrequently and that cause additional radiation exposure and radioactive contamination. These incidents are considered here as a component of normal transportation because they do not involve accidents that cause damage to the shipping vehicle. Included are such events as dropping of packages by material handlers, packages being run over and crushed by a vehicle, and skewering of packages by a fork lift, any of which may compromise package integrity. Other occurrences relate to packaging procedures and include failure to pack the radioactive materials properly, labeling packages with an incorrect TI rating (either too large or too small), failure to close seals properly, use of defective fittings, or failure to provide adequate shielding. Package loss is yet another in the class of abnormal occurrences, any of which may result in excess radiation exposure to handlers or to the general public.

The DOT received 144 hazardous material incident (HMI) reports involving radioactive materials during the 5-year period 1971-1975 (Ref. 4-12). Releases were indicated in only 36 of these reports. About half of these releases occurred in 1975 (20 incidents), indicating that fewer than one out of every 100,000 packages were involved in incidents leading to a release. Air carriers (including air freight forwarders) accounted for about half the total number of reports submitted. Highway carriers accounted for about 45 percent, and the remainder were filed by rail carriers. Over 60 percent of the releases were noted by highway carriers. Most of the air shipment incidents involved Type A or limited packages of radiopharmaceuticals. Appendix F includes 98 of these incidents in a list of hazardous material incident reports obtained from DOT.

Five of the twelve reported releases in the air mode involved packages dropped in handling, typically falling off a cargo handling cart and then being run over and crushed by a vehicle. Other releases for the air mode resulted from damage by other freight, external puncture, loose fittings or closures, or other improper packaging.

The reported highway incidents included Type A radiopharmaceutical packages, drummed low-specific-activity wastes, large casks, and radiography sources. Twelve of the reported incidents (only one of which involved a release of radioactivity) were caused by vehicular accidents and are therefore the subject of Chapter 5. Defective or improper packaging was responsible for over half the incidents that involved a release.

A principal impact produced by a damaged package is radiation exposure of individuals handling the package and others who are near the package for a period of time, especially before the damage is detected. Other impacts are associated with the resulting radioactive contamination, including the doses received by cleanup crews and the cleanup costs. For most packages (e.g., radiopharmaceuticals or small industrial sources), this is a small effect.

As an example of the radiation levels to which persons might be exposed, a 30-curie Ir-192 source with complete loss of shielding resulting from a packaging error could produce a dose rate of as much as 25 rem per hour at 1 meter from the center of the package. A single incident in which shielding was lost on one side of such a package is known to have occurred. Although the exposed individuals exhibited no detectable acute health effects (indicating a dose of less than 25-50 rem), it is clear that the potential exists for large individual doses under these circumstances.

Most radioactive materials are shipped in Type A packages, which are designed to withstand only normal conditions of transportation. The quantities of material released in package-damaging incidents are expected to be on the order of 10^{-3} of the package content. With this release fraction for Type A quantities of a radionuclide and assuming that 10^{-3} of the material released is inhaled, ingested, or absorbed, an average individual dose rate about 0.5 rem per year is expected. (This dose rate and release fraction are derived from the basis of the IAEA Type A quantity specification for each material.) Since most handling accidents are likely to occur in terminal areas, fewer than 10 people are likely to be exposed and the population exposure received per incident is unlikely to be greater than 5 person-rem. For the current 20 incidents involving a release per year, the expected annual population dose rate is expected to be less than 100 person-rem from this source.

4.6.1 IMPROPER LABELING OF PACKAGES

Estimates of the annual radiological impacts resulting from abnormal occurrences are difficult at best, since incidents involving release or partial loss of shielding are so diverse, and the numbers of persons exposed are usually not known. Some of the shipments reported in the 1975 Survey (Ref. 4-13, described in Chapter 1) may have included packages with incorrectly assigned transport indexes. If the total reported TI were too low, the annual normal dose is higher than that calculated in this chapter. On the other hand, if the total reported TI were too high, the annual dose would be lower than anticipated. However, assigning a TI higher than that warranted by the radiation level could cause shipments to be unnecessarily delayed because of restrictions on the maximum TI allowed on a transport vehicle. Improper labeling of packages usually occurs for one of the following reasons: (a) premature release of the package for shipment or (b) an error in measuring the radiation level at 3 feet from the package surface to determine the TI.

Premature release of a package for shipment is a particular problem with short-half-life materials because the decay that occurs between labeling and actual commencement of shipping is factored into the labeling process. If the time lag is underestimated consistently, an extra hazard may be incurred by the public and the industry.

Measurements of package TIs in 1973 showed a significant number had more TIs than stated on the label (Ref. 4-14). To combat this problem and that resulting from improper shielding, FAA has proposed that every package offered to the airlines be monitored before it is accepted for shipment. This procedure might catch shipping errors before the consequences could affect a large number of people.

4.6.2 IMPACT RESULTING FROM LOSS OF CONTROL OF RADIOACTIVE MATERIAL PACKAGES

The principal impact resulting from loss of control of a package is irradiation of people in the vicinity of the package who are unaware of its presence or contents. Loss of control might result when a package is separated from its radioactive labels or if it is dropped during transport. Either scenario is potentially more serious if shielding or package integrity is lost, especially if a long-half-life nuclide is involved.

A typical population dose may be computed by using Equation (D-9) of Appendix D, where allowance is made for the change of the TI with time due to radioactive decay:

$$D(T) = \frac{K_o}{0.693} I(x,d) PD (TI)_o t_{1/2} \left(1 - e^{\frac{-0.693T}{t_{1/2}}}\right) \quad (4\text{-}2)$$

where $I(x,d) = 2\pi \int_x^d \frac{1}{r} e^{-\mu r} B(r) dr$

$t_{1/2}$ = half-life of isotope

$(TI)_o$ = initial package TI

PD = population density

T = time during which package is lost

K_o = TI to dose rate constant conversion factor

Assuming a suburban population density of 719 persons per km^2 (6.68 x 10^{-5} persons per ft^2) and a 1.0-TI Type-A package of I-131 with a half-life of 8 days, the population dose received is about 7 x 10^{-3} person-rem, assuming the package is lost indefinitely. The population dose associated with a lost package in an area of higher population density would be proportionally higher, but is unlikely to reach a significant level.

The average time to recover a lost package is approximately 14 days (based on incidents reported during 1976). A high dose rate makes a package easier to locate using radiation survey equipment. Using the 14-day value in the above calculation, the population dose for an I-131 package loss is of the order of 0.005 person-rem. Records indicate an average of 5 losses per year over the last 9 years. Assuming all lost packages to be like the I-131 package just considered, an average annual population dose of 0.025 person-rem might be expected.

4.7 SHIPMENT BY FREIGHT FORWARDERS

The previously mentioned State surveillance studies (Ref. 4-15) examined four freight forwarder locations where consolidation of radiopharmaceutical packages is carried out. The average annual population exposure associated with these operations was found to be 4 person-rem per location. It is estimated that there are no more than 10 such locations throughout the country, resulting in a maximum annual population exposure of 40 person-rem.

4.8 EXPORT AND IMPORT SHIPMENTS

Export risks are considered to occur from the time the material leaves the shipper until it enters the country of its destination. This includes the secondary mode link from the shipper to the U.S. port of departure and the primary mode link to the first port of entry into the destination country, but not the secondary mode link to the ultimate destination within the foreign country. Import risks are considered to occur from the time the shipment first arrives in the U.S. until it reaches its ultimate U.S. destination. Thus, import risks are associated primarily with the secondary mode transport of the material from the U.S. port of entry to its destination.

4.8.1 EXPORT SHIPMENTS

The export normal risks were evaluated in ways completely analogous to the total normal risk evaluation using the export standard shipments model discussed in Appendix A, Section A.6.1. Secondary mode mileages were half of their counterparts in the total risk calculation, since the secondary mode link on the receiving end was not considered and the number of handlings were adjusted accordingly. The results are given in Tables 4-13 and 4-14 by transport mode and material, respectively. The total annual normal population dose resulting from export shipments is 61 person-rem, or 0.6 percent of the total 1975 normal risk.

The maximum individual dose due to export shipments is unlikely to be greater than that delivered to an airline passenger who happens to fly on a number of passenger aircraft flights carrying radioactive materials. The data indicated about 600 TI were exported by passenger aircraft. If these 600 TI were transported on 50 flights each carrying 12 TI and if an individual happened to fly on one-fourth of all flights with radioactive materials and experience the average 0.36 mrem per hour dose rate (0.030 mrem per hour TI x 12 TI) for an average of 8 hours per flight, his total dose would be 36 mrem.

4.8.2 IMPORT SHIPMENTS

Since imports reported in the 1975 Survey accounted for only an estimated 40 TI and the total TI transported annually is 4.5×10^6, the contribution of these to the total normal dose is considered negligible.

TABLE 4-13

ENVIRONMENTAL IMPACT OF NORMAL EXPORT SHIPMENTS (BY MODE)

SUMMATION OF GROUP POPULATION EXPOSURE TO RADIATION IN PERSON REM AS A RESULT OF TRANSPORT OF VARIOUS RADIOACTIVE MATERIALS BY VARIOUS TRANSPORT MODES UNDER NORMAL CONDITIONS

	GROUPS				SURROUNDING POPULATION				
					WHILE MOVING				
MODE OF SHIPMENT	PASSENGERS	CREWMEN	ATTENDANTS	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
PASS. AIR	1.002E+01	6.833E-02	4.794E-01	6.097E-01	0.	0.	1.512E-02	0.	1.119E+01
CARGO AIR	0.	5.320E+00	0.	3.610E+00	0.	0.	1.021E-01	0.	9.033E+00
TRUCK	0.	1.573E+00	0.	0.	4.827E-02	2.383E-02	1.723E-01	4.510E-02	1.863E+00
SEC. MODES	0.	7.055E+00	0.	6.156E+00	9.492E-01	4.006E+00	9.274E-01	3.739E+00	2.203E+01
RAIL	0.	0.	0.	0.	0.	0.	0.	0.	0.
OTHER	0.	7.669E+00	0.	3.855E+00	1.179E+00	0.	2.251E+00	8.193E-01	1.577E+01
TOTALS	1.002E+01	2.169E+01	4.794E-01	1.423E+01	2.177E+00	4.030E+00	3.467E+00	4.603E+00	6.869E+01

TABLE 4-14

ENVIRONMENTAL IMPACT OF NORMAL EXPORT SHIPMENTS (BY ISOTOPE)

SUMMATION OF GROUP POPULATION EXPOSURE TO RADIATION IN PERSON REM AS A RESULT OF TRANSPORT OF VARIOUS RADIOACTIVE MATERIALS UNDER NORMAL CONDITIONS

	GROUPS				SURROUNDING POPULATION				
					WHILE MOVING				
ISOTOPE SHIPMENT	PASSENGERS	CREWMEN	ATTENDANTS	HANDLERS	OFF LINK	ON LINK	STOPS	STORAGE	TOTALS
AM241-A	6.743E-01	2.113E-01	3.227E-02	1.672E-01	6.277E-03	1.331E-02	2.098E-02	2.815E-02	1.154E+00
AM241-B	1.099E-02	4.994E-03	5.258E-04	4.200E-03	1.288E-04	5.438E-04	3.015E-04	4.448E-04	2.213E-02
AU198	0.	4.845E-03	0.	9.000E-03	2.499E-04	1.051E-03	5.411E-04	7.982E-04	1.648E-02
CO57	3.502E-02	3.274E-03	1.676E-03	1.500E-02	2.386E-04	1.007E-03	9.018E-04	1.330E-03	5.845E-02
CO60-A	0.	2.781E-03	0.	3.000E-03	8.301E-05	3.503E-04	1.804E-04	2.661E-04	6.661E-03
CO60-B	0.	1.272E-01	0.	1.950E-02	3.334E-03	2.846E-03	4.965E-03	6.195E-03	1.640E-01
C-14	2.725E+00	2.524E-01	1.304E-01	4.464E-01	8.234E-03	3.475E-02	2.684E-02	3.959E-02	3.663E+00
IR192-A	0.	1.204E-02	0.	1.500E-02	4.150E-04	1.752E-03	9.018E-04	1.330E-03	3.144E-02
IR192-B	0.	1.202E-01	0.	2.208E-01	7.295E-03	3.079E-02	1.585E-02	2.338E-02	4.183E-01
MF+MCA	0.	1.190E-01	0.	1.674E-01	4.632E-03	1.955E-02	1.006E-02	1.485E-02	3.355E-01
I131-A	9.624E-01	3.041E-02	4.606E-02	1.152E-01	1.733E-03	7.315E-03	6.976E-03	1.022E-02	1.180E+00
MIXED-A	5.713E-03	4.222E-04	2.734E-04	2.100E-03	3.113E-05	1.314E-04	1.262E-04	1.862E-04	8.983E-03
MO99-A	4.124E+00	6.959E-01	1.974E-01	1.074E+00	2.191E-02	9.249E-02	8.125E-02	1.146E-01	6.401E+00
MO99-B	8.520E-01	7.176E-02	4.078E-02	8.100E-02	1.858E-03	7.843E-03	5.814E-03	8.578E-03	1.070E+00
P32-K	1.042E-01	6.856E-03	4.986E-03	1.806E-02	3.123E-04	1.318E-03	1.086E-03	1.602E-03	1.384E-01
XE133-A	1.004E-01	3.963E-03	4.806E-03	1.176E-02	1.743E-04	7.357E-04	7.713E-04	1.117E-03	1.237E-01
RA226-A	0.	1.702E-02	0.	2.408E-02	6.641E-04	2.803E-03	1.443E-03	2.128E-03	4.806E-02
KR85-A	1.252E-01	8.369E-02	5.992E-03	5.082E-02	5.297E-03	8.374E-03	6.256E-03	8.721E-03	2.943E-01
PU238-B	1.892E-02	1.716E-02	9.055E-04	1.512E-02	4.371E-04	1.845E-03	1.316E-03	1.868E-03	5.756E-02
U238	0.	7.413E-02	0.	2.673E-02	9.111E-03	8.062E-03	7.639E-03	1.030E-02	1.360E-01
UF6-E-LG	0.	7.362E+00	0.	7.420E+00	6.575E-01	2.291E+00	1.998E+00	2.586E+00	2.232E+01
UO2-E-LG	2.785E-01	1.113E+01	1.333E-02	3.251E+00	1.411E+00	1.353E+00	1.198E+00	1.628E+00	2.026E+01
UO2-RX	0.	1.339E+00	0.	1.071E+00	3.538E-02	1.493E-01	7.688E-02	1.134E-01	2.785E+00
TOTALS	1.882E+01	2.169E+01	4.794E-01	1.423E+01	2.177E+00	4.030E+00	3.467E+00	4.603E+00	6.069E+01

4.9 SUMMARY OF ENVIRONMENTAL IMPACTS FOR NORMAL TRANSPORT

In this summary only the radiological impacts from normal transport of radioactive materials are discussed in detail, since they are the predominant ones. Other impacts, e.g., area denial and resource use, are secondary. Because radioactive materials are carried most often on vehicles whose prime purpose is to carry passengers or other freight, these secondary impacts would occur regardless of the presence of the radioactive material package. The impacts predicted for 1985 are based on the scaled-up standard shipments model presented in Appendix A.

The radiological impact in terms of annual population doses is given in Table 4-15 for various population subgroups and modes of shipment. Table 4-16 shows similar information classified by isotope shipment rather than by mode of shipment. Tables 4-17 and 4-18 show the projected values for 1985. Table 4-19 summarizes the maximum individual annual dose values. From the data contained in these five tables, the following observations can be made:

1. Shipments of waste material account for 15 percent of the 1975 dose and 24 percent of the 1985 dose. These shipments are numerous and have large TI values. Shipment of isotopes for medical use accounts for approximately 52 percent of the total 1975 dose and 38 percent of the 1985 dose. While each such shipment emits radiation at relatively low intensity, the number of such shipments is very large. Shipments of isotopes for industrial use account for 24 percent of the 1975 dose and 22 percent of the 1985 dose. Nuclear fuel cycle shipments account for 9 percent of the 1975 dose and 15 percent of the 1985 dose. Limited shipments contribute 0.6 percent of the 1975 dose and 0.7 percent of the 1985 dose.

2. The highway transport modes (truck and delivery van) contribute 69 percent of the total 1975 dose. Passenger air transport accounts for 30 percent of the total 1975 dose.

3. On the basis of person-rem per TI carried, the passenger air mode causes the largest radiological effect for the material carried. Values for each mode are shown below:

Mode	Person-rem per TI carried
Passenger air	0.0067
Ship	0.00265
Secondary modes	0.00198
All-cargo air	0.00128
Truck	0.00116
Rail	0.00065

When the mean person-rem per TI for secondary transport modes is added o that for each primary transport mode, the ranking is as follows:

TABLE 4-15

ANNUAL NORMAL POPULATION DOSES (PERSON-REM) FOR 1975
SHIPMENTS BY POPULATION GROUP AND TRANSPORT MODE

Transport Mode	Population Group								Totals	% of Total
					Surrounding Population					
	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage		
Passenger Aircraft	2330.0	16.000	111	433.00	0	0	10.800	0	2902.00	30
Cargo Aircraft	0	4.090	0	16.10	0	0	0.413	0	20.60	-
Truck	0	2580.000	0	51.60	347.000	172.000	999.000	261.000	4406.00	45
Rail	0	0.893	0	92.50	22.500	0.012	0.879	0.666	117.00	1
Other	0	5.710	0	1.87	0.878	0	1.080	0.392	9.93	-
Secondary Modes	0	534.000	0	1143.00	51.200	216.000	79.200	310.000	2333.00	24
TOTALS	2330.0	3140.000	112	1740.00	422.000	388.000	1090.000	572.000	9790.00	
% OF TOTAL	24	32	1	18	4	4	11	6		

TABLE 4-16

ANNUAL NORMAL POPULATION DOSES (PERSON-REM) FOR 1975

SHIPMENTS BY POPULATION GROUP AND MATERIAL

Material		Passengers	Crew	Attendants	Handlers	Surrounding Population Off-Link	Surrounding Population On-Link	Surrounding Population Stops	Surrounding Population Storage	Totals	% of Total
Am-241	A	18.900	115.000	0.905	79.000	4.380	10.500	14.600	18.400	262.000	3.0
Am-241	B	.413	1.100	0.020	0.240	0.032	0.047	0.046	0.059	1.950	-
Au-198		15.500	25.200	0.740	16.600	0.938	2.180	2.440	3.140	66.700	1.0
C-14		2.790	1.230	0.134	0.805	0.046	0.109	0.079	0.107	5.300	-
Co-57		6.500	4.590	0.311	1.960	0.150	0.279	0.231	0.305	14.300	-
Co-60	LSA	7.490	110.000	0.358	43.900	3.720	7.280	10.400	13.100	197.000	2.0
Co-60	A	0	433.000	0	122.000	13.000	19.000	26.100	32.500	645.000	7.0
Co-60	B	0	10.900	0	3.290	0.265	0.131	0.864	1.04	16.400	-
Co-60	LQ_1	0	0.110	0	0	0.003	0.001	0.004	0.001	0.120	-
Co-60	LQ_2	0	0.627	0	0.800	0.075	0.038	0.076	0.020	1.640	-
Cs-137	A	3.440	138.000	0.165	130.000	5.300	16.300	27.100	33.800	355.000	4.0
Cs-137	B	0	0.605	0	0.222	0.02	0.039	0.054	0.067	1.010	-
Ga-67		3.360	7.940	0.161	6.030	0.312	0.781	0.955	1.22	20.800	-
H-3	LSA	0.321	0.213	0.015	0.253	0.010	0.032	0.026	0.035	0.906	-
H-3	A	0.314	0.169	0.015	0.115	0.006	0.015	0.012	0.016	0.663	-

TABLE 4-16 (continued)

Material	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
I-131 A	1000.000	504.000	48.000	426.00	20.500	54.600	43.000	57.900	2160.000	22.0
I-131 B	0.848	1.140	0.041	0.554	0.041	0.090	0.088	0.114	2.420	-
Ir-192 A	20.500	18.400	0.981	9.370	0.638	1.350	1.140	1.500	53.800	-
Ir-192 B	170.000	265.000	8.140	85.000	8.500	15.300	14.000	18.100	584.000	6.0
Kr-85 A	10.100	25.100	0.483	6.440	0.816	1.170	1.090	1.400	46.600	-
Kr-85 B	0.092	0.224	0.004	0.060	0.007	.011	0.011	0.014	0.424	-
Limited	17.800	26.600	0.853	11.600	0.878	1.660	1.690	2.170	63.300	1.0
MF+MC LSA	0	22.500	0	0	3.470	1.710	16.100	4.210	47.900	-
MF+MC A	0	18.600	0	0	8.940	4.410	32.200	8.440	72.700	1.0
MF+MC B	0	1.080	0	0	0.026	0.013	0.106	0.028	1.250	-
MF+MC LQ	0	0.326	0	0	0.008	0.004	0.011	0.003	0.351	-
Mixed LSA	1.250	19.000	0.060	6.970	0.626	1.170	1.670	2.090	32.800	-
Mixed A	1.680	25.000	0.080	17.600	0.956	2.300	3.540	4.440	55.700	1.0
Mixed B	0	1.500	0	0.576	0.050	0.096	0.147	0.183	2.550	-
Mo-99 A	873.000	715.000	41.800	393.000	25.100	53.800	47.600	62.600	2210.000	23.0
Mo-99 B	144.000	127.000	6.890	31.100	3.810	5.800	4.500	5.920	329.000	3.0
P-32	10.900	6.630	0.522	4.510	0.250	0.599	0.491	0.654	24.600	-
Po-210 A	0.019	0.018	0.0009	0.013	0.0007	0.002	0.002	0.002	0.056	-

TABLE 4-16 (continued)

Material	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
Po-210 LQ	0.171	0.150	0.008	0.058	0.005	0.010	0.008	0.011	0.421	-
Pu-238 A	0.080	0.179	0.004	0.158	0.007	0.020	0.024	0.031	0.505	-
Pu-238 B	0.589	1.250	0.028	0.357	0.038	0.063	0.066	0.084	2.480	-
Pu-239 B	0.915	27.900	0.044	6.190	0.825	1.170	1.530	1.910	40.500	-
Pu-239 LQ	0	0.003	0	0.003	0.0002	0.0008	0.0002	0.0003	0.008	-
Ra-226 A	0	58.700	0	27.300	1.97	3.790	5.820	7.260	105.000	1.0
Ra-226 B	0.104	1.330	0.005	1.380	0.065	0.204	0.314	0.396	3.800	-
Spent fuel - rail	0	0.068	0	6.800	0.175	0.222	0.089	0.427	7.780	-
Spent fuel - truck	0	31.300	0	50.800	3.8	1.880	4.820	1.260	93.800	1.0
Tc-99	3.440	42.200	0.165	57.700	2.160	7.050	11.200	14.000	138.000	1.0
UF6-nat	0	17.200	0	6.500	1.030	1.310	1.810	2.540	30.400	-
UF6-enr	0	3.140	0	0.147	0.118	0.135	0.218	0.107	3.870	-
U02-enr	0	19.500	0	2.970	2.830	3.250	5.210	2.570	36.300	-
U02-Rx	0	12.500	0	0.395	0.443	0.465	0.689	0.341	15.000	-
U308	0	113.000	0	172.000	47.000	38.900	47.800	67.100	485.000	5.0
U-Pu	1.840	12.700	0.088	1.960	0.356	0.422	0.439	0.553	18.400	-
Waste LSA	0	17.400	0	0	3.450	1.700	12.600	3.290	38.400	-

TABLE 4-16 (continued)

Materials	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
Waste A	0	139.000	0	0	254.000	125.000	746.000	195.000	1460.000	15.0
Waste B	0	0.565	0	0	0.357	0.176	1.580	0.413	3.090	-
Xe-133	10.8	12.800	0.516	5.460	0.421	0.789	0.743	0.964	32.500	-
TOTAL	2330.000	3140.000	112.000	1740.000	422.000	388.000	1090.000	572.000	9790.000	
PERCENT	24	32	1	18	4	4	11	6		

TABLE 4-17

ANNUAL NORMAL POPULATION DOSES (PERSON-REM) FOR 1985
SHIPMENTS BY POPULATION GROUP AND TRANSPORT MODE

Transport Mode	Population Group: Passengers	Crew	Attendants	Handlers	Surrounding Population: Off-Link	On-Link	Stops	Storage	Totals	% of Total
Passenger Aircraft	4010	27.30	192	702.00	0	0	17.30	0	4948.0	19
Cargo Aircraft	0	37.80	0	146.00	0	0	3.96	0	188.0	1
Truck	0	6649.00	0	308.00	1340.00	662.000	3870.00	1010.00	13840.0	54
Rail	0	3.86	0	499.00	97.40	0.052	3.85	2.92	607.0	2
Other	0	29.60	0	7.60	3.86	0	4.37	1.59	47.0	-
Secondary Modes	0	1220.00	0	2820.00	132.00	557.000	195.00	814.00	5732.0	23
TOTALS	4010	7970.00	192	4480.00	1580.00	1220.000	4090.00	1830.00	25400.0	
% OF TOTAL	16	31	1	18	6	5	16	7		

TABLE 4-18

ANNUAL NORMAL POPULATION DOSES (PERSON-REM) FOR 1985
SHIPMENTS BY POPULATION GROUP AND MATERIAL

Material	Passengers	Crew	Attendants	Handlers	Surrounding Population				Totals	% of Total
					Off-Link	On-Link	Stops	Storage		
Am-241 A	0	313.000	0	205.000	12.300	31.200	37.900	47.800	648.000	3.0
Am-241 B	0	2.980	0	0.625	0.908	0.149	0.119	0.152	4.110	-
Au-198	15.500	25.200	0.740	16.600	0.938	2.180	2.44	3.14	66.700	-
C-14	7.260	3.200	0.348	2.090	0.119	.283	0.205	0.278	13.800	-
Co-57	16.900	11.300	0.808	3.160	0.336	.500	0.517	0.366	33.900	-
Co-60 LSA	0	292.000	0	114.000	9.990	20.200	27.100	34.000	497.000	2.0
Co-60 A	0	1130.000	0	317.000	33.700	49.400	67.700	84.400	1680.000	7.0
Co-60 B	0	28.300	0	4.550	0.691	.341	2.180	2.720	42.700	-
Co-60 LQ_1	0	.286	0	0	0.007	.003	0.011	0.003	0.311	-
Co-60 CQ_2	0	1.570	0	2.000	0.131	.094	0.190	0.050	4.090	-
Cs-137 A	0	363.000	0	338.000	15.700	43.800	70.300	87.900	918.000	4.0
Cs-137 B	0	1.570	0	0.576	0.063	.102	0.140	0.175	2.610	-
Ga-67	24.800	5.490	1.180	15.700	0.438	1.850	0.942	1.390	51.700	-
H-3 LSA	0.836	.555	0.04	0.659	0.027	.083	0.068	0.091	2.360	-
H-3 A	0.817	.440	0.039	0.299	0.017	.040	0.031	0.042	1.720	-

TABLE 4-18 (continued)

Material	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
I-131 A	1000.000	504.000	48.000	426.000	20.500	54.600	43.000	57.900	2160.000	9.0
I-131 B	0.848	1.140	0.041	0.553	0.041	0.090	0.088	0.114	2.920	-
Ir-192 A	0	54.000	0	24.400	2.010	5.010	2.950	3.890	92.200	-
Ir-192 B	0	745.000	0	221.000	25.200	53.000	36.400	47.100	1130.000	4.0
Kr-85 A	26.200	65.200	1.260	16.700	2.120	3.050	2.830	3.630	121.000	1.0
Kr-85 B	0.240	0.582	0.011	0.156	0.018	0.029	0.029	0.038	1.100	-
Limited	46.300	69.400	2.220	30.200	2.290	4.320	4.390	5.670	165.000	1.0
MF+MC LSA	0	93.100	0	0	14.400	7.100	66.700	17.400	199.000	1.0
MF+MC A	0	77.100	0	0	37.000	18.300	134.000	34.900	301.000	1.0
MF+MC B	0	4.460	0	0	0.109	0.054	0.440	0.115	5.170	-
MF+MC LQ	0	1.360	0	0	0.033	0.016	0.046	0.012	1.460	-
Mixed LSA	3.250	49.500	0.156	18.200	1.630	3.050	4.350	5.450	85.600	-
Mixed A	4.370	65.100	0.209	45.800	2.480	5.970	9.210	11.500	145.000	1.0
Mixed B	0	3.890	0	1.500	.130	0.249	0.382	0.476	6.630	-
Mo-99 A	2270.000	1860.000	109.000	1020.000	65.300	140.000	124.000	163.000	5750.000	23.0
Mo-99 B	374.000	331.000	17.900	80.800	9.910	15.100	11.700	15.400	856.000	3.0
P-32	28.300	17.200	1.350	11.700	0.648	1.550	1.270	1.700	63.700	-
Po-210 A	0	0.059	0	0.043	0.004	.008	0.005	0.009	0.127	-

TABLE 4-18 (continued)

Material	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
Po-210 LQ	0	0.443	0	0.152	0.017	0.039	0.021	0.029	0.700	-
Pu-238 A	0.209	0.466	0.010	0.411	0.019	0.052	0.063	0.081	1.310	-
Pu-238 B	0	3.450	0	0.926	0.112	0.213	0.171	0.219	5.090	-
Pu-239 B	0	28.000	0	6.190	0.833	1.210	1.530	1.910	39.700	-
Pu-239 LQ	0	0.003	0	0.003	0.0002	0.0008	0.0002	0.0003	0.007	-
Pu-recycle	0	6.650	0	0.041	0.333	0	0.006	0	7.030	-
Ra-226 A	0	58.700	0	27.300	1.970	3.790	5.820	7.260	105.000	-
Ra-226 B	0	1.410	0	1.380	0.071	0.229	0.314	0.396	3.800	-
Spent fuel - rail	0	2.600	0	261.000	6.690	8.530	3.440	16.400	298.000	1.0
Spent fuel - truck	0	188.000	0	306.000	22.900	11.300	29.000	7.600	565.000	2.0
Tc-99	8.950	110.000	0.426	150.000	5.610	18.300	29.000	36.400	358.000	1.0
Tl-201	144.000	34.500	6.900	27.800	1.360	3.530	2.310	3.200	224.000	1.0
U308	0	467.000	0	710.000	195.000	161.000	198.000	278.000	2010.000	8.0
UF6-nat	0	71.000	0	26.900	4.240	5.410	7.480	10.500	126.000	-
UF6-enr	0	13.000	0	0.609	0.489	.560	0.904	0.444	16.000	-
U02-enr	0	80.700	0	12.300	11.700	13.400	21.500	10.600	150.000	1.0
U02-Rx	0	51.600	0	1.640	1.840	1.930	2.860	1.410	61.300	-

TABLE 4-18 (continued)

Material	Passengers	Crew	Attendants	Handlers	Off-Link	On-Link	Stops	Storage	Totals	% of Total
U-Pu	7.610	52.800	0.364	8.130	1.480	1.750	1.820	2.300	76.300	-
Waste LSA	0	71.900	0	0	14.300	7.040	52.000	13.600	159.000	1.0
Waste A	0	574.000	0	0	1050.000	516.000	3080.000	805.000	6010.000	24.0
Waste B	0	2.330	0	0	1.470	0.726	6.510	1.700	12.700	-
Xe-133	28.000	33.400	1.340	14.200	1.090	2.050	1.930	2.510	84.500	-
TOTALS	4010.000	7970.000	192.000	4480.000	1580.000	1220.000	4090.000	1830.000	25400.000	
% OF TOTAL	16	31	1	18	6	5	16	7		

TABLE 4-19

SUMMARY OF MAXIMUM ANNUAL INDIVIDUAL DOSES FROM RADIOACTIVE MATERIAL TRANSPORT

Population Subgroup	1975 Max. (Avg.) Probable Dose (mrem)	
Airline Passengers	108	(0.34)
Cabin Attendants	13	(2.9)
Passenger Aircraft Flight Crew	2.5	(0.53)
All-Cargo Aircraft Flight Crew	61	(12)
Air Crew (other air modes)	5	
Truck Crew	870	
Van Crew	70	
Train Crew	1.2	
Ship Crew	3.7	
Freight Handlers	500	
Bystanders (pass. air)	85	
Bystanders (cargo air)	106	
Bystanders (other air modes)	60	
Bystanders (truck)	1.3	
Bystanders (rail)	1.65	
Off-link (truck/van)	0.009	
Off-link (rail)	0.017	
On-link (truck/van)	1.9	
Storage (rail)	25	

Mode (including secondary link)	Person-rem per TI carried
Nonexclusive trucks	0.00889
Passenger air	0.00814
Ship	0.00524
All-cargo air	0.0035
Rail	0.00183
Exclusive-use trucks (no secondary link)	0.00058

4. The estimated total annual population dose is 9,790 person-rem in 1975 and 25,400 person-rem in 1985. This dose has the same general characteristics as other chronic exposures to radiation such as natural background. The predicted result of public exposure to this radiation is approximately 1.19 latent cancer fatalities and 1.7 genetic effects in 1975 and 3.08 latent cancer fatalities and 4.4 genetic defects in 1985. While the value of 9,790 person-rem may seem large, it is small when compared with the 4×10^7 person-rem received by the total U.S. population in the form of natural background radiation (see Chapter 3). The total population at risk for radioactive material transport is estimated to be about 20×10^6 people (1975), based on estimates of numbers of aircraft passengers, persons in air terminals, and persons living within 0.5 mile of truck and van routes. Thus, the average annual individual dose is approximately 0.5 mrem, which is a factor of 300 below the average individual dose from background radiation. These results are shown in Table 4-20.

5. Exports and imports of radioactive materials make only a very small contribution to the overall normal risk.

TABLE 4-20
RESULTS - NORMAL TRANSPORT OF RADIOACTIVE MATERIALS

	1975	1985
Total Annual Population Dose (Person-rem)	9,790	25,400
Expected Annual LCF's	1.2	3.1
Expected Annual Genetic Effects	1.7	4.4

$$\text{1975 Average Individual Dose} = \frac{9790}{20 \times 10^6} = 0.5 \text{ Mrem}$$

Annual Normal Dose Attributable to Export and Import Shipments in 1975 = 61 Person-Rem

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CHAPTER 5

IMPACTS OF TRANSPORTATION ACCIDENTS

5.1 INTRODUCTION

Two factors are considered in evaluating the impact of accidents that involve vehicles carrying radioactive shipments: probability and consequence. The probability that an accident releasing radioactive material will occur can be described in terms of the expected number of accidents (of given severity) per year for each transport mode, together with the package response to those accidents and the dispersal that is expected. The consequence of an accident is expressed in terms of the potential effects of the release of a specified quantity of dispersible radioactive material to the environment or the exposure resulting from damaged package shielding.

The product of probability and consequence is called the "annual radiological risk" and is expressed in terms of the expected radiological consequences per year. This risk can be quantified for each shipment type. Summing the risks over all shipments gives the total annual risk resulting from all shipments. Since this method does not distinguish high probability-low consequence risks from low-probability/large-consequence risks, shipments with potentially severe consequences are, in addition, considered separately from the risk calculations.

The actual method by which risk is calculated is outlined in Appendix G and detailed in Reference 5-1. Figure 5-1 outlines the informational flow used in the calculation of impacts due to transportation accidents. It also shows the additional impacts that add to the annual risk discussed above.

This chapter is divided into eight additional sections. Section 5.2, which follows this introduction, includes discussions of accident rates for various transport modes and severities and of package release fractions. Section 5.3 discusses the dispersion/exposure model and the inherent assumptions used in the meteorological calculation. The results of the risk calculations using the 1975 standard shipments and their 1985 projections (see Appendix A) are presented in Section 5.4. Section 5.5 discusses the potential effects and cleanup costs of the radioactive contamination from a transportation accident. In Section 5.6 the "worst-case" shipment scenarios are considered, i.e., those that have the potential for very severe consequences but have a very low occurrence probability. Section 5.7 discusses the impact due to export/import shipments. Section 5.8 discusses the nonradiological impacts of transportation accidents, and Section 5.9 summarizes the results of the accident risk and consequence calculations. A sensitivity analysis for the risk computation is performed in Appendix I.

5.2 DETAILED ANALYSIS

Direct radiological impacts on man are considered to be the most important component of the environmental impact. Direct impact to man may result from transportation by any mode or

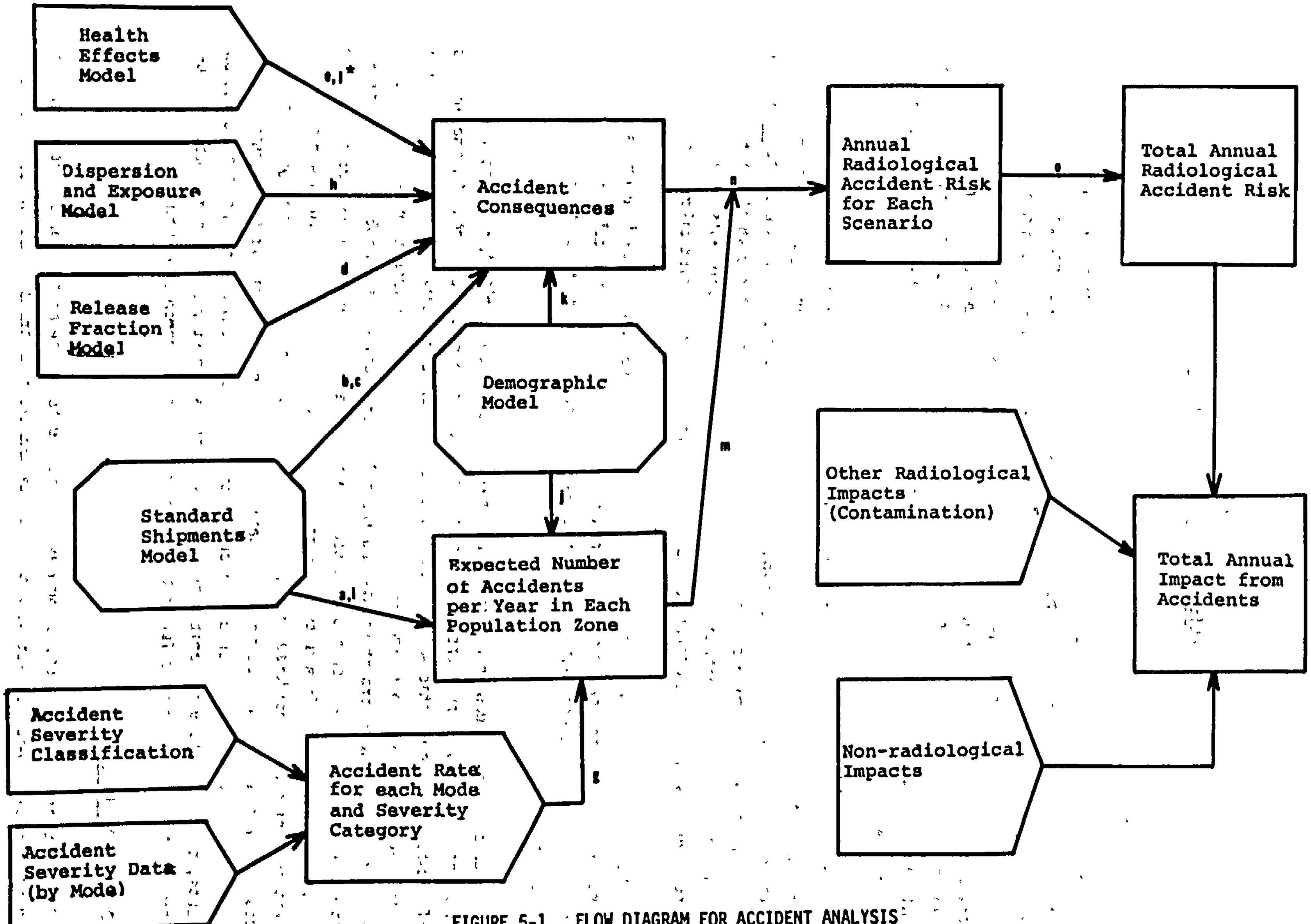


FIGURE 5-1. FLOW DIAGRAM FOR ACCIDENT ANALYSIS

*See notes on following page.

FIGURE 5-1 (continued)

Notes:

a. Shipment mode.

b. Type of packaging.

c. Type of radionuclide; chemical and physical form.

d. Amount of dispersible material released or amount of unshielded material.

e. Dosimetric data for radionuclide.

f. Overall accident rate for each mode.

g. Accident rate for each mode-severity combination.

h. Amount of dispersible material inhaled or external exposure from unshielded material.

i. Number of shipments per year; average distance per shipment.

j. Fractions of accidents expected in each population zone.

k. Population densities.

l. Biological effects of exposure.

m. Average number of accidents per year of each severity.

n. Summation over all severities.

o. Summation over all scenarios.

submode. The probability that a transport vehicle of a particular mode will be involved in an accident of a specific severity depends on the accident rate per vehicle-kilometer, the number of shipments per year by that mode, and the distance traveled by each shipment transported by that mode. The "consequences" of an accident involving a specific mode depend on the quantity and type of radioactive material carried, the fraction of the material that is released in the accident, the population density in the area where the release occurs, the local meteorology at the time of the accident, and the biological effect of the material on the environment.

5.2.1 ACCIDENT RATES

In order to compute the probability of an accident, it is first necessary to know the accident rate for the mode under consideration. The accident rates used in this assessment are specified per vehicle-kilometer and are summarized in Table 5-1, which also lists the sources for the information.

5.2.2 ACCIDENT ENVIRONMENTAL SEVERITY CLASSIFICATION

The amount of radioactive material released to the environment in an accident depends upon the severity of the accident and the package capabilities. Very severe accidents might be expected to release a considerable amount of the radioactive material carried, while minor accidents are unlikely to cause any release. Thus, in addition to the overall accident rate for each mode, the distributions of accidents according to severity must be determined. In this section, the accident severity classification scheme used in this assessment is discussed, and the distributions of accidents according to severity are determined for air, truck, rail, and waterborne transport modes. In addition, estimates of the relative occurrences of accidents of each severity, in each population zone, and for each transport mode are discussed.

5.2.2.1 Aircraft Accidents

The classification scheme devised for aircraft accidents follows that of Clarke, et al. (Ref. 5-2) and is illustrated in Figure 5-2. The ordinate is the speed of impact onto an unyielding surface, and the abscissa is the duration of a 1300°K fire. The results of Clarke et al. indicate that impact speed and fire duration are the most significant parameters with which to categorize aircraft accidents and that crush, puncture, and immersion are lower-order effects (Ref. 5-3). Unyielding surface rather than real surface impacts were chosen in order to make use of the data of Clarke et al. and to facilitate comparison with the regulatory standards. A derating model is introduced into the analysis later to account for the probability of impact on real surfaces rather than on unyielding targets.

The first two scale divisions for impact speed were chosen to correspond to standards for Type A and Type B packagings, respectively. Thus, Category I accidents (with no fire), equivalent to a drop from 4 feet (1.2 m) or less onto an unyielding surface, should not produce a loss of containment or shielding in a Type A package. A 30 foot (9.1 m) equivalent drop was chosen as the division between Category II and Category III impact accidents, corresponding to the Type B container test specification. The remaining impact category divisions were

TABLE 5-1

ACCIDENT RATES

Mode	Accident Rate (per vehicle-kilometer)	Reference
Aircraft	1.44×10^{-8}	5-2*
Truck, Delivery van	1.06×10^{-6}	5-2, 5-5
ICV	$.46 \times 10^{-6}$	5-5, 5-7
Train	$.93 \times 10^{-6}$**	5-2, 5-7, 5-8
Helicopter	$.63 \times 10^{-6}$	5-9
Ship, Barge	6.06×10^{-6}	5-10

*Also see K. A. Soloman, "Estimate of the Probability that an Aircraft Will Impact the PVNGS," NUS-1416, June 1975.

**Rail accidents are given as railcar accidents per railcar-kilometer.

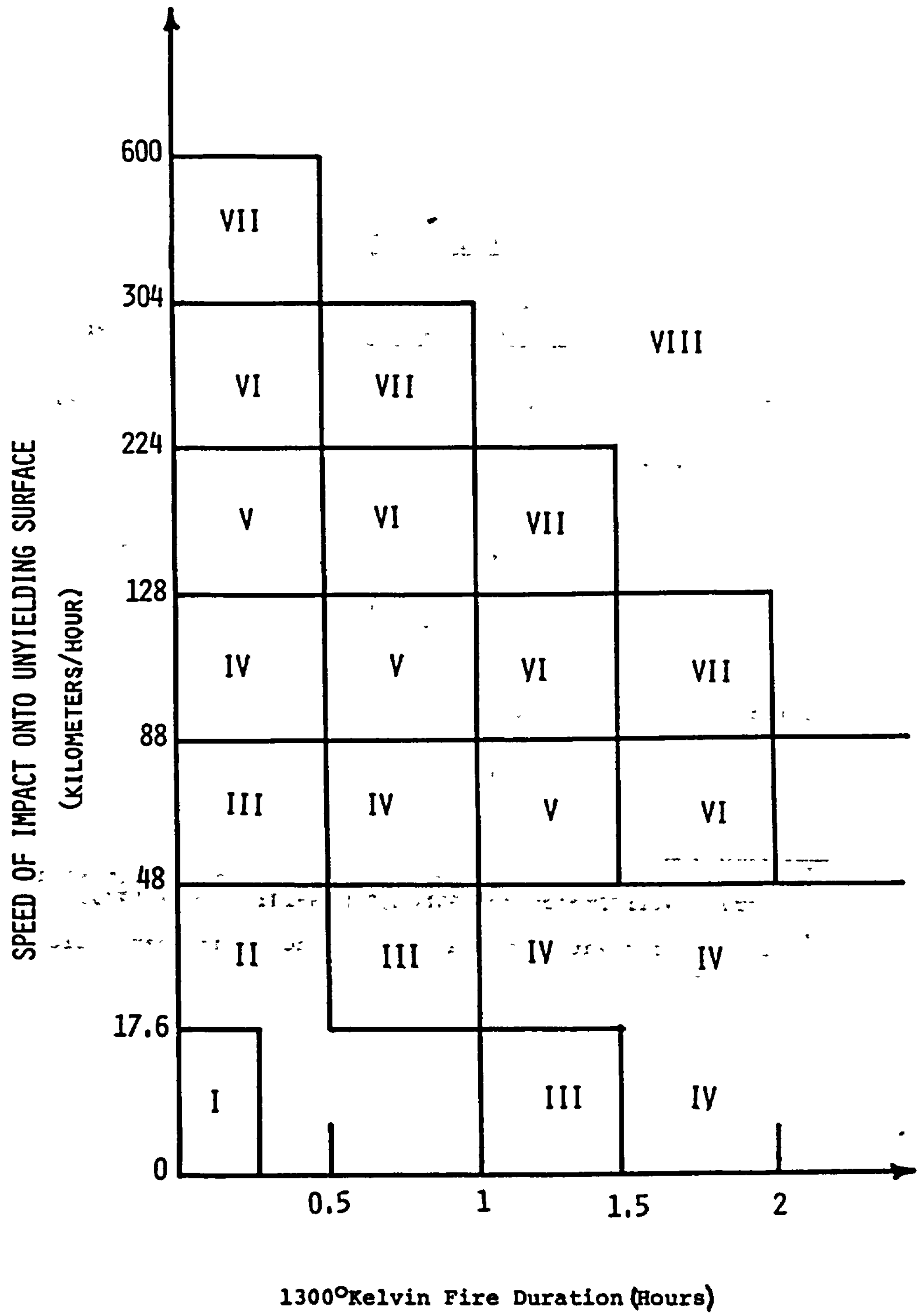


FIGURE 5-2. ACCIDENT SEVERITY CATEGORY CLASSIFICATION SCHEME - AIRCRAFT

chosen more or less arbitrarily from the aircraft accident data compiled by Clarke et al. (Ref. 5-3) in such a way that

1. 95% of the accidents involving impact are severity Category VII or less,

2. 85% of the accidents involving impact are severity Category VI or less,

3. 80% of the accidents involving impact are severity Category V or less,

4. 70% of the accidents involving impact are severity Category IV or less, and

5. 60% of the accidents involving impact are severity Category III or less.

The fire duration category divisions were chosen in such a way that, with the exception of certain Category IV accidents, increasing the fire duration by 30 minutes is equivalent to increasing the impact to the next higher level. Impacts at less than 48 kilometers per hour would not be sufficient to [illegible] an accident of severity Category V or greater regardless of how long the fire burned. The fire temperature was chosen as 1300°K to facilitate comparison with previous data (Ref. 5-2) and to correspond roughly to the temperature of a jet fuel fire.

Note that Category I accidents can involve a fire of as much as 15 minutes' duration. A Type A package involved in a Category I accident in which a fire occurs would not be required by the regulations to survive the accident without loss of shielding or containment.

The fractions of aircraft accidents expected in each of the eight aircraft accident severity categories are given in Table 5-2. The numbers under the column heading "Unyielding Surface" were taken from the accident severity data of Clarke et al. (Ref. 5-3) and were adapted to the accident severity classification scheme used in this study.

The fractional occurrences listed under the heading "Real Surfaces" account for the fact that most aircraft accidents involve impact onto surfaces that yield or deform to provide at least some cushioning effect and result in impact forces that are less severe than would occur on an unyielding surface. These fractional occurrences are obtained by derating those for unyielding surfaces, based upon occurrence statistics for surfaces of varying hardness. The details and rationale for this procedure are discussed in Appendix H. The derating of accident severities was made beginning with Category VIII and working back as far as Category III. No real surface derating is expected for Categories I and II, since these low-severity accidents are expected to occur while the aircraft is on the ground at the airport.

A subclassification within each severity category was made to estimate the fraction of those accidents that occur in a given population density zone. Three zones were used in this assessment: low, medium, and high, characterized by average population densities of 6, 719, and 3861 persons/km^2, respectively (the derivation of these values is discussed in Appendix E). Since accident reports do not generally include the population density of the surrounding areas, the data to determine the accident occurrence fractions in various population zones do

TABLE 5-2

FRACTIONAL OCCURRENCES* FOR AIRCRAFT ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences f_i		Fractional Occurrences According to Population Density Zones		
	Unyielding Surface	Real Surface	Low	Medium	High
I	.57	.447	.05	.9	.05
II	.16	.447	.05	.9	.05
III	.09	.0434	.1	.8	.1
IV	.05	.0107	.1	.8	.1
V	.03	.0279	.3	.6	.1
VI	.03	.0194	.3	.6	.1
VII	.04	.0046	.98	.01	.01
VIII	.03	.0003	.98	.01	.01
TOTAL	1.00	1.00			

*Overall Acident Rate = 1.44×10^{-8} accidents/kilometer for commercial aircraft (K. A. Soloman, "Estimate of the Probability that an Aircraft Will Impact the PVNGS," NUS-1416, June 1975.)

not exist. Thus, estimates were based on the following assumptions relating severity to accident locations:

1. Accidents of severities I and II are assumed to occur at airports. Since most airports are in suburban (or medium) population density zones, 90% of all class I and II accidents were estimated to occur in medium density zones, with 5% each in low- and high-density zones.

2. Accident Categories III-VI were expected to be mainly takeoff and landing accidents and thus were expected to occur near airports.

3. The fractional occurrence of accidents in low-population-density zones was assumed to increase somewhat with accident severity, since a greater percentage of Categories V and VI accidents occur at higher speeds, which implies greater distance from the airport.

4. Accidents of severity Categories VII or VIII are mainly in-flight accidents and are expected to occur at random along the flight path. They are very strongly weighted toward the rural, or low density, areas since about 98% of the land area of the United States is considered rural (Ref. 5-4). The remainder is estimated to be split between medium population density (1.9% of the total land area) and high population density (0.1% of the total land area).

The accident rate for U.S. certified route carriers used in this assessment is 1.44×10^{-8} per kilometer. This accident rate represents an average over all aircraft types for the years 1967-1972, but within those years the range was 1.13×10^{-8} to 2.0×10^{-8} per kilometer. The accident rate for each severity level was obtained by multiplying the overall accident rate by the fractional occurrence for real surfaces for that severity class. For each scenario in the standard shipments model, three risks are computed, assuming the shipments occur entirely in a low-, medium-, or high-population density zone. The actual risk is obtained by forming the sum of these three risk values, weighted by the fractional accident occurrence in each population density zone for that scenario. This same computational technique is used for all transport modes.

5.2.2.2 Truck Accidents

The severity classification scheme for truck accidents is shown in Figure 5-3. In this case the ordinate is crush force rather than impact. Foley et al. (Ref. 5-5) have shown that, in the case of accidents involving motor carriers, the dominant factors in the determination of accident severity are crush force, fire duration, and puncture. The crush force may result from either an inertial load (e.g., container crushed upon impact by other containers in load) or static load (e.g., container crushed beneath vehicle).

The fractional occurrences of truck accidents in each of the eight severity categories are listed in Table 5-3. Since the dominant effect is crush rather than impact, no real-surface derating is involved. The fractional occurrences were taken from the data of Foley et al. (Ref. 5-5). Note that the values for Categories VII and VIII are much lower than for

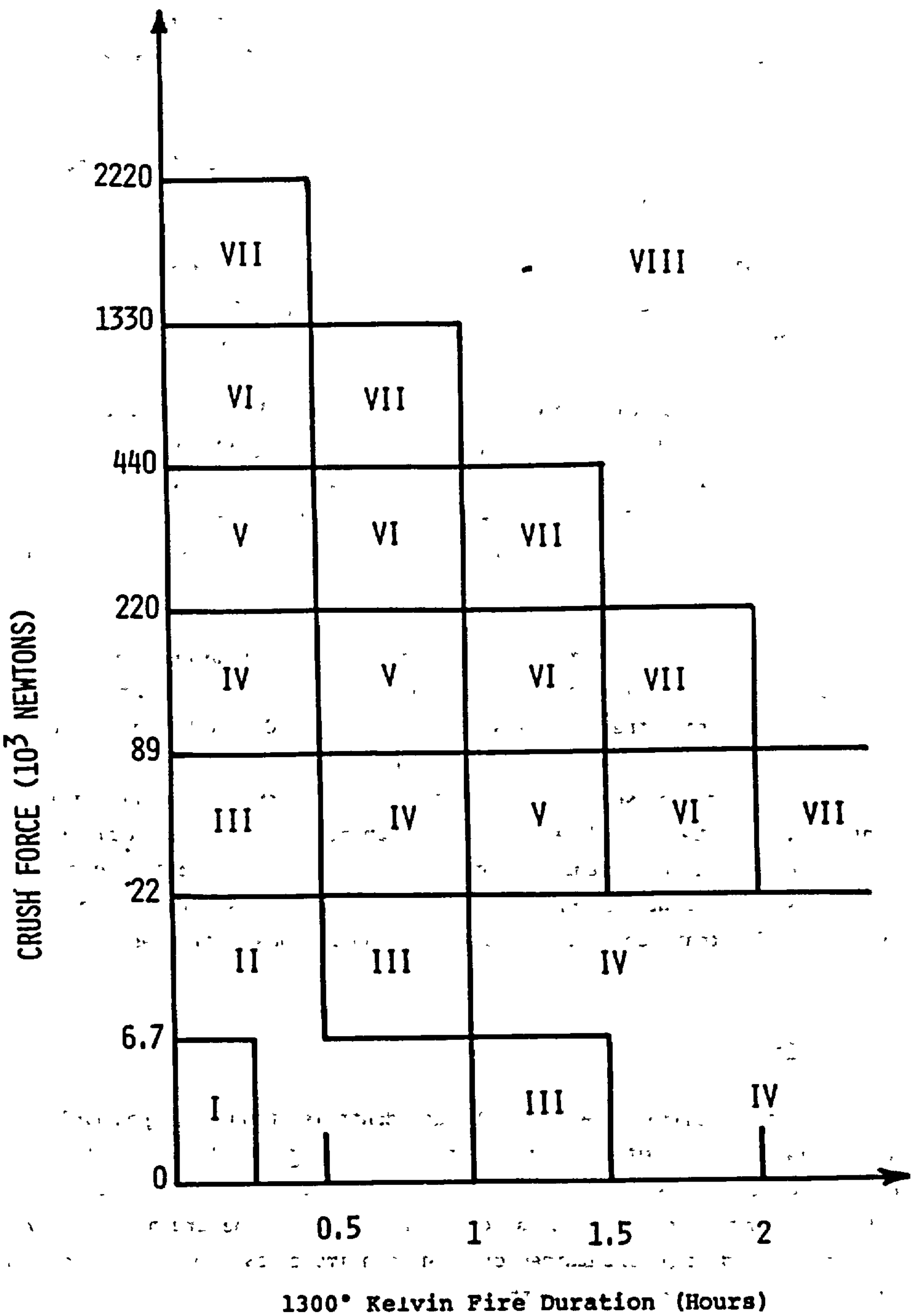


FIGURE 5-3. ACCIDENT SEVERITY CATEGORY CLASSIFICATION SCHEME - MOTOR TRUCKS

TABLE 5-3

FRACTIONAL OCCURRENCES* FOR TRUCK ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences f	Fractional Occurrences According to Population Density Zones		
		Low	Medium	High
I	.55	.1	.1	.8
II	.36	.1	.1	.8
III	.07	.3	.4	.3
IV	.016	.3	.4	.3
V	.0028	.5	.3	.2
VI	.0011	.7	.2	.1
VII	8.5×10^{-5}	.8	.1	.1
VIII	1.5×10^{-5}	.9	.05	.05

*Overall Accident Rate (Ref. 5-5) = 1.06×10^{-6} accidents/kilometer
(0.46×10^{-6} accidents/kilometer for ICV's)

aircraft accidents. The overall accident rate for motor carriers transporting hazardous materials used for this assessment is 1.06×10^{-6} accidents/kilometer.

The estimated fractions of truck accidents in each severity category occurring in each population density zone are also shown in Table 5-3. The very low severity accidents are expected to occur mainly in urban areas. The table reflects a gradual shift of accidents to rural areas with increasing severity as average velocity increases.

Current plans are to require shipment of plutonium in 1985 by Integrated Container Vehicles (ICV) (Ref. 5-6). These are trucks with large vault-like cylinders designed to withstand accident forces and attempted penetration by thieves or saboteurs. Using ERDA nuclear weapons shipment data, the accident rate (which includes the effects of a reduced speed limit, freeway travel, no weekend driving, etc.) is expected to be 0.46×10^{-6} accidents/kilometer (Ref. 5-7). The fraction of accidents within each severity category and the fraction of accidents in each population zone are expected to be the same for ICVs as for other trucks.

5.2.2.3 Delivery Van Accidents

The accident severity classification scheme for delivery vans is the same as that for trucks, as shown in Figure 5-3. Fractional occurrences by severity and the overall accident rate are shown in Table 5-4 and were taken to be the same as for trucks. The fractional occurrences in the three population zones, however, are different. In the standard shipments model, delivery vans are used only as a secondary transport mode. There is practically no rural travel since most of the radioactive materials transport in delivery vans is to and from airports, truck terminals, and railroad depots. There are expected to be more low-severity accidents in high-population-density zones and more severe accidents on freeways in medium-population density zones as a result of the higher freeway speeds.

5.2.2.4 Train Accidents

Figure 5-4 illustrates the accident severity classification scheme used for train accidents. The ordinate in this case is impact velocity, taking into account the effects of puncture. In their analysis of train accidents, Larson et al. (Ref. 5-8) considered crush to be an important factor. However, they were concerned with containers shipped in carload lots and with the crush forces resulting from interaction with other cargo in the rail car. Since the principal rail shipment considered is spent fuel, which is not shipped on the same car as other cargo, crush as a severity criterion is not of prime importance.

Table 5-5 lists the fractional occurrences for train accidents by severity class and by population density zone. The f_i-values were taken from the data of Larson et al. (Ref. 5-8). As with truck accidents, no real-surface derating of the fractional occurrences is required, since the predominant mode of damage in severe accidents is puncture. The overall accident rate is 0.93×10^{-6} railcar accidents/railcar-kilometer, assuming an average train length of 70 cars and an average of 10 cars involved in each accident (Refs. 5-7 and 5-8). As in the case of motor trucks, the more severe accidents are assumed to occur in lower-population-density zones where velocities are higher.

TABLE 5-4

FRACTIONAL OCCURRENCES* FOR DELIVERY VAN ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences f	Fractional Occurrences According to Population Density Zones: Low	Medium	High
I	.55	.01	.39	.60
II	.36	.01	.39	.60
III	.07	.01	.39	.60
IV	.016	.01	.50	.49
V	.0028	.01	.50	.48
VI	.0011	.01	.50	.49
VII	8.5×10^{-5}	.01	.60	.39
VIII	1.5×10^{-5}	.01	.60	.39

*Overall Accident Rate = 1.06×10^{-6} accidents/kilometer

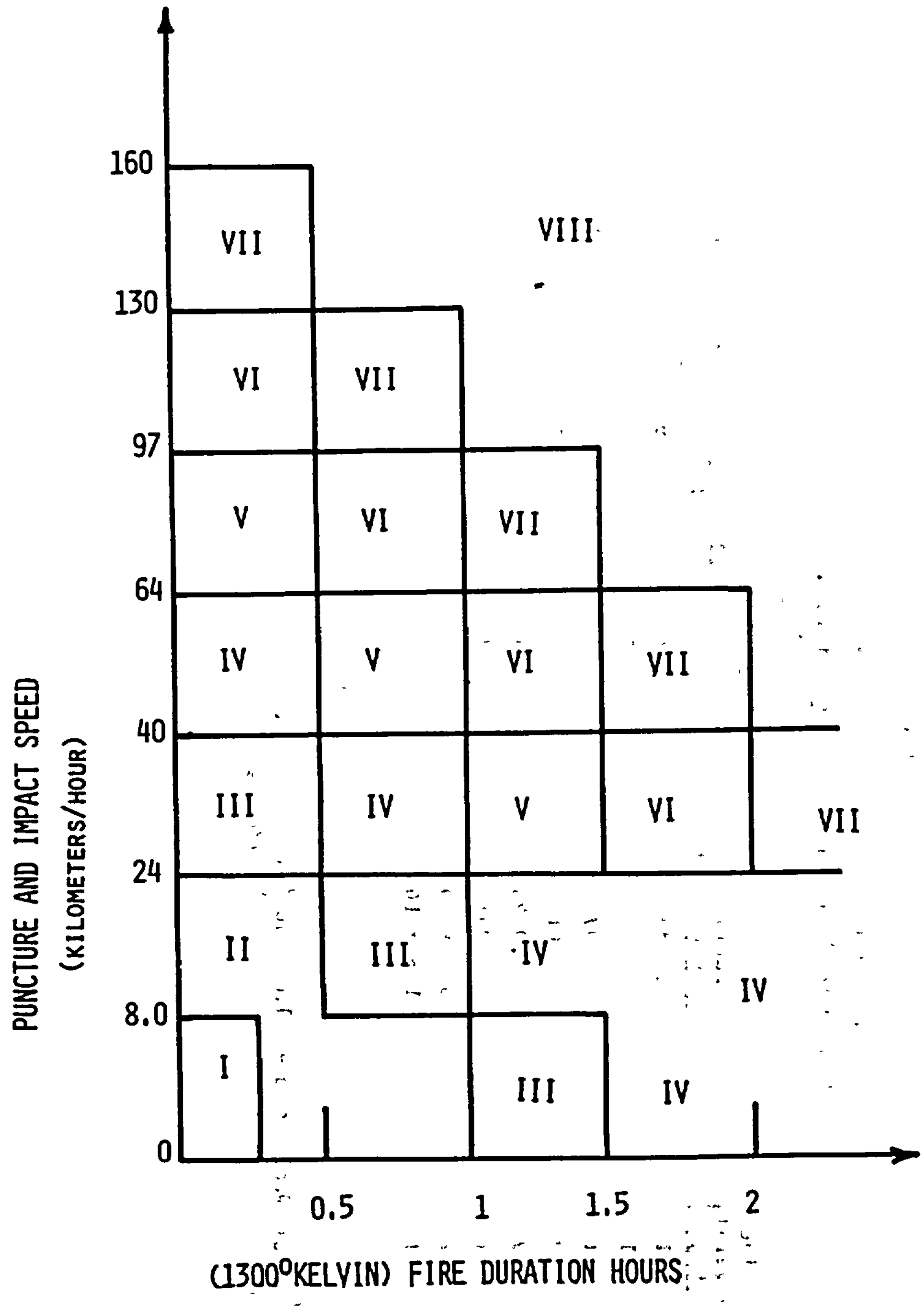


FIGURE 5-4. ACCIDENT SEVERITY CATEGORY CLASSIFICATION SCHEME - TRAIN

TABLE 5-5

FRACTIONAL OCCURRENCES* FOR TRAIN ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences	Fractional Occurrences According to Population Density Zones		
		Low	Medium	High
I	.50	.1	.1	.8
II	.30	.1	.1	.8
III	.18	.3	.4	.3
IV	.018	.3	.4	.3
V	.0018	.5	.3	.2
VI	1.3×10^{-4}	.7	.2	.1
VII	6.0×10^{-5}	.8	.1	.1
VIII	1.0×10^{-5}	.9	.05	.05

*Overall Accident Rate = 0.93×10^{-6} railcar accidents/railcar-kilometer.

5.2.2.5 Helicopter Accidents

Helicopter accidents are classified in a manner similar to aircraft accidents (Figure 5-2). The overall accident rate is 0.63×10^{-6} accidents/kilometer (Ref. 5-9), and the fractional occurrences, shown in Table 5-6, are taken to be the same as for aircraft impacting on real surfaces. However, the fractional occurrences in the three population density zones are different since helicopters are used principally as a secondary transport mode to and from airports.

Accidents represented by the first two severity categories occur while the helicopter is on the ground either at the airport or at a pickup or delivery point, all of which would be located primarily in medium- and low-population density zones. It is anticipated that helicopter flights, particularly those carrying extremely hazardous material, would be routed to avoid flying over high-population-density zones whenever possible. Thus, the takeoff and landing accidents (severity Categories III-VI), as well as the in-flight accidents (Categories VII-VIII), are expected to be concentrated in the medium- and low-population-density zones. Category VII and VIII accidents involving helicopters are considered to be midair collisions and would be expected to occur mainly in the immediate vicinity of an airport; thus most of these accidents should occur in medium-population-density zones.

5.2.2.6 Ship And Barge Accidents (Ref. 5-10)

Records for calendar year 1973 for domestic waterborne traffic show a total of 6.67×10^{11} ton-miles. Precise data are not available to indicate what fraction of those ton-miles was barge traffic; however, a reasonable estimate seems to be 1.73×10^{11} ton-miles of barge traffic. According to the Coast Guard's annual statistics of casualties, there were an estimated 1395 barge accidents in 1973, of which about 60% involved cargo barges.

The available data cannot be analyzed in the same way as the data for rail or truck transport. On the basis of discussions with the U.S. Coast Guard, it is estimated that the average net cargo weight of a typical barge is about 1200 tons. The total number of barge miles would then be about 1.44×10^{8}. This yields an accident rate of about 6.0 accidents per million barge kilometers.

Very little data are available on the severity of accidents involving barges. Since barges travel only a few miles per hour, the velocity of impacts in accidents is small. However, because of the large mass of the vehicle and cargo, large forces could be encountered by packages, for instance, spent fuel casks aboard barges. A forward barge could impact on a bridge pier and suffer crushing forces as other barges are pushed into it. A coastal or river ship could knife into a barge. Fires could result in either case. An extreme accident, i.e., an extreme impact plus a long fire, is considered to be of such low probability that it is not considered a design-basis accident. The likelihood of a long fire in barge accidents is small because of the availability of water at all times. Also, since casks could be kept cool by sprays or submergence in water, there is compensation for loss of mechanical cooling.

TABLE 5-6

FRACTIONAL OCCURRENCES* FOR HELICOPTER ACCIDENTS BY ACCIDENT SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category	Fractional Occurrences (Real Surfaces)	Fractional Occurrences According to Population Density Zones: Low	Medium	High
I	.447	.35	.60	.05
II	.447	.35	.60	.05
III	.0434	.45	.45	.10
IV	.0107	.45	.45	.10
V	.0279	.45	.45	.10
VI	.0194	.45	.45	.10
VII	.0046	.19	.80	.01
VIII	.0003	.19	.80	.01

*Overall Accident Rate = 0.63×10^{-6} accidents/kilometer

The likelihood of cargo damage occurring in barge accidents is much less than in the case of rail accidents. The accident severity breakdown for ship and barge is shown in Table 5-7.

If a cask were accidentally dropped into water during barge transport, it is unlikely that it would be adversely affected unless the water was very deep. Most fuel is loaded into casks under water, so immersion would have no immediate effects. The water would remove the heat, so overheating would not occur. Each cask is required by NRC regulations (10 CFR § 71.32(b)) to be designed to withstand an external pressure equal to the water pressure at a depth of 15 m (50 ft), and most designs will withstand external pressure at much greater depths. If a cask seal were to fail due to excessive pressure in deep water, only the small amount of radioactivity in the cask coolant and gases from perforated elements in the cask cavity would be likely to be released. Even if the cask shielding were ruptured as a result of excessive pressure, the direct radiation would be shielded by the water. About 10 m of water, which is the depth of most storage pools, would be ample shielding for radiation, even from fully exposed fuel elements.

In a recent study (Ref. 5-11) it was concluded that the pressure seals on a spent fuel cask that is dropped into the ocean might begin to fail at a depth of 200 meters, a typical depth at the edge of the continental shelf, and release contaminated coolant. The fuel elements, which contain most of the radioactive material, provide excellent containment. In an operating reactor, the fuel elements are under water at elevated temperatures and at pressures on the order of 1000 to 2000 psi. Thus exposure to water pressures at depths of 600 to 1200 m should have no substantial effect on the fuel elements themselves. The study concluded that they would not fail until they reached a depth of approximately 3000 meters. Once they failed, the fuel pins would release fission products into the ocean, but these would be dispersed into such a large volume of the ocean that the concentrations would be very small. Certain nuclides such as cesium and plutonium could be reconcentrated through the food chain to fish and invertebrates that could be eaten by man; but, as pointed out in the study, the possibilities of a single person consuming large quantities of seafood, all of which was harvested from the immediate vicinity of the release, is very remote, especially since most seafood is harvested in areas over the continental shelves.

In virtually all cases, except those in which the cask was submerged to extreme depths, recovery would be possible with normal salvage equipment. If the cask and elements could not be recovered, corrosion could open limited numbers of weld areas within about 2000 years (Ref. 5-11), with possible localized failures occurring sooner. However, by that time most of the radioactivity would have decayed. Subsequent release would be gradual, and the total amount of radioactivity released at any one time and over the total period would be relatively small. Considering the extremely low probability of occurrence, the major reduction in radioactivity due to radioactive decay, and the dilution that would be available, there would be little environmental impact from single events of this kind.

Should a shipment be accidentally dropped during transfer to a barge, the main effect will likely be limited to that of rather severe damage to the barge. It is possible that a fuel cask could penetrate the barge decks and fall into the relatively shallow water of the breakwater basin. As previously discussed, there would be at most only minor radiological

TABLE 5-7

FRACTIONAL OCCURRENCES* FOR SHIP AND BARGE ACCIDENTS BY SEVERITY CATEGORY AND POPULATION DENSITY ZONE

Accident Severity Category**	Fractional Occurrences**	Accident Severity Category	Fractional Occurrences (this assessment)	Fractional Occurrences According to population density zone		
				Low	Medium	High
minor-2	.897	I	.897	0	.5	.5
minor-3	.0794	II	.0798	0	.5	.5
moderate-2	.00044					
moderate-3	.00113	III	.00113	0	.9	.1
moderate-4	.0186	IV	.0186	0	.9	.1
severe-2	.0000052	V	.0000052	.1	.9	0
severe-3	.000072	VI	.000072	.1	.9	0
severe-4	.000195	VII	.000195	.1	.9	0
extra severe-1	.000013	VIII	.000013	.1	.9	0

*Overall accident rate = 6.06×10^{-6} accidents/kilometer

**From Ref. 5-10.

consequences, since the cask (or drums) could be recovered easily and rather quickly. The environmental impact resulting from damage to the barge (including its sinking) would also be minor, since salvage could readily be started. The most significant effect would be the economic loss from recovery operations.

Waterborne traffic spends a very small fraction of its travel in high-population-density regions. The highest traffic density will probably occur in the port areas and, as a result, be associated with lower speed. Categories VI, VII, and VIII accidents probably require relatively large forces, a long-term fire, or an explosion, which are more likely to occur in open water. Categories III through V are more likely to be the result of a lower speed collision in a dock area, either with another vessel or a pier. The population density of dock areas of most cities was considered to be representative of a medium-population zone. Hence, Class III-V accidents are assumed to occur in a medium-population zone. Categories I and II accidents are not likely to involve another vessel, since they are very minor in nature. Hence, they are considered to occur either in open waters or while securely moored. These assumptions are reflected in Table 5-7.

5.2.3 RELEASE FRACTIONS

In order to assess the risk of a transportation accident, one must be able to predict the package response to an accident of given severity. In particular, one needs to know the fraction of the total package contents that would be released for an accident of given severity. The actual releases for a given package type would not necessarily be the same for a number of accidents of the same severity class. In some cases there may be no release, while in others there may be, for example, a 10% release. Indeed, in a given accident involving a number of radioactive material packages transported together, some of the packages may release part of their contents while others have no release at all. The approach taken in this assessment is to derive a point estimate for the average release fraction for each severity category and package type and assume all such packages, including each package in a multipackage shipment, respond to such an accident in the same way without regard to the type or form of the contents.

The paucity of data on package responses to severe accidents makes it difficult to predict even the average release fraction, much less a distribution. Since the packaging standards do not require tests to failure there has been, until recently, little information relating the response of packages to accident environments.

Recently, a series of severe impact tests was carried out at Sandia Laboratories using several types of containers commonly used to ship plutonium (Refs. 5-12 and 5-13). All container types survived tests with no structural damage to the inner container after impacts onto unyielding targets occurred at speeds up to those typical of a Category V impact accident. Several containers exhibited some minor structural damages and cracking in Category VI impacts, but no verified release occurred. Tests of containers typical of those in commerce resulted in failure of a nonspecification cast iron plug and allowed material loss and also compromised the overall integrity of the inner containers. In one test a container lost 6% of its contents (magnesium oxide powder) in a Category VII impact; others survived Category VIII impacts with no loss of contents. Although none of the containers in this test series was subjected to fire, others of the same type survived less severe impacts followed by a 1300°K environment lasting for a half-hour with no release. Using this test information or assuming that packagings begin to fail at severities just above those that they are required to survive, the responses of packages are estimated by the methods detailed below. The release fraction estimates for all packagings evaluated are shown in Table 5-8.

Two specific release fraction models are considered. Model I specifies total release of package contents for all accident severities exceeding that specified by Federal regulations. This somewhat unrealistic model assumes that zero release occurs up to the regulatory test level and that the packaging fails catastrophically in all environments that exceed that level. Clearly, packagings do not behave in this fashion, but this approach does present a simplistic evaluation of present regulations. Model II is considered to be a more realistic model, although it too has inherent conservatism as is discussed later. Models I and II are used for the 1975 and 1985 risk assessment, and Model II is used for consideration of transportation alternatives in Chapter 6.

5.2.3.1 Release Fractions For Plutonium Shipping Containers

Two sets of release fractions for Type B plutonium shipping containers are listed for Model II; both are derived from the container impact test data described earlier (Refs. 5-12 and 5-13). Those release fractions listed under the heading 1975 Pu show a small release (1%) in a Category VI accident. This accounts for the possibility that small amounts of material might be forced through the cracks observed in the inner container. The 5% release in Category VII reflects the results of the one test in which a measurable amount of material escaped. The Category VIII release fraction of 10% is an estimate of the upper limit to the release fraction based upon analysis of all test data.

The 1985 Pu release fractions acknowledge that in the interim period from 1975 to 1985, package development programs currently underway are likely to produce packages that will have higher integrity. As a result only a 1% release is expected in Category VII and 10% in Category VIII. Even lower release fractions are likely to be justifiable for containers currently under development, but no lower values were shown without complete test data and assurance that older containers will be out of use.

The Integrated Container Vehicle (ICV) is currently being discussed as the principal transport vehicle for plutonium shipments in 1985 and is expected to change the release fractions associated with plutonium shipments appreciably. The massive vault-like containers will be highly accident resistant. The release fractions assumed for these containers are also shown in Table 5-8.

5.2.3.2. Other Type B Containers

Federal regulations require that Type B packagings be able to withstand tests designed to simulate certain accident conditions (Ref. 5-14). In the absence of test data on safety margins for Type B packages, the assumption is made that most containers begin to fail just beyond the accident conditions at which they were tested, although not in the catastrophic

TABLE 5-8

RELEASE FRACTIONS

Model I

Severity Category	LSA Drums	Type A	Type B	Cask (Exposure)	Cask (Release)
I	0	0	0	0	0
II	1.0	1.0	0	0	0
III	1.0	1.0	1.0	1.0	1.0
IV	1.0	1.0	1.0	1.0	1.0
V	1.0	1.0	1.0	1.0	1.0
VI	1.0	1.0	1.0	1.0	1.0
VII	1.0	1.0	1.0	1.0	1.0
VIII	1.0	1.0	1.0	1.0	1.0

TABLE 5-8 (continued)

RELEASE FRACTIONS

Model II

Severity Category	LSA Drum	Type A	Type B No Pu	Type B 1975 Pu	Type B 1985 Pu	Cask (exposure)	Cask (release)	ICV
I	0	0	0	0	0	0	0	0
II	.01	.01	0	0	0	0	0	0
III	.1	.1	.01	0	0	0	.01	0
IV	1.0	1.0	.1	0	0	0	.1	0
V	1.0	1.0	1.0	0	0	0	1.0	0
VI	1.0	1.0	1.0	.01	0	3.18×10^{-7}	1.0	0
VII	1.0	1.0	1.0	.05	.01	3.18×10^{-5}	1.0	0
VIII	1.0	1.0	1.0	.1	.1	3.12×10^{-3}	1.0	.1

manner assumed with Model I. Above the threshold test at which release occurs, the release fractions are assumed to increase with increasing accident severity as assumed for plutonium containers. Note that catastrophic failure (i.e., complete release) is assumed for accident severity categories above IV. This is a conservative assumption in the absence of tests to failure.

5.2.3.3. Type A And Low Specific Activity Containers

The same rationale used for Type B containers is used for Type A containers. A small release is assumed for Category II with progressively greater releases with increasing severity in the same way as for Type B containers. An independent test carried out at Sandia Laboratories on a single Type A (Mo-99 generator) container under Category IV impact conditions resulted in extensive packaging damage but zero release. Thus, the release fractions assumed for this type of packaging are believed to be conservative.

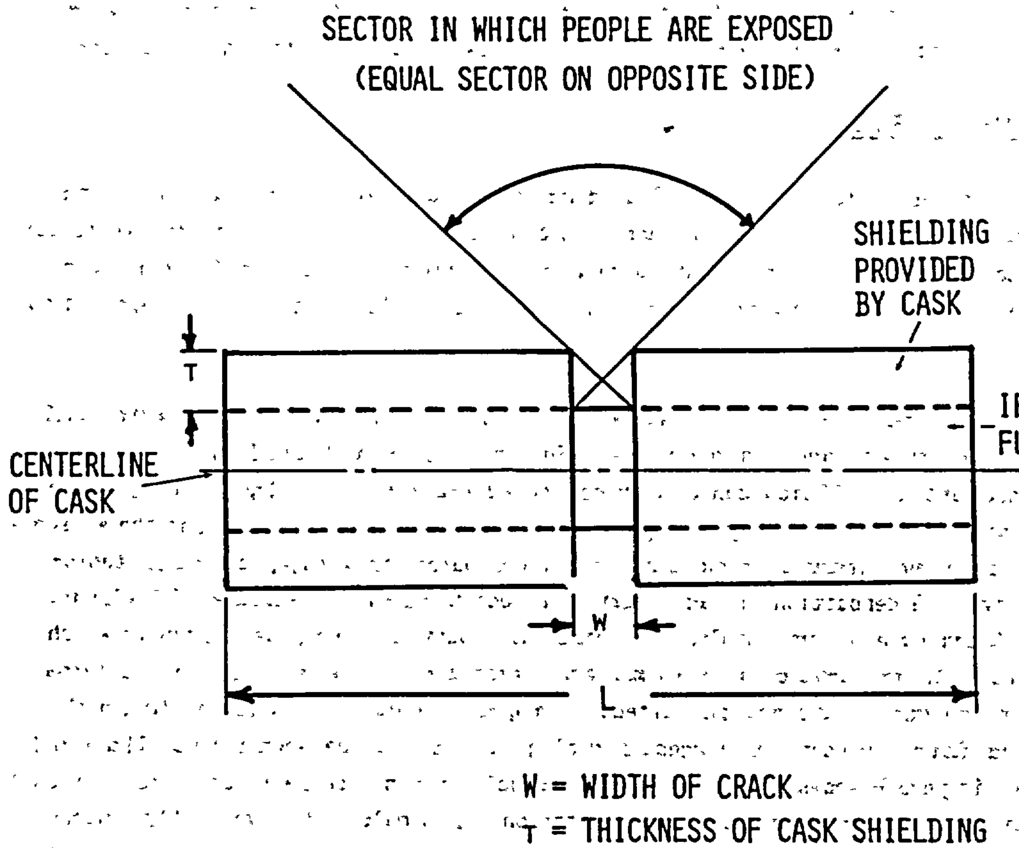
5.2.3.4 Casks

Large casks are used for shipments of large irradiator or teletherapy sources, irradiated fuel, and high-level fuel cycle waste. In analyzing release fractions, therefore, two types of releases must be considered: direct release of contents to the environment and exposure of the surrounding environment to neutron or gamma radiation through a breach in shielding. These two problems must be addressed separately.

Spent fuel can be thought of as a combination of two components: gaseous and volatile materials in the coolant, plenums, and void spaces in fuel rods and non-volatile fission products and activated material held in the matrix of the fuel pellets. Since packagings for large-quantity shipments such as spent fuel must meet Type B standards, the Type B packaging release fractions discussed previously are used to evaluate the release of available gaseous and volatile materials (Ref. 5-14). Drop tests using spent fuel shipping containers were conducted at Sandia Laboratories (Ref. 5-15). There were no releases at impact velocities up to 394 kilometers per hour onto hard soil.

The effect of loss of shielding is modeled by assuming that a circumferential crack is produced in the cask by the accident forces (see Figure 5-5). Using probabilities and descriptions of breaches suggested in Reference 5-16, a Category VI accident was considered the minimum accident with forces sufficient to cause a crack through the entire cask. This was modeled as a circumferential crack 0.1 cm wide around the entire cask. In a Category VII accident this crack is assumed to be 1 cm in width; in a Category VIII accident, it is assumed to be 10 cm in width.

The "release fraction" for the loss of shielding case is not really a release fraction at all, but is the product of the fraction (W/L) of the source length that is exposing the surrounding population and the fraction $[1 - 2/\pi \tan^{-1}(T/W)]$ of the surrounding area that lies within the sector being exposed (see Figure 5-5). The computation of the integrated population dose is then carried out assuming a fictitious point source whose strength is the total



$$\text{FRACTION OF SURROUNDING POPULATION EXPOSED} = 1 - \frac{2}{\pi} \text{TAN}^{-1}\left(\frac{T}{W}\right)$$

FIGURE 5-5. RELEASE FRACTION MODEL FOR EXPOSURE-TYPE SOURCES SHIPPED IN CASKS

number of curies contained multiplied by the "release fraction," with the integration extending over the entire area. The values in Table 5-8 were determined for a cask length, L, of 2.54 meters and a shielding thickness, T, of 0.4 meter.

5.2.4 SHIPMENT PARAMETERS

The shipment parameters that contribute to the accident impact calculation include the number of curies per package, the number of packages per shipment, the physical/chemical form of the material, the dosimetric aspects of the material, the number of shipments per year by each mode, and the distance traveled by each shipment. These data are presented in Appendix A.

5.3 DISPERSION/EXPOSURE MODEL

Once a release has occurred, the released material is assumed to drift downwind and disperse according to a Gaussian diffusion model and can produce such environmental effects as internal and external radiation doses, contamination, or buildup in the food chain. If the accident involves a material in special form, only external radiation exposure is assumed to occur.

Environmental impacts result both from a release to the atmosphere and from external radiation exposure from a large source whose shielding has been damaged in an accident. Atmospheric transport and diffusion can disperse released material over large areas, but the degree of dispersion is determined by atmospheric turbulence, which is a function of the season of the year, time of day, amount of cloud cover, surface characteristics, and other meteorological parameters. The deposition of radionuclides associated with the passage of a cloud of released material can have a very complex environmental impact. Some possible ways in which the dispersed material can produce a dose to man are summarized in Figure 5-6. Direct external or internal dose to man is the principal effect from gamma emitters. Material that emits alpha or beta radiation produces the largest radiological consequence when aerosolized and inhaled by man. Figure 5-6 shows that deposited radionuclides can also be taken into the food chain. They can be transferred from soil to vegetation to animals and eventually to man. However, radiation doses to man through the food-chain pathway are usually more significant (relative to doses through inhalation, for example) if there exists a continuous source of release to the environment.

5.3.1 ATMOSPHERIC DISPERSION MODEL

The dispersion model is based on Gaussian diffusion, a technique widely used in analysis of atmospheric transport and diffusion. Accidents that involve a release of dispersible material are assumed to produce a cloud of aerosolized debris instantaneously at the accident site. The initial distribution of aerosol mass with height is assumed to be a line source extending from the ground to a height of 10 meters. The initial concentration increases with height in a manner consistent with data obtained in experimental detonations of simulated weapons (Ref. 5-17). The use of such an initial distribution is justified for accidents in which fires or residual energy provide an aerosol cloud to be released from the accident site. Since the dose from a 10-meter-high line source is indistinguishable from that of a point

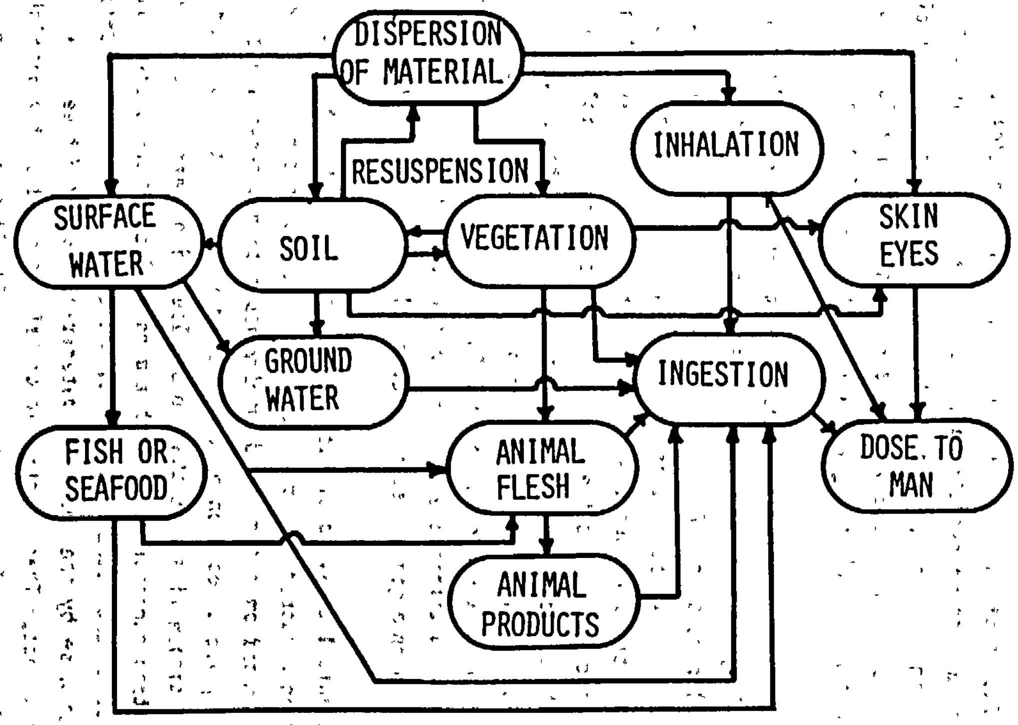


FIGURE 5-6. POSSIBLE ROUTES TO MAN FROM RADIONUCLIDE RELEASE

source at downwind distances greater than about 100 meters, the initial distribution with height is unimportant. Doses calculated using this model are conservative, since most potential accidents involve energy releases that may carry aerosolized materials to heights greater than 10 meters. The degree of conservatism increases as the height of release increases and is especially conservative for elevated sources such as a release that might result from midair aircraft collisons.

Transport and diffusion of the aerosol cloud (composed of particles so small that gravitational settling is minimal) occur symmetrically about the mean wind velocity vector. This process is described using climatological distributions of horizontal and vertical components of turbulence intensities and wind speed. The aerosolized material is allowed to diffuse horizontally without constraint and vertically to an altitude of 1400 meters (Ref. 5-18).

A year or more of meteorological data recorded at sites near White Sands, New Mexico, and Aiken, South Carolina, is used in the model. These data are used to generate values for the lateral and vertical dimensions of the aerosol cloud, which are expressed in terms of the measured lateral and vertical turbulence intensities (Ref. 5-19). These values are calculated for various downwind locations to provide estimates of the dilution that has occurred as a function of the downwind distance and the amount of aerosolized material involved. The results obtained for each of the meteorological data sets are examined to determine the area within which a given dilution factor is not exceeded (this is an area in which a given concentration is exceeded). A curve of area exceeded in only 5% of all meterological conditions versus dilution factor not exceeded within the area is shown in Figure 5-7. This area is taken as a credible upper limit in which a given dilution factor will not be exceeded.

In order to make a full analysis of actual inhalation hazard, the phenomena of deposition and resuspension must be considered. As the cloud of aerosolized material is transported by the wind, material is scavenged from the cloud by dry deposition processes and deposited on the ground. Wet deposition, i.e., deposition by rain and snowfall, is not considered in this model; the neglect of wet deposition will mean that this calculation overestimates the population dose in areas where precipitation can interact with the aerosol cloud. Dry deposition occurs continuously, and its effect is estimated by depleting the total quantity of material that would contribute to inhalation dose by the amount of material deposited between the source release point and a point of interest. The amount of material deposited at any point is calculated using a deposition velocity, V_d (m/sec), which, when multiplied by the time-integrated concentration (Ci-sec/m^3), yields the amount deposited, D (Ci/m^2). A value of 0.01 m/sec is used for V_d based on a previous analysis (Ref. 5-20) and for consistency with the resuspension model used in this document. Dry deposition removes material from the cloud and reduces the downwind concentration, as shown in the lower curve on Figure 5-7.

Resuspension occurs when deposited particle material on a surface is made airborne as a result of mechanical forces (walking, vehicle traffic, plowing, etc.) and wind stress on the deposition surface (as in sandstorms or blowing snow). The resuspended material becomes available for inhalation by people in the contaminated area and can cause an additional component of body burden and radiation dose accumulating with time. Methods used to calculate

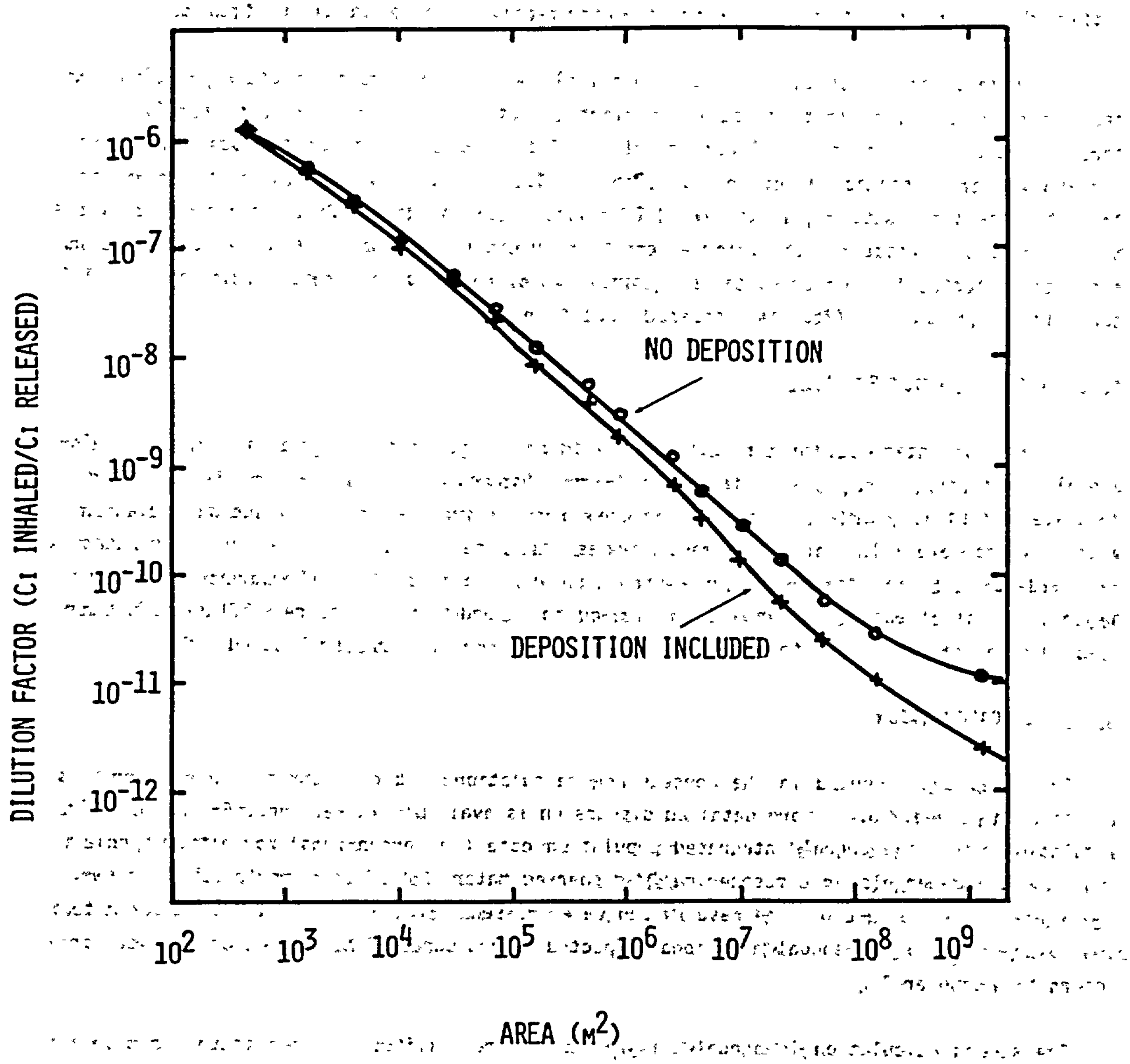


FIGURE 5-7. DOWNWIND DILUTION FACTOR AS A FUNCTION OF AREA

resuspension involve an empirical "resuspension factor," K/m, which is the ratio of the air concentration at a point to the surface concentration just below that point in the contaminated area. An initial value of 10^{-5}/m decreasing exponentially with a 50-day half-life to a constant value of 10^{-9}/m is used in this study to evaluate the dose contributed by resuspension (Ref. 5-20). Because of radioactive decay, short-half-life materials such as Tc-99m provide little resuspension dose, whereas long-half-life nuclides such as Pu-239 increase the initial dose by a factor of up to 1.6 over the dose received during actual cloud passage.

Two effects can be calculated once the actual downwind concentration and deposition patterns are known. The first and most important effect is the inhalation dose received by persons in the downwind area. The calculation of this dose is discussed in Appendix G, and the results are presented later in this chapter. The second effect, which can be determined from the deposition pattern, is the level of surface contamination. Contamination on surfaces has two principal effects: the material can be resuspended and inhaled (as previously discussed), and affected land or crops can be quarantined or condemned if the contamination level is sufficient. The latter effect is discussed in Section 5.5.

5.3.2 EXTERNAL EXPOSURE MODEL

If the postulated accident results in shielding damage to a package containing a nondispersible material, e.g., one of the special-form shipments such as Co-60 or Ir-192, or an irradiated fuel cask, direct external exposure results from the gamma or neutron radiation emitted by the material. This assessment assumes that after an accident the source remains at the accident site for 1 hour with no evacuation and no introduction of temporary shielding The area in which people are exposed is assumed to extend for a distance of 0.8 kilometer radially from the location of the source. This calculation is discussed in Appendix G.

5.3.3 DOSE CALCULATION

Two doses are computed in the consequence calculation, and the computation of each is discussed in Appendix G. A more detailed discussion is available in Reference 5-1. The first calculation is of the annual integrated population dose (in person-rems) for either special form exposure materials or atmospherically dispersed materials. This computation is shown schematically in Figure 5-8. The results can be expressed either as person-rems delivered to particular organs or as annual additional expected latent cancer fatalities using conversion factors from Chapter 3.

The second calculation is annual early fatality probability. If an isotope can give a sufficient dose to cause an early fatality, either from external exposure or excessive pulmonary exposure, the annual probability of this occurrence is computed as shown in Figure 5-9.

5.4 APPLICATION OF THE MODEL TO 1975 AND 1985 STANDARD SHIPMENTS

The annual population dose calculations were carried out for the standard shipment scenarios discussed in Appendix A using the methods discussed previously. The results are presented

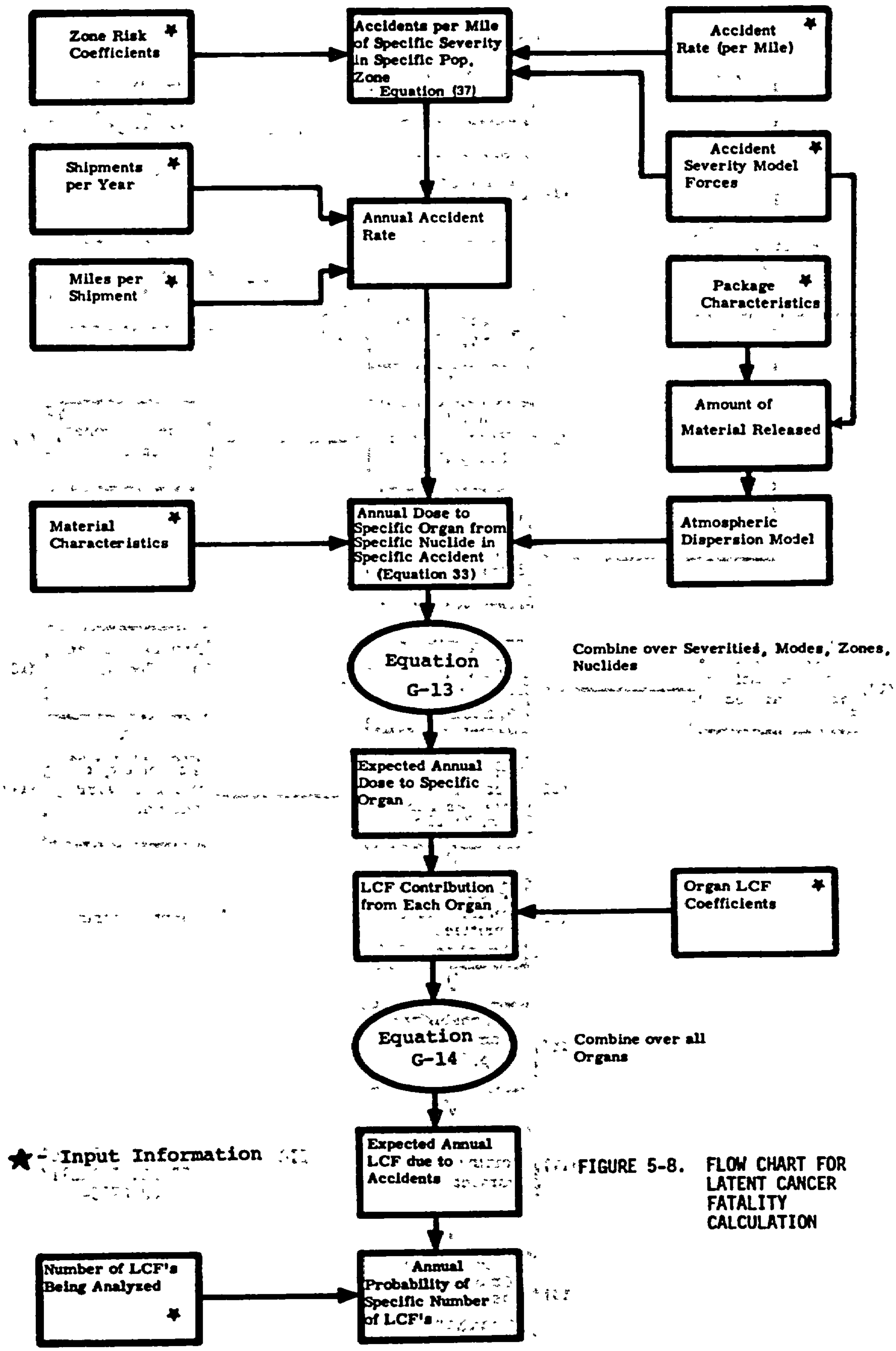


FIGURE 5-8. FLOW CHART FOR LATENT CANCER FATALITY CALCULATION

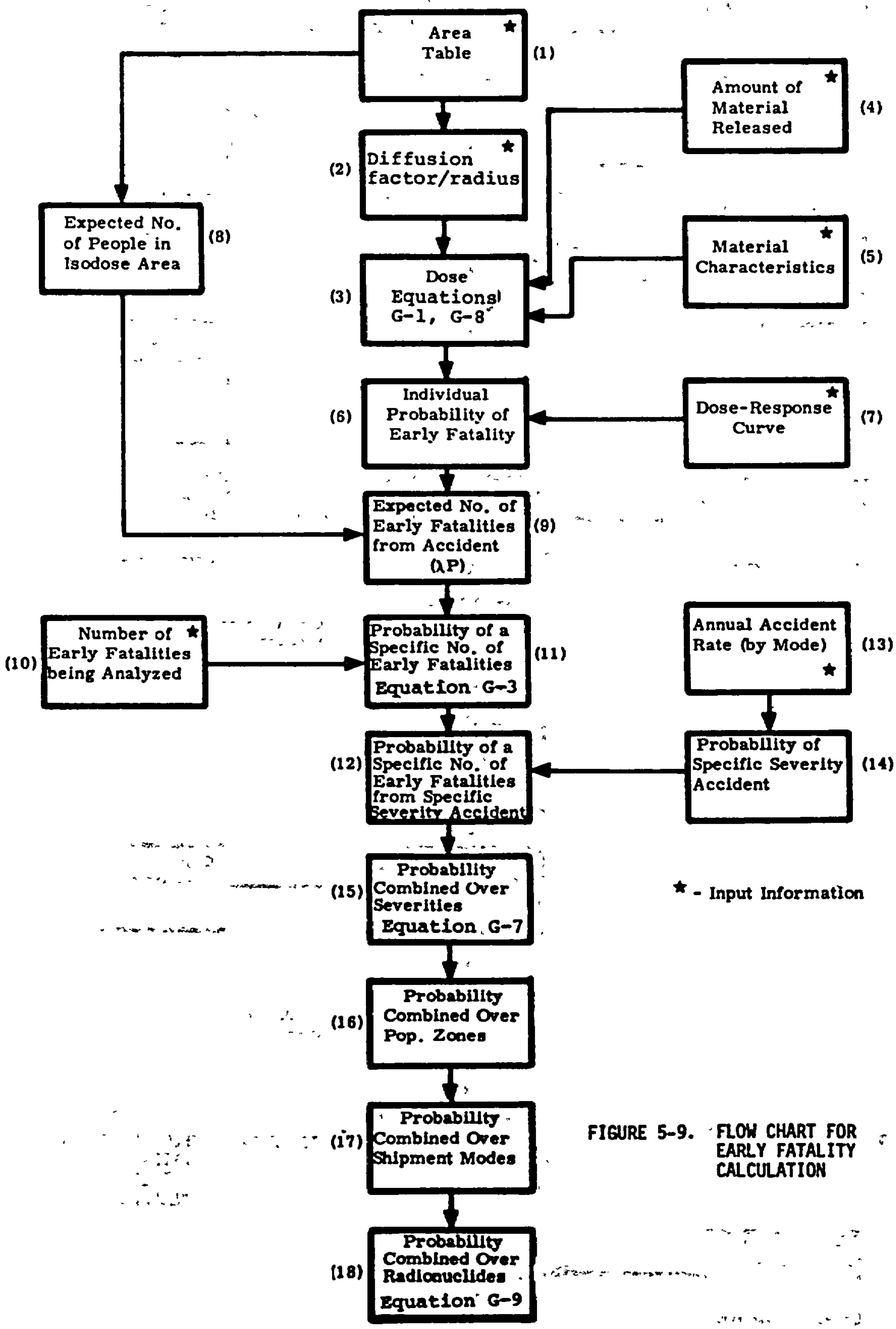


FIGURE 5-9. FLOW CHART FOR EARLY FATALITY CALCULATION

in Table 5-9 for both 1975 and 1985 standard shipments. The annual probability of more than a given number of early fatalities is plotted on Figure 5-10 for 1975 and 1985. Note that a total of 5.37×10^{-3} latent cancer fatalities were expected to result in 1975 from all radioactive material shipments, with the principal contributor being the 144-curie Po-210 shipment scenario with 24% of the 1975 LCFs.* The mixed fission product/corrosion product shipments taken together are of similar importance to Po-210, and the shipments of uranium-plutonium mixtures are third, representing 10.7% of the total LCFs in 1975.

The picture in 1985 is similar, except that the plutonium shipments become much less important. This results from the expected improvement in packaging release fractions in plutonium containers.

The data plotted in Figure 5-10 indicate an annual probability of one or more early fatalities (within 1 year of an accident) of approximately 3.5×10^{-4}, while the probability of 10 or more is 2.5×10^{-6}. This implies that an accident serious enough to kill one person from acute radiological effects would occur only once in 2000 years at 1975 shipping levels.

Results using Model I release fractions for 1975 and 1985 data are presented in Table 5-10 and Figure 5-11. The results shown in Table 5-10 show clearly the impact of the Model I release fractions, which imply that the containment capability of the containers is no better than the regulations require. The most important shipments in this analysis are those with the large quantities of very hazardous materials. The expected LCFs in this case are 9.8 per year in 1975, more than 1000 times that for Model II. The data plotted in Figure 5-11 for the probability of early fatalities using Model I release fractions are also very different from the Model II results. They indicate a probability of less than 0.1 of having one or more early fatalities per year for 1975 using this unrealistic, but legally possible, release fraction model.

5.5 CONSEQUENCES OF CONTAMINATION FROM ACCIDENTS

In addition to direct radiological impacts to man, an accident involving radioactive material may result in environmental contamination leading to loss of crops or contamination of buildings and necessitating evacuation of residents. Analysis of these impacts has been addressed in some detail for the case of a reactor accident in Reference 5-20, and a similar methodology has been adopted for this report.

The potential contamination consequences of a transportation accident involving radioactive materials are, in general, several orders of magnitude smaller than those for a reactor accident. The potential for ingestion of radioactive materials is reduced considerably by the

*There are many factors that can modify the risks identified in Table 5-9. One of these factors is the accident resistance of the package used to ship particular radionuclides. Not included in this analytical model, and thus not reflected in the results, is the fact that all large-quantity shipments of polonium were made in the same accident-resistant packages used to ship plutonium. If considered, this would result in much smaller releases in many of the accident severity categories, and in a smaller total risk attributed to polonium.

TABLE 5-9

ACCIDENT RISK ANALYSIS RESULTS - EXPECTED LATENT CANCER FATALITIES

1975 AND 1985 - MODEL II RELEASE FRACTIONS

Standard Shipment	Expected Latent Cancer Fatalities 1975	Percent of Total Risk	Expected Latent Cancer Fatalities 1985	Percent of Total Risk
Po-210 (144 ci)	.00131	24.4	.00373	22.4
MF+MC (LSA)	.000709	13.2	.00294	17.7
U-Pu Mix	.000514	10.7	.00022	1.3
MF+MC (A)	.000478	8.9	.00198	11.9
Waste (A)	.000388	7.2	.00160	9.6
UF_6 (natural)	.000328	6.1	.00135	8.2
Waste (B)	.000182	3.4	.000752	4.5
Co-60 (40,000 ci)	.00013	2.4	.000336	2.0
Pu-239 (B)	.000129	2.4	.0000122	0.0
Mixed (A)	.00011	2.1	.000286	1.7
U_3O_8	.0000817	1.5	.000338	2.0
MF+MC (392 ci)	.0000800	1.5	.000334	2.0
Mo-99 (A)	.0000708	1.3	.000184	1.1
UF_6 (enriched)	.0000594	1.1	.000246	1.5
Limited	.0000579	1.1	.000151	0.9
Mo-99 (B)	.0000573	1.1	.000149	0.9
Co-60 (LSA)	.0000478	0.9	.000126	0.8
I-131 (A)	.0000384	0.7	.0000384	0.2
Mixed (B)	.0000383	0.7	.0000997	0.6
Spent fuel	.0000356	0.7	.000422	2.5
All others	.000482	9.0	.00136	8.2
TOTAL	.00537		.0166	

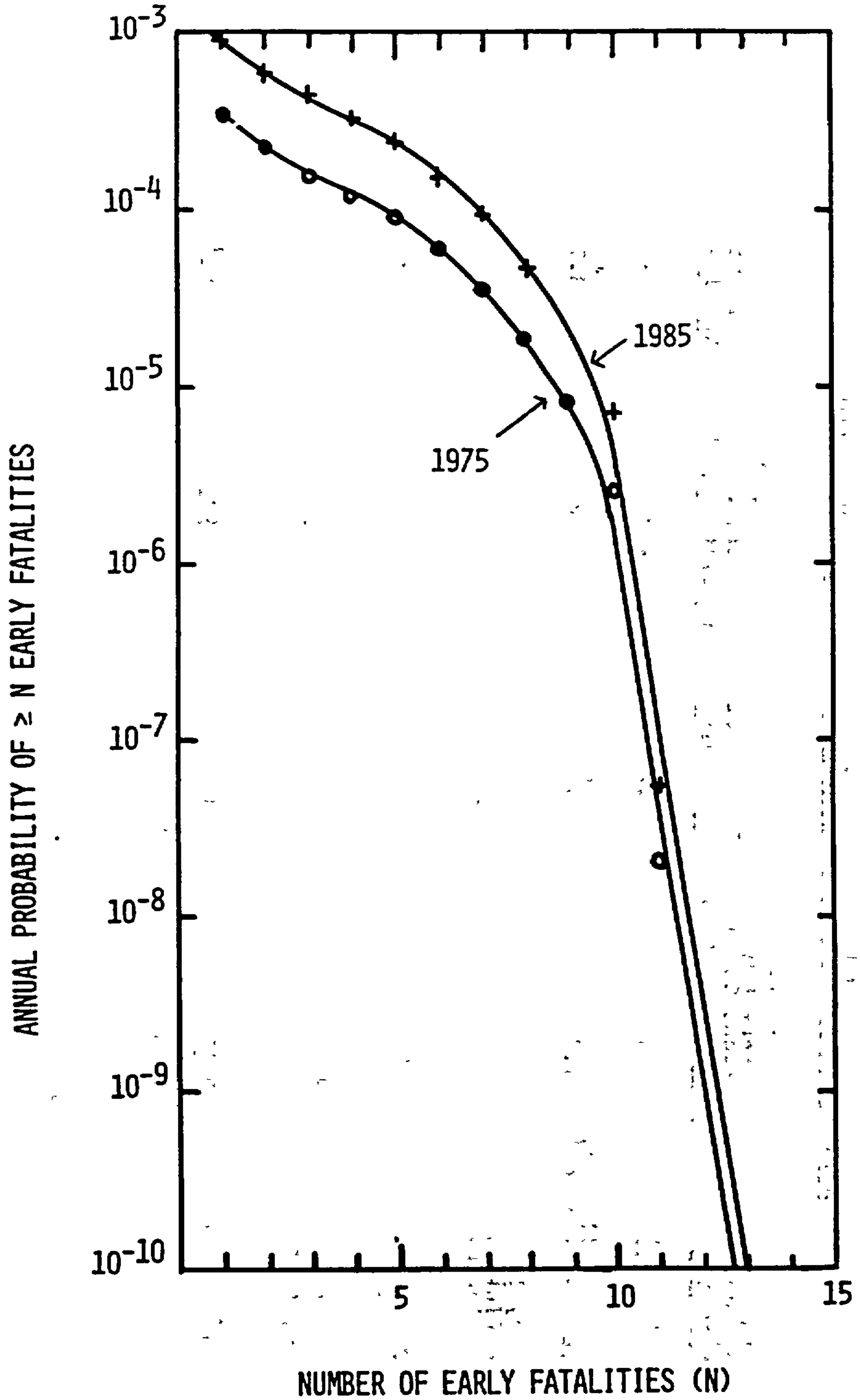


FIGURE 5-10. CUMULATIVE ANNUAL EARLY FATALITY PROBABILITY - 1975, 1985 - MODEL II

TABLE 5-10

ACCIDENT RISK ANALYSIS RESULTS - 1975, 1985 - MODEL I RELEASE FRACTIONS

Standard Shipment	Expected Latent Cancer Fatalities -1975	Percent of Total Risk	Expected Latent Cancer Fatalities - 1985	Percent of Total Risk
U-Pu Mixture	7.9	80.2	32.8	86.6
Pu-239 (1169 ci)	1.78	18.0	1.78	4.7
Recycle plutonium	-	-	1.83	4.8
Spent fuel (rail)	0.021	0.2	0.8	2.1
Spent fuel (truck)	0.047	0.5	0.29	0.8
All others	0.11	1.1	0.038	0.1
	9.86	100	37.9	100

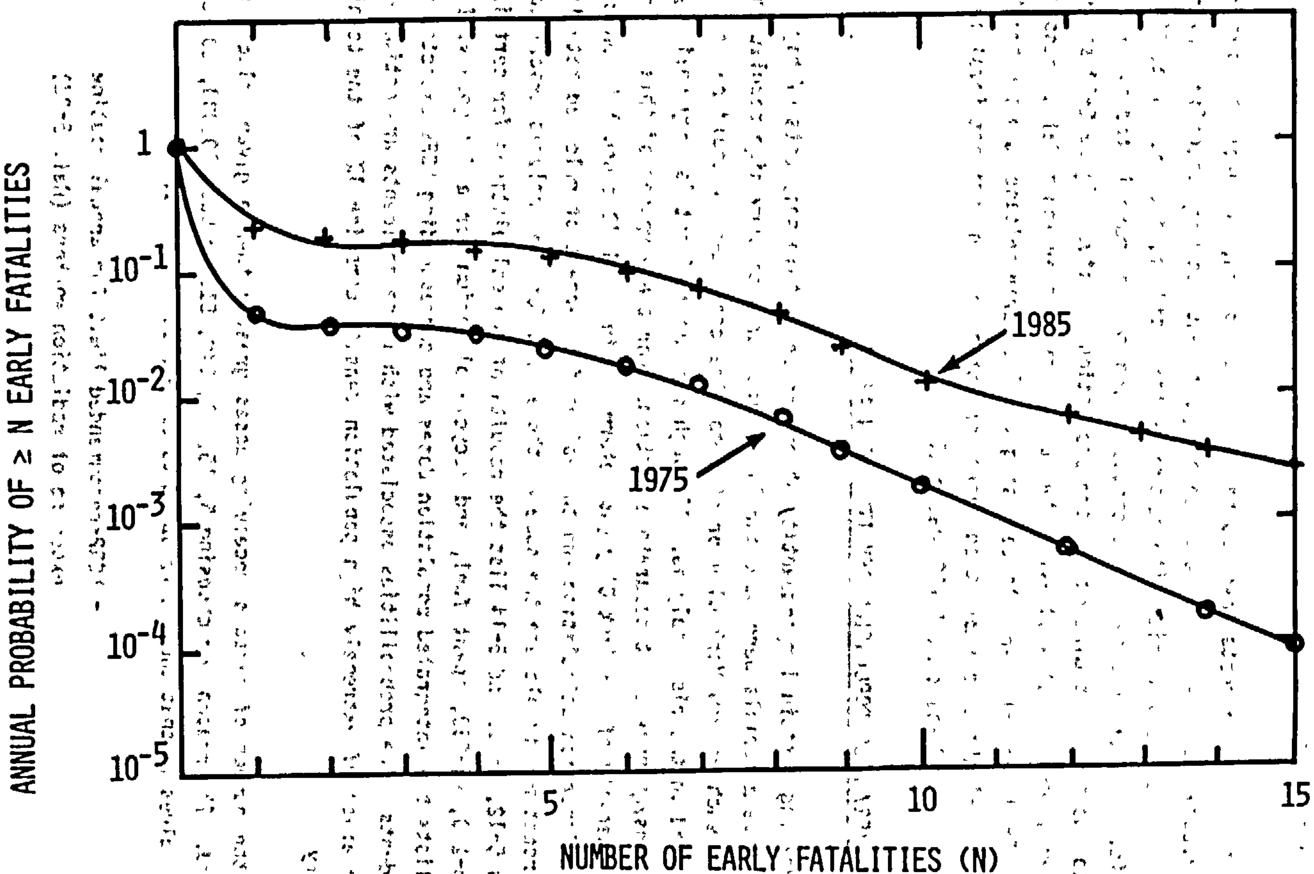


FIGURE 5-11. CUMULATIVE ANNUAL EARLY FATALITY PROBABILITY - 1975, 1985 - MODEL I

fact that contaminated areas are smaller and could be cordoned off. Contaminated crops, milk, and possibly even animals might have to be condemned and destroyed.

A detailed analysis of decontamination costs for four land-use situations for contamination by both a long-lived and a short-lived isotope is presented in this Section. A cleanup level of 0.65 μCi/m^2 was used, based on the Palomares, Spain, nuclear weapons incident (Ref. 5-21). The assumptions and results are shown in Table 5-11. Values associated with Table 5-11 were extracted from Reference 5-20.

The analysis of decontamination costs involves many assumptions and, of necessity, represents only order-of-magnitude accuracy. More accurate analysis requires very specific information about land use near the accident site, the nature of the accident, the weather at the time of the accident, etc. However, the cost of decontamination may be approximated as being directly proportional to the area contaminated and the population density. Figure 5-12 shows the area contaminated versus curies released using the atmospheric dispersion model discussed in Section 5.3. Figures 5-13 and 5-14 were plotted using the 600-curie release as a benchmark. These figures show the approximate decontamination costs resulting from an accident involving a given size shipment of long- and short-half-life material.

5.6 SEVERE ACCIDENTS IN VERY HIGH POPULATION DENSITY URBAN AREAS

If an accident involving certain large-quantity shipments or certain shipments of highly toxic or highly radioactive materials were to occur in an urban area of very high population density (i.e., $>10^4/km^2$) such as New York City or Chicago, the consequences could be more serious than any considered in the risk analysis. Although such an accident is very unlikely, its potentially severe consequences merit separate attention. For the purposes of this analysis, the average urban density of New York City (as determined in the 1970 census) is used: 15,444 people/km^2. The dispersion calculation and the values for percent of released material aerosolized and the percent respirable are the same as those used for the analysis described in Section 5.3. Tables 5-12, 5-13, and 5-14 list the results of the calculations for certain shipments of Co-60, Po-210, Pu-239, spent fuel, and recycle plutonium for a Category VIII accident. Table 5-12 lists the integrated population doses and corresponding LCFs expected to result from these accidents. The probabilities associated with these accidents are estimated by assuming that urban areas of extremely high population density comprise 1% of the total urban area in the country.

Table 5-13 shows the number of persons receiving doses greater than a given value for each accident considered. The reason for choosing 5, 15, 50, 340, 510, 3,000, 10,000, 20,000 and 70,000 rems as dose values is that these correspond to certain benchmark values:

15 rems to lungs	- NCRP-recommended limit for annual routine exposure of radiation workers (Ref. 5-22)
3000 rems to lungs	- threshold for pulmonary morbidity from short-lived gamma and beta emitters (Ref. 5-20)

TABLE 5-11

ESTIMATED DECONTAMINATION COST FOR 600 CURIE RELEASE OF VARIOUS MATERIALS [a]*

		Long-Lived Contaminant		Short-Lived Contaminant [b]	
Population Zone	Land Use	Decont. Technique	Estimated Cost ($)	Decont. Technique	Estimated Cost ($)
Rural (6 person/km^2)	undeveloped/ uninhabited	(1) DF<20- bury by deep plowing [c]	$7.8x10^5$	(1) cordon off for 60 days [e]	$29,000
		(2) DF ≥ 20- scrape and bury [d]	$3.04x10^5$		
			Total = $1.08x10^6$		Total = $29,000
	farmland/ dairyland	(1) DF < 20 bury by deep plowing	$7.8x10^5$	(1) cordon off for 60 days	$29,000
		(2) DF ≥ 20 scrape and bury	$3.04x10^5$	(2) 270 evacuees for 60 days	$3.65x10^4$
		(3) decon. homes/barns a. DF<20 [f]	$6.22x10^5$	(3) purchase & dispose of crops, forage, milk [k]	$9.77x10^5$
		b. DF≥20 [g]	$7.42x10^4$		
		(4) 270 evacuees [h]	$3.65x10^4$		
		(5) purchase & dispose of crops, forage, and milk [i]	$1.15x10^6$ [j]		
			Total = $2.97x10^6		Total = $1.04x10^6$

*See notes at end of table.

TABLE 5-11 (continued)

Population Zone	Land Use	Long-Lived Contaminant: Decont. Technique	Long-Lived Contaminant: Estimated Cost ($)	Short-Lived Contaminant [b]: Decont. Technique	Short-Lived Contaminant [b]: Estimated Cost ($)
Suburban (719 persons/km^2)	98.5% single family dwellings	(1) Decon. homes a. DF < 20 [l] b. DF ≥ 20 [m]	 $56.1x10^6$ $12.1x10^6$	(1) cordon off all residential areas with DF ≥ 20 [t]	$7.2x10^4$
	0.8% public areas (schools, etc.)	(2) $3.24x10^4$ evacuees	$4.4x10^6$	(2) Decon. homes DF>20	$12.3x10^6$
	0.4% commercial & industrial areas	(3) Decon. public areas a. DF < 20 [n] b. DF ≥ 20 [o]	 $1.83x10^5$ $1.0x10^5$	(3) cordon off all parks [u]	$2.84x10^5$
	0.3% parks, cemeteries, etc.	(4) Decon. commercial & industrial areas a. DF < 20 [p] b. DF ≥ 20 [q]	 $9.15x10^4$ $9.77x10^4$	(4) Decon. public areas	$2.84x10^5$
		(5) Decon. parks by replacing lawn [r]	$1.12x10^6$	(5) Decon. commercial & industrial areas	$1.89x10^5$
		(6) indiv. and corporate income loss [s]	$7.33x10^6$	(6) 2035 evacuees for 60 days. 30,320 evacuees for 10 days	$5.74x10^6$
				(7) income loss	$9.64x10^6$
			Total = $82x10^6		Total = $28.5x10^6

TABLE 5-11 (continued)

Population Zone	Land Use [w]	Long-Lived Contaminant: Decont. Technique	Long-Lived Contaminant: Estimated Cost ($)	Short-Lived Contaminant: Decont. Technique	Short-Lived Contaminant: Estimated Cost ($)
Urban (3861 persons/ km^2)	20% high density resid. (6 story apts) [cc]	(1) Decon. apartment buildings a. DF<20 [x] b. DF≥20 [y]	 1.7×10^6 1.06×10^6	(1) cordon off resid. areas with DF≥20 [t]	7.2×10^4
	20% single fam. resid [cc]	(2) Decon. single fam. residences a. DF<20 [l] b. DF≥20 [m]	 11.4×10^6 2.45×10^6	(2) cordon off all parks and vacant areas	3.2×10^6
	20% public land	(3) Decon. public land a. DF<20 b. DF≥20	 4.6×10^6 2.5×10^6	(3) Decon. resid. with DF ≥ 20	3.5×10^6
	20% Ind. & commercial	(4) Decon. commercial & industrial area a. DF<20 b. DF≥20	 4.6×10^6 4.9×10^6	(4) Decon. commercial & industrial areas	9.5×10^6
	10% parks	(5) Decon parks	5.67×10^6	(5) 10,900 evacuees for 60 days; 1.63×10^5 for 10 days	30.8×10^6
	10% undevel. or vacant land	(6) Decon vacant areas (scrape and bury)	4.83×10^5	(6) Decon. public areas	7.1×10^6
		(7) 1.64×10^5 evacuees	22×10^6	(7) income loss	51.8×10^6
		(8) income loss	37.2×10^6		
			Total = 98.6×10^6		Total = 106×10^6 [aa,v]

Notes for Table 5-11

a. $4.5 \times 10^7 m^2$ (1.11×10^4 acres) require decontamination; $2.82 \times 10^6 m^2$ (698 acres) require a DF $\geq$ 20. 400 cpm/m^2 (.65 μci/m^2).
b. I-131 is used as an example/$t_{1/2}$ = 8 days/7 x $t_{1/2}$ = 60 days.
c. $75 per acre.
d. $435 per acre - includes costs of reburial.
e. $5 per hour per guard/4 guards per shift (based on conversations with private security agencies). This could be reduced if National Guard or active duty military were used.
f. $4915 per building/2 buildings per 4-person family (home and barn).
g. $8725 per building/2 buildings per 4-person family (home and barn).
h. $13.5 per day per evacuee; 10 day evacuation required.
i. $104 per acre (based on 48-state average - less Alaska and Hawaii).
j. If orchards are involved, the cost could be considerably higher (up to $5000 per acre) to account for the loss of crops in subsequent years.
k. The entire year's crops are purchased/60-days of milk products are purchased/the average dairy yield per acre is $16 per year.
l. 5 houses per acre/$1095 per house (includes street cleanup).
m. 5 houses per acre/$3510 per house (includes street cleanup).
n. $2200 per acre.
o. $18,000 per acre.
p. $2200 per acre.
q. $35,000 per acre.
r. $0.13 per ft^2 to replace lawns/0.61 acres of parks per 100 persons.
s. $1100 per capita per quarter - individual/$940 per capita per quarter - corporate/10 days of lost income.
t. 10 guards on patrol per shift.
u. 1 guard per 5 acre park per shift.
v. If total evacuation for 60 days with no decontamination were used, the approximate cost would be $261 x 10^6 for suburban and $1.4 x 10^9 for urban. However, this approach would probably not be socially acceptable.
w. Based on approximate values for an average U.S. city (New York City Planning Commission, "Plan for New York City - Volume 1 (initial issue)," 1969)- streets are included with appropriate categories.
x. $15 per occupant for 6-story apartment building } all residents assumed to
y. $140 per occupant for 6-story apartment building } live in multi-story buildings
z. 20 guards on patrol per shift.
aa. Clearly, the method used to deal with a spill of this sort would be the least expensive method - probably outright cleanup rather than long-term evacuation.
bb. Single family units.
cc. The single family units are assumed to have 4 persons per unit, 5 units per acre. The remaining people are assumed to live in multi-story buildings.

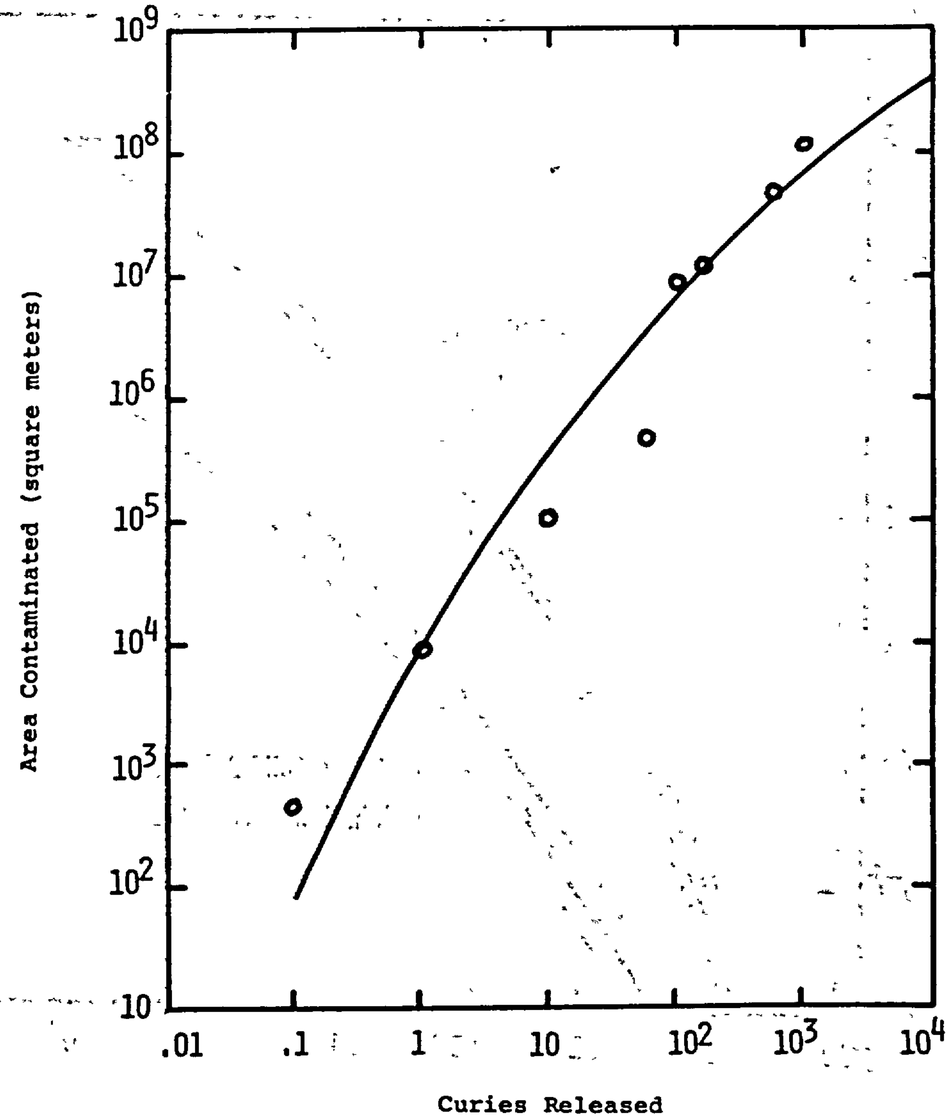


FIGURE 5-12. AREA CONTAMINATED TO A LEVEL OF 0.65 $\mu Ci/m^2$ FOR A GIVEN RELEASE

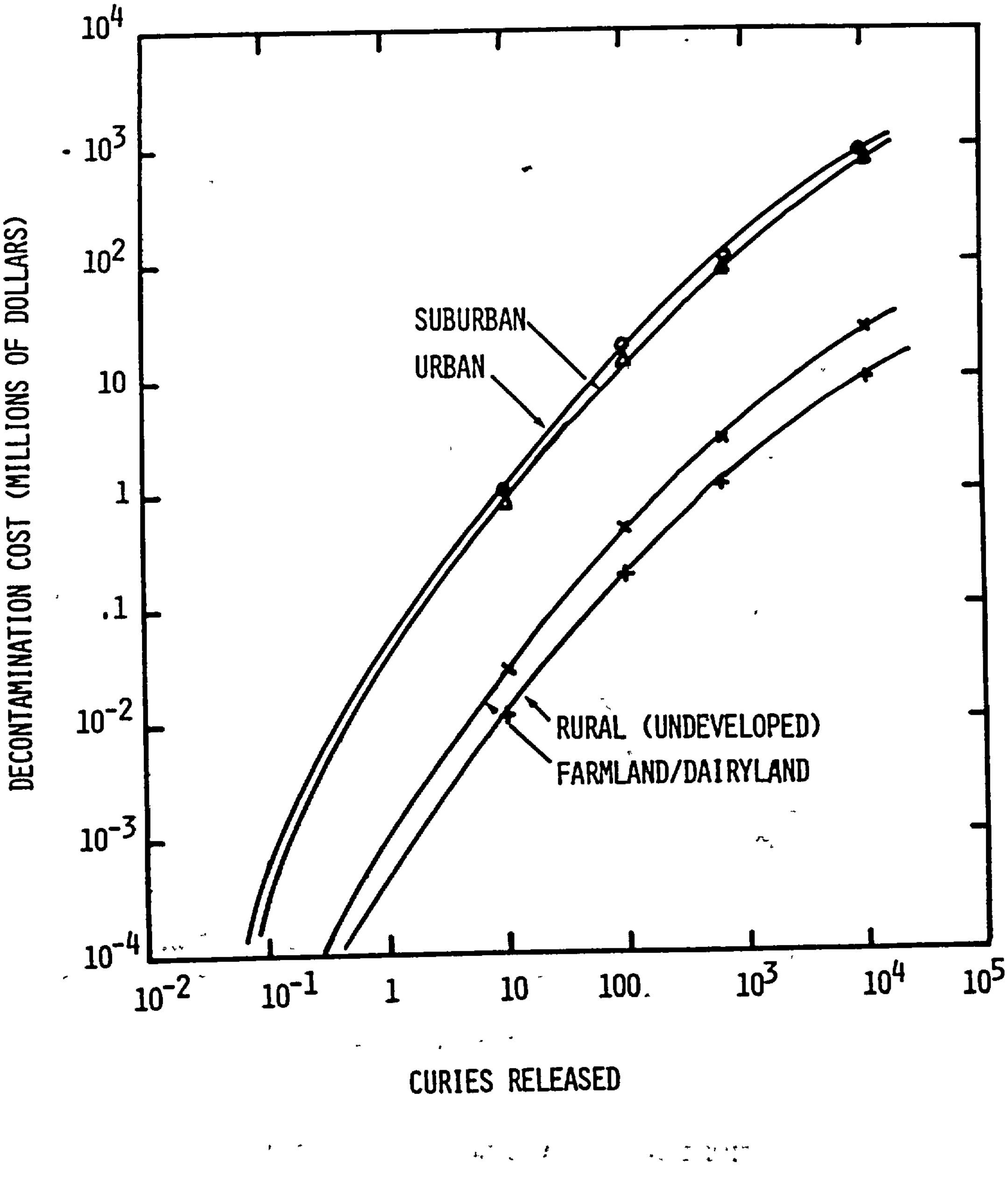


FIGURE 5-13. DECONTAMINATION COSTS FOR RELEASES OF LONG-LIVED ISOTOPES

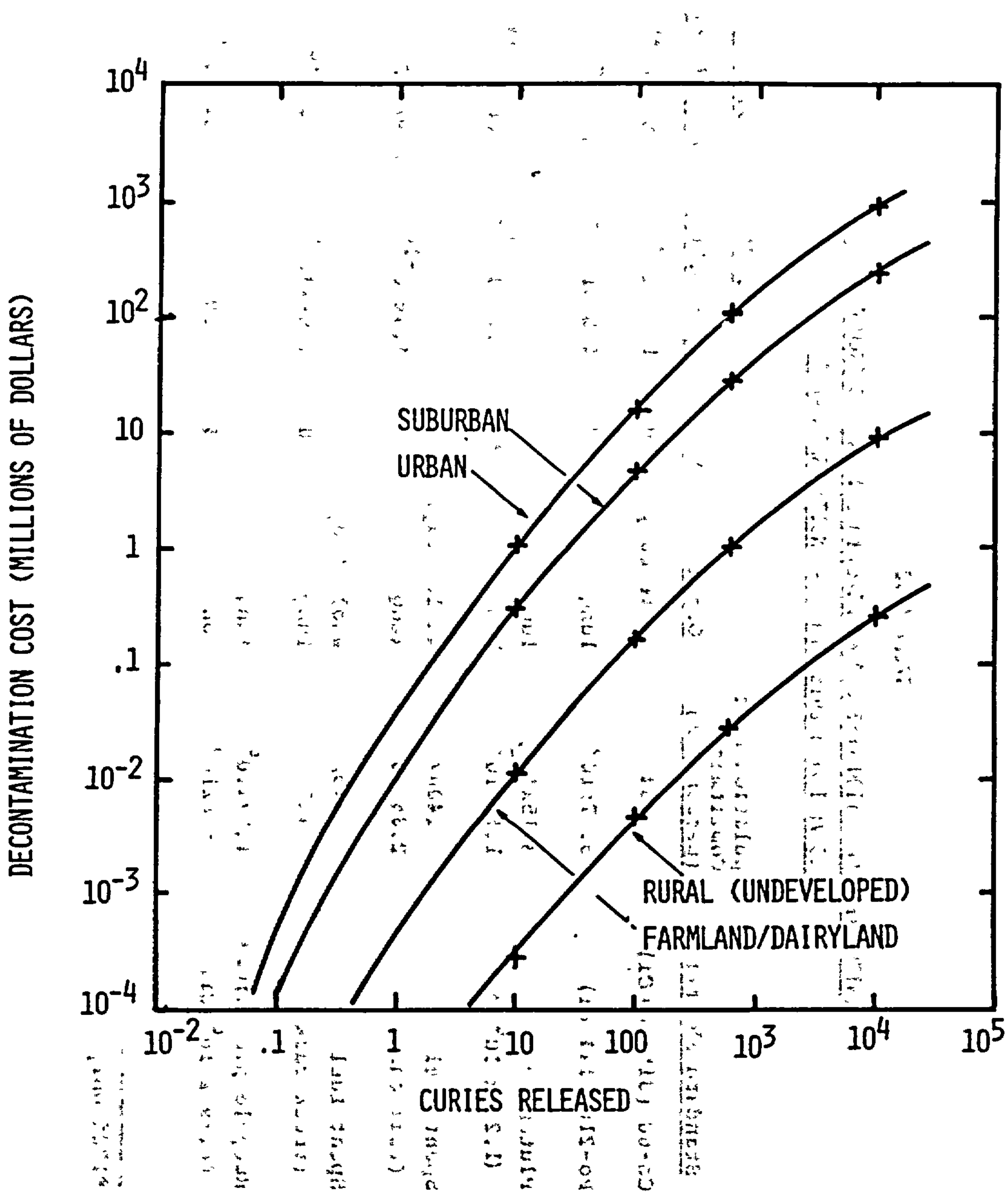


FIGURE 5-14. DECONTAMINATION COSTS FOR RELEASES OF SHORT-LIVED ISOTOPES

TABLE 5-12

INTEGRATED POPULATION DOSE AND EXPECTED LATENT CANCERS FROM CERTAIN CLASS VIII ACCIDENTS IN HIGH-DENSITY URBAN AREAS

Standard Shipment	Population Dose Commitment (person-rem)	Organ	LCF	1975 Probability	1985 Probability
Co-60 (315,000 Ci)	284	whole body	0	$1.02x10^{-10}$	$2.55x10^{-10}$
Po-210 (144 Ci)	$5.27x10^{6}$	lung	117	$2.57x10^{-10}$	$8.2x10^{-10}$
Plutonium (1.23×10^{6} Ci)	$3.15x10^{6}$/ $1.11x10^{7}$	lung/ bone	147	$1.06x11^{-11}$	$1.06x10^{-11}$
Spent fuel (rail cask)	1400/ $2.85x10^{4}$	whole body/ lung	1	$1.8x10^{-10}$	$6.91x10^{-9}$
Spent fuel (truck cask)	215/ 4450	whole body/ lung	0	$2.99x10^{-9}$	$1.8x10^{-8}$
Recycle plutonium* (6.19×10^{6} Ci)	$1.59x10^{6}$/ $5.6x10^{6}$	lung/ bone	74*	0.0	$2.24x10^{-10}$

*1985 only.

TABLE 5-13

NUMBER OF PEOPLE RECEIVING DOSES GREATER THAN OR EQUAL TO VARIOUS SPECIFIED ACUTE DOSES (IN REMS) OF INTEREST IN CERTAIN CLASS VIII ACCIDENTS IN HIGH-DENSITY URBAN AREAS

Shipment	Organ	Time Period for Dose	5	15	50	340	510	3000	10,000	20,000	70,000
Co-60 (315,000 Ci)	Whole Body	1 hr	75	-	12	0	0	-	-	-	-
Po-210 (144 Ci)	Lung	1 yr	-	$3.42x10^4$	-	-	-	59	-	2	-
Plutonium ($1.23x10^6$ Ci)	Lung	1 yr	-	2337	-	-	-	-	0	-	0
Spent Fuel (truck cask)	Whole Body	1 hr	61	-	8	0	0	-	-	-	-
	Lung	1 yr	-	0	-	-	-	0	-	0	-
Spent Fuel (rail cask)	Whole Body	1 hr	440	-	40	7	0	-	-	-	-
	Lung	1 yr	-	48	-	-	-	0	-	0	-
Recycle Pu ($6.19x10^6$ Ci)	Lung	1 yr	-	2475	-	-	-	-	0	-	0

TABLE 5-14

EARLY FATALITIES AND DECONTAMINATION COSTS
CLASS VIII ACCIDENTS - EXTREME DENSITY URBAN AREAS

Isotope	Total Curies	Percent Released	Percent Aerosolized	Early Fatalities	Decontamination Cost*
Co-60	315,000	0	0	0	NA
Po-210	144	100	100	1	$300 x 10^6
Plutonium	1.2 x 10^6	10	5	0	$800 x 10^6
Recycle Pu (1985 only)	6.2 x 10^6	10	5	0	$1200 x 10^6
Spent fuel	9.1 x 10^6	100**	100**	0	$400 x 10^6
Spent fuel	1.4 x 10^6	100**	100**	0	$200 x 10^6

*Adjusted for increased evacuation and income loss costs resulting from higher population density.

**Of available gaseous and volatile fission products only.

10,000 rems to lungs	- threshold for pulmonary morbidity from long-lived alpha emitters when received as an acute dose (Refs. 5-20 and 5-23)
20,000 rems to lungs*	- produces early fatality from pulmonary morbidity resulting from short-lived beta-gamma emitters when received as an acute dose (Ref. 5-23)
70,000 rems to lungs*	- produces early fatality from pulmonary morbidity resulting from long-lived alpha emitters when received as an acute dose (Ref. 5-23)
5 rems to whole body	- NCRP-recommended limit for annual whole-body radiation for radiation workers (Ref. 5-22)
50 rems to whole body	- threshold for noticeable physiological effects from acute exposure to whole-body radiation (Ref. 5-22)
340 rems to whole body**	- produces early fatality from bone marrow destruction from acute exposure with minimal medical treatment (Ref. 5-20)
510 rems to whole body**	- produces early fatality from bone marrow destruction from acute exposure with supportive medical treatment (Ref. 5-20)

5.7 EXPORT AND IMPORT SHIPMENTS

The annual radiological risk calculation for accidents involving import and export shipments was done in the same way as for the 1975 and 1985 standard shipments models. A separate standard shipments model was devised for 1975 export shipments only and is discussed in Appendix A.

The total annual radiological risk computed for export shipments in 1975 is 1.57×10^{-5} LCF per year, or 0.3% of the total accident risk. Table 5-15 shows a breakdown of the annual accident risk by material and major transport modes. Over half of the risk results from enriched uranium shipments because this is the dominant exported material. Since most exported enriched uranium shipments are transported by ship, these dominate the risk; shipments by aircraft and truck are of lesser importance. It is not anticipated that export shipments would contribute a significantly greater percentage of the annual risk in 1985 than they did in 1975. A detailed analysis of the environmental effects of U.S. nuclear power export activities is given in Reference 5-24.

*LD 50/360 value (lethal dose within 360 days for 50% of a population so exposed).

**LD 50/30 value (lethal dose within 30 days for 50% of a population so exposed).

TABLE 5-15

ANNUAL EXPECTED LATENT CANCER FATALITIES RESULTING FROM ACCIDENTS INVOLVING EXPORT SHIPMENTS OF RADIOACTIVE MATERIALS - 1975 EXPORT SHIPMENTS MODEL

Material	Major Transport Mode(s)	Annual Expected Latent Cancer Fatalities	Percent of Total Export Shipment Risk
Enriched UO_2	Ship	5.5×10^{-6}	35.1%
Enriched UF_6	Ship	4.4×10^{-6}	28.1%
MF+MC - Type A	Cargo Air	3.3×10^{-6}	21.1%
Co-60 - Type B	Truck	1.4×10^{-6}	8.9%
Enriched UF_6	Cargo Air Truck	7.5×10^{-7}	4.6%
Mo-99 - Types A,B	Pass Air, Cargo Air	1.4×10^{-7}	0.9%
All Other Exports	Ship, Truck Pass. Air, Cargo Air	1.9×10^{-7}	1.3%
TOTAL		1.57×10^{-5}	100%

According to the 1975 Survey (see Appendix A), virtually all of the curies imported in 1975 were contained in four Type B Co-60 shipments, each containing only one package with an average of 1.8×10^5 curies per package. The average distance per shipment was 670 km, and the shipments were all transported by truck. One of the scenarios considered in the 1975 standard shipments model, Co-60-LQ2, involved four Co-60 shipments by truck, 3.2×10^5 curies per shipment and 3200 km per shipment. These four shipments result in an annual risk of 1.2×10^{-10} LCF per year. The risk for the four import shipments can be determined from this figure, reduced in proportion to the curies transported and the shipment distance. The result is 1.4×10^{-11} LCF per year.

5.8 NONRADIOLOGICAL RISKS IN TRANSPORTATION ACCIDENTS

Most radioactive materials are shipped incidental to other freight shipments, i.e., the shipment would take place whether or not the radioactive material were on board. For these shipments the only impacts chargeable to the radioactive material are the normal population dose discussed in Chapter 4 and the radiological accident risk discussed earlier in this chapter.

However, for exclusive-use shipments, i.e., those that require the exclusive use of the transport vehicle, there are certain nonradiological risks that must also be considered, e.g., the risk that the driver of a exclusive-use vehicle will be injured or killed in an accident, not from radiological causes, but from the accident itself. In addition to fatalities, nonradiological injuries and property damage must be considered as part of the environmental impact of radioactive materials transport along with the radiological effects.

It has been estimated (Ref. 5-25) that transport of cold fuel to nuclear power plants and shipments of irradiated fuel and solid wastes from the plants by exclusive-use vehicles could result in 0.03 injuries and 0.003 fatalities per reactor year if all fuel and solid waste transport were by truck and irradiated fuel transport were by rail or barge. For the approximately 60 power reactors in operation in 1975, this translates into 2 injuries and 0.2 fatalities per year.

Probably the greatest use of exclusive-use trucks for other than fuel cycle materials is in the transport of radiopharmaceuticals, primarily Mo-99/Tc-99m generators. If it is estimated that 10% of the generators that were transported by truck in the 1975 standard shipments model are transported by exclusive-use trucks in average aggregate quantities of 80 TI per shipment, about 130 such shipments per year would be expected. For an average shipment distance of 960 kilometers, the total distance traveled would be 1.25×10^5 kilometers per year. Utilizing the accident statistics and injury and fatality data that were used to estimate the nonradiological impact for shipments to and from power plants (Ref. 5-25), the transport of Mo-99/Tc-99m generators by exclusive-use trucks would produce about 0.07 injuries and about 0.004 fatalities per year.

Finally, certain all-cargo airlines make routine flights exclusively for shipment of radioactive materials, primarily Mo-99/Tc-99m generators. It is estimated that these flights cover 320,000 kilometers per year. Using the commercial aircraft accident rates of

1.44×10^{-8} accidents per kilometer, these flights would be expected to result in about 0.005 accidents per year. Assuming that a crew of two would be killed in each accident, an average of 0.01 fatalities per year would be expected.

Thus, the estimated nonradiological impacts resulting from transport in vehicles used exclusively for radioactive material shipments is 2.05 injuries and 0.213 fatalities per year. The major contribution is made by transport of cold and spent fuel to and from nuclear power plants.

5.9 SUMMARY OF RESULTS

The results of the calculations of the risk resulting from potential transportation accidents involving radioactive materials shipments may be summarized as follows:

1. The accident risk for the 1975 level of shipping activity, as determined from the 1975 shipping survey, is very small: roughly 0.005 additional LCF per year, or one additional LCF every 200 years, plus an equal number of genetic effects. This number of LCFs is only 0.3% of those resulting from normal transport population exposures.

2. Over 70% of the accident risk is attributable to shipments of Po-210, plutonium, waste, mixed fission and corrosion products, and UF_6 (Table 5-9).

3. The projected accident risk in 1985 is 0.0166 LCF per year, or about 3.5 times the 1975 risk, but is still very small in comparison to the LCFs resulting from normal transport. Even though the 1985 calculation takes into account a modest amount of plutonium recycle, the risk from plutonium (U-Pu mix) is 1.3% of the total risk.

4. Using Model II release fractions, the annual probability of one or more early fatalities from radiological causes in a transportation accident is about 5×10^{-4} in 1975 and about 10^{-3} in 1985.

5. Costs of decontamination following a transportation accident involving a 600-curie release can be as much as 100×10^{6} dollars in an urban population zone.

6. In spite of their low annual risk, specific accidents occurring in very-high-density urban population zones can produce as many as 1 early fatality, 150 LCFs, and large decontamination costs. Although such accidents are possible, their probability of occurrence is very small.

7. The contribution to the annual accident risk from export and import shipments is less than 0.01 times the domestic transport risk and is likely to remain so in 1985.

8. The principal nonradiological impacts are those injuries and fatalities resulting from accidents involving vehicles used exclusively for the transport of radioactive materials. The number of expected annual nonradiological fatalities is almost 50 times greater than the

expected number of additional LCFs resulting from radiological causes but is less than one fatality every five years.

The annual individual probability of an early (radiological) fatality resulting from a transportation accident involving a radioactive materials shipment is presented in Table 5-16 together with annual individual probabilities of an early fatality from other types of accidents. The numbers listed in the table are based on the assumptions that all accidents occur randomly throughout the population and that the number of persons at risk for early fatalities resulting from radiological causes following a transportation accident is 75×10^6 (estimating that approximately one-third of the population lives along major transport routes). The table shows, for example, that an individual is 10^5 times as likely to be killed as a result of being struck by lightning as he is to die from radiological causes within one year following a transportation accident involving a shipment of radioactive materials. The table shows that there are many commonly accepted accident risks that are very much greater than the accident risk of transporting radioactive materials.

TABLE 5-16

INDIVIDUAL RISK OF EARLY FATALITY BY VARIOUS CAUSES (Ref. 5-20)

Accident Type	Number per Year	Individual Risk per Year
Motor Vehicle	5.5×10^4	1 in 4,000
Falls	1.8×10^4	1 in 10,000
Fires	7.5×10^3	1 in 25,000
Drowning	6.2×10^3	1 in 30,000
Air Travel	1.8×10^3	1 in 100,000
Falling Objects	1.3×10^3	1 in 160,000
Electrocution	1.1×10^3	1 in 160,000
Lightning	160	1 in 2,000,000
Tornadoes	91	1 in 2,500,000
Hurricanes	93	1 in 2,500,000
100 Nuclear Reactors	3×10^{-3}*	1 in 5,000,000,000
Transportation of Radioactive Material (from Radioactive causes)	3.5×10^{-4}**	1 in 200,000,000,000***

*Statistical estimate.
**Statistical estimate for 1975.
***Using a population at risk of 75 million people.

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CHAPTER 6
ALTERNATIVES

6.1 INTRODUCTION

The analysis of the impact of transportation of radioactive materials presented in Chapters 1 through 5 was based on current shipping practices as revealed in the 1975 survey and in the 1985 projections of those shipping practices. In this chapter, the environmental effects of various alternatives to shipping practice as projected for 1985 are evaluated. The 1985 standard shipments model was used rather than the 1975 model because it was felt that by the time any new regulation to implement a particular alternative went into effect, the shipping activity would be more accurately described by the 1985 model. Thus, the impacts of various alternatives are evaluated by using the 1985 standard shipments model and are compared with the 1985 baseline, i.e., the risk computed in the previous chapter for 1985.

An alternative that results in a lower annual population dose is desirable from a radiological point of view but should be balanced against nonradiological impacts and the cost of implementation. Similarly, one alternative may be desirable from a safeguards viewpoint but undesirable from a radiological safety viewpoint. Thus, a quantitative comparison of the radiological impacts may be made in terms of the number of excess latent cancer fatalities (LCFs) produced, but the assessment of the total impact of a given alternative on the environment often will include qualitative consideration of other factors.

Three radiological impacts relative to 1985 shipping activity are quantified for each alternative: (1) the annual normal population dose in terms of both person-rem per year and the annual LCF, (2) the annual expected number of LCFs due to accidents, and (3) the annual probability of one or more early fatalities resulting from accidents. Comparison is made to the 1985 baseline case, the radiological impact of which is summarized in Table 6-1.

TABLE 6-1

RADIOLOGICAL IMPACTS FOR THE BASELINE CASE

1985 STANDARD SHIPMENTS WITH MODEL II RELEASE FRACTIONS

Annual normal population dose	25,360 person-rem (3.07 LCF)
Annual expected number of LCFs due to accidents	0.017 LCF
Annual probability of one or more early fatalities due to radiological exposure from accidents	9.12×10^{-4}

Certain alternatives considered in the draft version were eliminated as a result of comments from authoritative sources concerning their impracticality. These include shifting all material carried by all-cargo aircraft to passenger aircraft, flights only under VFR (visual flight rules), daytime-only flights, and specific aircraft model requirements.

Where appropriate, the cost of implementing an alternative is estimated, and this cost is compared to the benefit resulting from the alternative. Benefits are expressed in terms of the estimated reduction in annual population dose or LCFs resulting from implementation of the alternative. To compare benefits to incremental costs, it is necessary to assign a monetary value to an LCF. For the purposes of this assessment, the official NRC estimate of $1000 per person-rem (Ref. 6-1) is used along with the whole-body dose-effect value of 121 LCF per 10^6 person-rem (Ref. 6-2), resulting in a value of $\$8.22 \times 10^6$ for each LCF.

The alternatives discussed in this chapter may be classified by three general types:

1. Transport mode shifts
2. Operational constraints
3. Packaging or material constraints

Transport mode shifts involve additional or alternative regulations that would eliminate the use of certain transport modes for either all radioactive material shipments or for certain of the potentially more hazardous materials, e.g., polonium or plutonium. In evaluating the effects of these mode shifts, the assumption is made that the material involved would continue to be transported in the same total annual quantities but by a different mode.

The alternatives of the second type are those that would require specific operational constraints on transport to limit accident rates or consequences, e.g., restricting route, lowering speed limits for surface modes, no weekend driving, monitoring airport packages, and lowering allowable radiation levels in aircraft.

The alternatives of the third type are those that would:

1. Restrict the form of the material shipped to reduce its dispersibility and/or respirability in the case of an accident severe enough to breach the packaging.

2. Reduce the quantity of material shipped on a given transport vehicle to reduce the amount that could be dispersed in a severe accident.

3. Introduce new packaging standards to require the use of extradurable packaging for shipments involving Type B and large quantities of the potentially more hazardous isotopes.

4. Lower the package quantity limits or package transport index (TI) limits.

Each of these general alternative types is discussed in detail in Sections 6.2 through 6.4 of this chapter. Risk estimates are made and compared to the risks due to current shipments. The results are summarized in Section 6.5.

6.2 TRANSPORT MODE SHIFTS

In this section, the effects expected from shifting various classes of radioactive material from one transport mode to another are assessed. Various combinations that have been suggested as likely to yield a decrease in radiological impact are considered.

6.2.1 ALL AIR TRANSPORT BY TRUCK

This section considers the effects of transporting by truck all materials considered for transportation by either passenger aircraft or all-cargo aircraft in the 1985 standard shipments model. No change is assumed for the average distance per shipment for each scenario. However, because transport by truck is considerably slower, this alternative might necessitate shipping a greater number of curies and TIs per package for the short half-life materials to compensate for the additional radioactive decay.

It is estimated that the minimum time required from shipment to use is approximately 20 hours (essentially 1 day) for shipments by aircraft within the continental United States. In a similar time period, destinations within about 1290 kilometers could be served by truck with no additional radioactive material required to compensate for the loss resulting from radioactive decay. However, for longer distances, shipments must contain more radioactivity at the time of shipment. The amount required can be estimated using the following relationship:

$$\frac{A_t}{A_a} = \exp\left[\frac{0.693\left(\frac{x}{u} - 20\right)}{t_{1/2}}\right], \text{ where } \frac{x}{u} \geq 20 \qquad (6\text{-}1)$$

and
- A_t = initial activity for truck shipment
- A_a = initial activity for air shipment
- x = destination distance from shipper
- u = mean transport speed for trucks
- $t_{1/2}$ = nuclide half-life (in hours)

The only isotopes listed in the standard shipments model that have half-lives sufficiently short to require additional radioactivity when transported by truck are Tc-99m, Au-198, Ga-167, and Mo-99. Of these isotopes, only Mo-99 is transported an average distance greater than 1290 kilometers. Equation (6-1) suggests that about 10 percent more radioactivity would be required for Mo-99 shipments transported by truck instead of by air. This small change in amount carried will have a negligible effect on the radiological impact but might result in some significant increase in expense for the radiopharmaceutical supplier.

6.2.1.1 Radiological Impacts

The radiological impacts computed with this alternative are:

Annual normal population dose	26,290 person-rem (3.18 LCF)
Annual LCFs from accidents	0.021 LCF
Annual probability of one or more early fatalities	9.28×10^{-4}

Comparison of the radiological impact of this alternative with that of the baseline case (Table 6-1) indicates an increase of 930 person-rem per year in the normal population dose. The additional dose received by crewmen is the largest contributor to the overall increase. The annual accident LCF is increased as a result of the higher accident rate for trucks as compared to aircraft. The annual early fatality probability is also increased slightly.

6.2.1.2 Nonradiological Impacts and Cost-Benefit Balance

The shift of all radioactive materials from an air mode to truck mode implies an increase in the number of truck shipments from 2.34×10^6 to 4.14×10^6 shipments per year in 1985 or a factor of approximately 2. In order to estimate the freight cost savings resulting from shifting all air shipments to truck, an average package mass of 22.7 kilograms and an average distance of 1600 kilometers are assumed. The freight rates for such a package were obtained from local (Albuquerqûe, New Mexico) airfreight and truck offices and were found to be \$0.70 per kilogram for airfreight shipments under 45.4 kilograms and \$0.26 per kilogram for truck shipments under 45.4 kilograms. Thus, the transport of a 22.7-kilogram package for 1600 kilometers costs \$10.11 more by airfreight than by truck. The shift of 1.8×10^6 packages per year from air transport to truck transport would therefore result in an estimated annual saving of about $\$18 \times 10^6$.

An additional saving would be realized for the cargo aircraft shipments that are shifted to truck because of the decreased secondary mode distance (160 kilometers per shipment for cargo aircraft versus 80 kilometers per shipment for truck). The shift of cargo aircraft shipments to truck involves about 1.4×10^5 packages. With each package traveling, on the average, 80 fewer kilometers by secondary surface mode, about 5.6×10^6 fewer kilometers by secondary mode transport would be required, assuming an average of two packages per shipment. Assuming that delivery vehicles get 12.8 kilometers per liter, that gasoline costs \$0.14 per liter, that driver salaries and other costs amount to \$5 per hour, and that the average speed is 48 kilometers per hour, the additional saving for the decreased secondary mode travel would be $\$0.8 \times 10^6$. The radiological cost would be the additional annual population dose of 930 person-rem. At \$1000 per person-rem, this amounts to $\$0.93 \times 10^6$ per year. Based on these assumptions, this alternative appears to be cost effective with a net saving of $\$17.9 \times 10^6$.

6.2.2 ALL PASSENGER AIR TRANSPORT BY ALL-CARGO AIRCRAFT

This section considers the effect of transporting by all-cargo aircraft all materials transported by passenger aircraft in the 1985 baseline calculation. All other baseline shipments are left unchanged. This shift necessarily involves an increase in secondary surface mode transportation because all-cargo aircraft serve fewer airports than passenger aircraft. This assessment assumes a 160-kilometer average secondary mode distance per shipment for cargo aircraft and 80-kilometer for passenger aircraft.

The mode shift described in this alternative may not be readily achievable without shifting some shipments entirely to the truck mode, but, for the purposes of this comparison, that possibility will not be considered. Rather, it is assumed that the required coverage can be achieved by the package airfreight lines that have begun to serve many parts of the United States. It should be noted that a shift to package airfreight would involve transport in smaller aircraft and therefore would result in greater exposure to crew members. However, because of the lack of quantitative information, this was not taken into account in the calculation.

No significant increase in package curie content has been postulated in this alternative to account for increased time between shipment and use. While it is expected that shipments will be slightly slower, the effect is not expected to be significant because the ground transport link is limited to 160 kilometers.

6.2.2.1 Radiological Impacts

The radiological impacts computed with this alternative are as follows:

Annual normal population dose	21,830 person-rem (2.64 LCF)
Annual LCFs from accidents	0.017 LCF
Annual probability of one or more early fatalities	9.12×10^{-4}

The decrease of 3,530 person-rem in annual normal population dose from the baseline case (Table 6-1) results from the elimination of the dose to airline passengers and attendants, although this decrease is partially offset by an increased dose to the surrounding population resulting from the increased secondary mode travel.

6.2.2.2 Nonradiological Impacts and Cost-Benefit Balance

If the secondary (ground) link is not considered, no significant additional nonradiological impacts result from this alternative other than the possibility of the increased costs required to serve outlying cities by package airlines. Some scheduling difficulties are likely as a result of fewer flights of all-cargo aircraft as compared to those of passenger aircraft.

However, the additional secondary mode distance required by this alternative is significant. The shift of all passenger aircraft shipments to cargo aircraft involves about 1.7×10^6 packages. Using the cost parameters introduced in Section 6.2.1, the increased secondary mode distance will cost $\$9.2 \times 10^6$. The 3,530 person-rem decrease in normal population dose is equivalent to only $\$3.5 \times 10^6$ savings at $1000 per person-rem. Thus, from a cost-effectiveness viewpoint, the alternative of shifting all passenger aircraft shipments to cargo aircraft does not appear desirable.

6.2.3 ALL ALL-CARGO AIR SHIPMENTS BY TRUCK

In this alternative, all-cargo air shipments in the 1985 baseline are transferred to the truck mode. The actual distance in the truck mode is estimated to be approximately the same as the airline distance. As in the first alternative, which considered the shift of both cargo aircraft and passenger aircraft shipments to the truck mode, this alternative would require that Mo-99 shipments contain about 10 percent more radioactivity than in the baseline case to make up for the Mo-99 that decays during the extra travel time required by the truck mode. An 80-kilometer average secondary van link was assumed for the additional truck shipments resulting from this alternative.

6.2.3.1 Radiological Impacts

The radiological impacts computed with this alternative are as follows:

Annual normal population dose	26,160 person-rem (3.16 LCF)
Annual LCFs from accidents	0.020 LCF
Annual probability of one or more early fatalities	9.28×10^{4}

Just as in the alternative shifting all air shipments to truck, this alternative results in an increase in annual normal population dose and an increase in LCFs over the baseline case (Table 6-1). However, the increase is not as great as in the previous alternative since fewer shipments are involved. The increase in normal dose is principally due to higher crew dose.

6.2.3.2 Nonradiological Impacts and Cost-Benefit Balance

In the discussion of the alternative shifting all air shipments to the truck mode, it was estimated that for an average size package (22.7 kg) traveling an average distance (1600 km) the truck mode rate would be lower by $10.11 per package. This shift of 1.4×10^5 packages from all-cargo aircraft to truck would be expected to result in an annual saving of about $\$1.4 \times 10^6$ based on this rate difference. Since the secondary mode distance for trucks is 80 kilometers per shipment while 160 kilometers per shipment are estimated for all-cargo air shipments, an additional saving of $\$7.7 \times 10^6$ would be realized from the decreased secondary mode travel (using the same secondary mode assumptions as in Section 6.2.1). The cost would be an additional 800 person-rem population dose from normal transport and an additional 0.003 LCF from accidents, which is a dollar equivalent of $815,000 per year. Thus, this alternative, as well as the one in which all air shipments are shifted to truck, appears to be cost effective.

6.2.4 HIGH-HAZARD DISPERSIBLE MATERIAL BY TRUCK OR BY RAIL

Certain dispersible materials in the standard shipments model are more hazardous than others. This section considers the effect of requiring certain of the more hazardous of the 1985 standard shipments to be transported by truck or rail. The shipments considered are those dispersible materials with both a curie-per-package value greater than 100 and a rem-per-curie (inhaled) value greater than 10^6 The materials that meet these criteria are MF + MC (large quantity), Po-210 (large quantity), Pu-239B, Pu-239B (large quantity), U-Pu mixture, and recycle plutonium.

Shipments by aircraft could be shifted to either truck or rail without additional physical constraints. The packages used are typically the size of 206-liter (55-gallon) drums or smaller and weigh a few hundred kilograms or less. The materials' half-lives are sufficiently long that loss by radioactive decay during transport is not important. Because of tne value of plutonium as weapon material, a mode shift for plutonium (or any other special nuclear material) shipments in strategic quantities requires careful consideration of the security required for protection against theft or sabotage. Because that aspect of the problem is discussed in Chapter 7, consideration in this section will be confined to the radiological and other nonradiological aspects of the environmental impact.

Truck shipments of MF + MC, Po-210, and Pu-239 (1169 curies) are assumed to be made in exclusive-use trucks. Truck shipments of Pu-239 (1.2×10^6 curies) and U-Pu mixture are assumed to take place in Integrated Container Vehicles (ICV, see Section 5.2.3). For rail shipments of Pu-239 (1.2×10^6 curies) and U-Pu mixture, the ICV trailer is assumed to ride "piggyback" on the rail car.

6.2.4.1 Radiological Impacts

If the dispersible materials considered above are transported by rail only, the following results are obtained:

Annual normal population dose	25,260 person-rem (3.06 LCF)
Annual LCFs from accidents	0.019 LCF
Annual probability of one or more early fatalities	9.08×10^{-4}

If these materials are shipped by truck only, the radiological impacts are:

Annual normal population dose	25,400 person-rem (3.07 LCF)
Annual LCFs from accidents	0.019 LCF
Annual probability of one or more early fatalities	9.25×10^{-4}

Since the costs of ICVs cannot be evaluated at this time, a definitive statement on cost effectiveness cannot be made. However, the radiological changes resulting from this alternative do not appear to be significant.

6.2.5 ALL SPENT FUEL BY TRUCK

Truck casks for transporting irradiated fuel carry fewer fuel elements than rail casks. Thus, if all spent fuel were transported by truck, more shipments would be required. Considering that truck casks transport only a single element while rail casks transport seven fuel elements in a single cask, as much as a sevenfold increase in the number of shipments might be required under this alternative (Ref. 6-3).

6.2.5.1 Radiological Impacts

The radiological impacts computed with this alternative are summarized as follows:

Annual normal population dose	26,250 person-rem (3.18 LCF)
Annual LCFs from accidents	0.017 LCF
Annual probability of one or more early fatalities	9.12×10^{-4}

The 890 person-rem increase in normal dose ($9 x 10^5 equivalent) over the baseline case (Table 6-1) results from the increase in the number of truck shipments.

6.2.5.2 Nonradiological Impacts and Cost-Benefit Balance

The estimated costs for shipment of irradiated fuel by rail and by truck are listed in Table 6-2. It is evident from the table that the cost for transporting seven single-element casks by legal-weight truck is about the same as for transporting one 7-element cask by a unit train. It is assumed in this assessment that about 6.5 times as much spent fuel is carried in a rail cask as in a truck cask (Ref. 6-3).

TABLE 6-2

ECONOMICS OF RAIL-TRUCK MODE SHIFT FOR SPENT FUEL

Mode	Cost per Shipment*
Legal-weight truck	$10,000
Non-unit train**	45,000
Unit train**	73,000

*1200-1300 MWe reactor, 1600-kilometer shipment, 68 truck or 11 rail shipments per year.

**A unit train is one devoted exclusively to the carriage of a particular cargo, spent fuel in this case.

An additional consideration is the procurement cost of a truck cask versus that of a rail cask. Costs of three representative casks are shown on Table 6-3.

TABLE 6-3

COSTS OF REPRESENTATIVE SHIPPING CASKS

Cask Model	Use	Purchase Cost	Lease Cost
Transnucleaire TN-9	truck	$1 x 10^6	$1600/day + maintenance contract
General Electric IF 300	rail	$4 x 10^6	$1 x 10^6/year (4-5 year minimum)
National Lead NL 1024	rail	$2 x 10^6	$2400/day

Assuming a 3-day truck trip (plus 3 days return) and an 8-day rail trip (plus 8 days return) (Ref. 6-3) and 10 maintenance days per year, each truck cask can be used 59 times per year and each rail cask can be used 22 times per year. Using the 1985 baseline shipment information, 26 truck casks and 30 rail casks would be required at a purchase cost of $116 x 10^6 (assuming half the rail casks are purchased from each supplier) or an annual lease cost of $43 x 10^6 If all irradiated fuel were shipped by truck, 98 truck casks would be required at a purchase cost of $98 x 10^6 or an annual lease cost of $57 x 10^6.

Using these data and assumptions, the alternative of changing from the combination truck plus non-unit train shipments of irradiated fuel described in the 1985 standard shipments model to all truck shipments would cost an additional $\$14 \times 10^6$ in cask leasing charges, and the 5,768 total shipments would cost an additional $\$13 \times 10^6$ for shipping. When these costs are combined with the equivalent of $\$9 \times 10^5$ additional radiological costs, the alternative of shipping all irradiated fuel by truck is not cost effective to the extent of $\$28 \times 10^6$ per year.

6.2.6 ALL SPENT FUEL BY RAIL

As discussed above, rail casks have up to seven times the capacity of truck casks for irradiated fuel. The annual number of shipments would therefore be reduced if rail were the only mode used to ship irradiated fuel.

6.2.6.1 Radiological Impacts

The radiological impacts computed with this alternative are summarized as follows:

Annual normal population dose	24,900 person-rem (3.01 LCF)
Annual LCFs from accidents	0.017 LCF
Annual probability of one or more early fatalities	9.12×10^{-4}

The reduction of 460 person-rem per year in normal population dose as compared to the baseline case (Table 6-1) has a dollar equivalent of $460,000 per year.

6.2.6.2 Nonradiological Impacts and Cost-Benefit Balance

Using the data and assumptions in Section 6.2.5, the alternative of changing from the combination truck plus non-unit train shipments of irradiated fuel described in the 1985 standard shipments model to all non-unit train shipments is found to be cost effective. The 887 annual rail shipments would save $\$6 \times 10^6$ in cask leasing charges, $\$5 \times 10^6$ in shipping charges, and $\$5 \times 10^5$ in equivalent radiological costs. This alternative would therefore be cost effective by about $\$11 \times 10^6$ per year.

6.2.7 ALL FEASIBLE IRRADIATED FUEL BY BARGE

It has been suggested that a viable means of transporting irradiated fuel from nuclear power plants to reprocessing sites would be to use barges on the navigable waterways in and around the United States. A preliminary review was made of the feasibility of this alternative by examining the location of reactor sites as projected to 1985 (Refs. 6-4 and 6-5) and their proximity to navigable waterways (Refs. 6-6 and 6-7). This analysis revealed that approximately 74 percent of the projected 1985 nuclear generating capacity will be sited within 80 kilometers of navigable waterways (including the ocean), and 88 percent will be sited within 240 kilometers of navigable waterways. The only currently projected reprocessing site (Barnwell, South Carolina) is approximately 48 kilometers from navigable water.

If it is assumed that the only barge shipments would be those in which the total secondary link distance is less than 240 kilometers and if shipments through the Panama Canal are excluded, approximately 48 percent of the 1985 projected total MWe (71 percent of the sites) could be serviced by barge. Under these assumptions, the average distance by barge would be about 3500 kilometers, and the average distance by secondary mode (truck) would be about 130 kilometers. This would amount to 212 barge shipments per year, each barge carrying two rail casks.

6.2.7.1 Radiological Impacts

If it is assumed that the remainder of the plants are serviced by rail (460 shipments per year), the radiological impacts are as follows:

Annual normal population dose	25,040 person-rem (3.03 LCF)
Annual LCFs from accidents	0.017 LCF
Annual probability of one or more early fatalities	9.12×10^{-4}

If the remainder are serviced by truck (3,000 shipments per year) instead of rail, the results are:

Annual normal population dose	25,700 person-rem (3.11 LCF)
Annual LCFs from accidents	0.017 LCF
Annual probability of one or more early fatalities	9.23×10^{-4}

The first case results in a decrease of 320 person-rem per year ($320,000 equivalent) as compared to the baseline case (Table 6-1); the second case results in an increase of 340 person-rem per year ($340,000 equivalent).

6.2.7.2 Nonradiological Impacts and Cost-Benefit Balance

These radiological impacts must be considered in light of the cost necessary to accomplish this mode shift. The cost of a barge/tug combination is estimated by the American Waterways Operations, Inc., of Washington, D.C., at 0.0027 to 0.0041 dollars per tonne-kilometer (0.004-0.006 dollars per ton-mile). If the average irradiated fuel load is 1360 metric tons (1270 metric tons for the two loaded rail casks (Ref. 6-3) and 91 metric tons for auxiliaries, including generators, emergency equipment, etc), the water portion of an average trip will cost between $13,000 and $20,000. The secondary link will add an additional $1625 (at $6.25 per kilometer for truck and assuming two truck loads per barge load). Thus, the 212 barge shipments projected for 1985 would cost approximately $\$3.8 \times 10^6$. The additional rail or truck service to the remaining 29 percent of the sites would cost between $\$47 \times 10^6$ per year (remainder by truck) and $\$16 \times 10^6$ per year (remainder by train) for a total annual cost of between $19 million and $51 million. The annual cost of the 1985 baseline truck/rail mix is $\$46.4 \times 10^6$, using the truck/rail costs from Table 6-2 (trucks and non-unit trains). Thus, the barge alternative can provide a net saving of up to $27 million if the remainder is serviced by rail. These figures include only transport costs.

The barge alternative requires 46 rail casks and 51 truck casks (if the remainder goes by truck) or 67 rail casks (if the remainder goes by rail). In both cases, a 19-day one-way barge shipment (3520 kilometers at 8 kilometers per hour) plus a 10-day annual maintenance period is assumed. This results in a range of $67 x 10^6 to $76 x 10^6 for annual lease costs. The 1985 baseline lease cost is $43 x 10^6.

Thus, the overall nonradiological effect could be a saving of as much as $3 x 10^6 if the remainder is serviced by rail.

In addition to transport costs, various one-time site-specific costs may be required to give a site the capability to handle barge traffic. These costs would include dredging (at $1-$13 per cubic meter (Ref. 6-8)), pier construction (at $100,000 to $500,000, as estimated by Williams Crane and Rigging of Washington, D.C.), etc. These costs should not alter the apparent cost effectiveness of this alternative.

The fact that transportation costs are so much lower for barges than for other modes makes this alternative certainly worth additional investigation. Barge transportation of irradiated fuel may be a viable alternative, at least for some specific reactor sites, if not as a nationwide scheme.

6.3 OPERATIONAL CONSTRAINTS ON TRANSPORT

In this section, the effects of various alternatives designed to reduce risk by the use of constraints on transport operations are considered. No transport mode shifts are involved, nor are there any restrictions on packaging. Restrictions considered in this section would apply to carriers.

6.3.1 RESTRICT RADIOACTIVE MATERIAL TRANSPORT TO AVOID HIGH-POPULATION ZONES

In this alternative, using airports in suburban-population zones rather than major metropolitan airports and ground link routing around cities is considered. An example of such a change would be using Ontario Airport in Ontario, California, in place of Los Angeles International Airport. This alternative is modeled by changing the fraction of travel in high-population zones for trucks, aircraft, and the associated van links. Travel fractions for trucks are changed from .05 urban/.05 suburban to .01 urban/.09 suburban; the corresponding fractions for aircraft are changed from .02/.10 to 0/.12 and, for vans, from .4/.6 to .2/.8. If aircraft routes are chosen to avoid high-population-density zones, the radiological risk resulting from aircraft accidents would be reduced since most airplane accidents occur in the vicinity of airports during takeoff or landing (Ref. 6-9) and since the consequences of air or ground accidents are more severe if they occur near urban centers. However, most destination points are in or near cities, so that deliveries would still have to be made in urban areas. By appropriate controls, delivery vehicles could be routed to use beltways or outlying roads and avoid the central city as much as possible. For these reasons, the average secondary mode distances are assumed to increase to a minimum of 160 kilometers per shipment.

If shipments through high-population zones are restricted, the probabilities of occurrence of accidents with potentially large consequences, as discussed in Chapter 5, would be reduced.

6.3.1.1 Radiological Impacts

The radiological risks computed for this alternative are as follows:

Annual normal population dose	23,850 person-rem (2.89 LCF)
Annual LCFs from accidents	0.018 LCF
Annual probability of one or more early fatalities	9.49×10^{-4}

The increases in accident LCFs and early fatality probability over the baseline case (Table 6-1) are due to the substantially increased secondary mode distance, with its associated higher accident rate. The decrease in normal dose is due to the reduced exposure to on- and off-link populations resulting from travel in lower-population-density zones. This effect is partially offset by a slight increase in the secondary mode crew dose that results from higher secondary distances.

6.3.1.2 Nonradiological Impacts and Cost-Benefit Balance

Some additional considerations relating to this alternative are:

1. The choice of available air carriers could be restricted since not all major carriers, particularly cargo air carriers, provide comprehensive service to smaller airports.

2. An examination of the 1985 standard shipments model, with an additional 80 kilometers per shipment added to most scenarios, reveals an additional 320×10^6 kilometers in secondary mode travel. Using the same assumptions used in Section 6.2.1 for estimating secondary mode costs except for allowing for a higher average speed (72 kilometers per hour), the cost of the additional secondary mode travel resulting from this alternative is computed to be about $\$33 \times 10^6$ per year.

3. It should be noted that some major urban airports are already located in lower-population-density zones (e.g., Dulles International Airport).

This alternative is clearly not cost effective since there is a saving of $\$1.5 \times 10^6$ associated with the decreased radiological impact but a cost of $\$33 \times 10^6$ associated with the additional secondary mode distance.

6.3.2 ROUTE TRUCKS ON TURNPIKES OR INTERSTATE HIGHWAYS

The effect of this alternative is to reduce the truck accident rate by about 10 percent (Ref. 6-10).

6.3.2.1 Radiological Impacts

The lower accident rate causes a significant reduction in the annual accident LCFs and early fatality probability. The normal population dose is reduced from the baseline case (Table 6-1) because of less exposure to surrounding population. The radiological impacts computed for this alternative are as follows:

Annual normal population dose	24,290 person-rem (2.94 LCF)
Annual LCFs from accidents	0.015 LCF
Annual probability of one or more early fatalities	8.22×10^{-4}

6.3.2.2 Nonradiological Impacts and Cost-Benefit Balance

Turnpike routing is used by most long-haul carriers because limited-access highways usually provide the most direct routes and minimum driving time. However, the truck must still pick up merchandise, make deliveries, and refuel in populated areas. Thus, the nonradiological impacts of this alternative are considered negligible. Because of the net reduction in normal dose (equivalent to $\$1.1 \times 10^6$ per year), this alternative is considered cost effective.

6.3.3 RESTRICT TRUCK DRIVING TO GOOD WEATHER

The effect of this alternative would be a reduction in the truck accident rate by 10 percent (Ref. 6-10).

6.3.3.1 Radiological Impacts

The radiological impacts of this accident reduction below the baseline case (Table 6-1) are as follows:

Annual normal population dose	25,360 person-rem (3.07 LCF)
Annual LCFs from accidents	0.015 LCF
Annual probability of one or more early fatalities	8.21×10^{-4}

6.3.3.2 Nonradiological Impacts and Cost-Benefit Balance

Restricting trucks to good-weather driving has the potential problem that a truck could be forced to stop for several days to wait for clear weather. Increased warehouse storage, schedule delays, and loss of additional radioactive material by decay would result. The costs associated with these nonradiological impacts would appear to outweigh the reduction in accident risk.

6.3.4 RESTRICT TRUCKS CARRYING RADIOACTIVE MATERIALS TO A MAXIMUM SPEED OF 72 KM/HR (45 MPH)

Restricting trucks to a lower speed limit (for instance, 16 kilometers per hour below posted limits) reduces the highway accident rates by about 5 percent (Ref. 6-10).

6.3.4.1 Radiological Impacts

The computed radiological impacts are as follows:

Annual normal population dose	26,770 person-rem (3.24 LCF)

Annual LCFs from accidents	0.016 LCF
Annual probability of one or more early fatalities	8.67×10^{-4}

The accident risk is reduced only slightly from the 1985 baseline case (Table 6-1). However, since truck shipments take longer, the dose received by people living along the highway and by people sharing the highway with such trucks is increased.

6.3.4.2 Nonradiological Impacts and Cost-Benefit Balance

A nonradiological impact of this alternative would be the additional travel time required. In the 1985 standard shipments model, the 2.7×10^9 annual truck kilometers traveled at 72 kilometers per hour rather than 89 kilometers per hour would require an additional 7.2×10^6 hours per year. Assuming each shipment requires two drivers at $5 per hour, $72 $\times 10^6$ in additional salaries would be required annually. The costs might be partially offset by a small decrease in operating expenses resulting from improved fuel consumption and reduced maintenance. Since all trucks would not be affected, law enforcement officials would be hampered in their ability to enforce the reduced speed limit. The increase in normal population dose of 1410 person-rem corresponds to an additional cost of $1.4 $\times 10^6$ per year. This alternative does not appear to be cost effective.

6.3.5 RESTRICT TRUCKS FROM TRAVELING ON WEEKENDS

Prohibiting intercity truck travel on weekends provides a significant reduction of 50 percent in truck accident rates (Ref. 6-11).

6.3.5.1 Radiological Impacts

The resulting radiological impacts are as follows:

Annual normal population dose	25,360 person-rem (3.07 LCF)
Annual LCFs from accidents	0.0074 LCF
Annual probability of one or more early fatalities	4.62×10^{-4}

Although the normal dose is unchanged from the baseline case (Table 6-1), the accident LCFs and the early fatality probability are substantially reduced. In the analysis of this alternative, it is assumed that secondary mode transport is not restricted to weekdays so that the air and rail shipping modes continue to be served.

6.3.5.2 Nonradiological Impacts and Cost-Benefit Balance

Prohibition of weekend truck travel might prove to be a burden to radiopharmaceutical shippers and users since a large number of short half-life isotopes are shipped on Saturday evening to arrive for use on Monday morning. If these shipments had to be made on Friday instead of Saturday evening, an increase in the amount of material shipped would be required in some cases to allow for additional radioactivity decay. The package TI values would be increased and more shielding required. In order to circumvent this problem, a restructuring of radiopharmaceutical use by physicians might be possible.

The monetary equivalent of this reduction in accident LCFs would be $75,000 per year. This relatively small benefit would probably be offset by the cost of equipment "dead time" on weekends and holidays. Since this type of restriction would prevent shipment roughly 30 percent of the time, exclusive-use vehicles, special loading equipment, etc., would be idle. In addition, if a shipment were only halfway to its destination when the weekend arrived, temporary storage would be required and thereby add to the population dose. Thus, this alternative is not considered cost effective.

6.3.6 RESTRICT IRRADIATED FUEL SHIPMENTS TO SPECIAL TRAINS ONLY

The Association of American Railroads has recommended that shipments of irradiated (or spent) fuel be made in special trains the significant characteristics of which are as follows:

1. No freight other than the spent fuel casks is carried.

2. Special trains travel at speeds not faster than 56 kilometers per hour (35 mph).

3. When a special train transporting an irradiated fuel cask passes or is passed by another train, one of the trains is to remain stationary while the other train passes at a speed not faster than 56 kilometers per hour.

At present, irradiated fuel shipments by rail are handled by ordinary freight trains in which other freight accompanies the irradiated fuel. For ERDA irradiated fuel shipments, the railcar carrying the irradiated fuel cask is usually placed at the rear of the train just in front of the caboose.

Items requiring excess clearance or having excess weight are currently transported by special trains. To date, we know of only one accident involving special train service, and it caused no damage to the lading and no injuries. There have been no railcar accidents involving irradiated fuel shipments by regular train out of a total of nearly 2000 shipments (Ref. 6-12). Thus, an assessment of the advantages of special trains as opposed to regular trains for irradiated fuel shipments on the basis of past accident experience is not possible since there are insufficient accident data to use for the comparison.

In a special ERDA study (Ref. 6-12) on the safety of special trains, the conclusion, based on regular freight train accident data, indicated that the maximum reduction in the freight train accident rate resulting from a 56-kilometer-per-hour speed limitation is 19 percent. A "train accident" was defined as one that resulted in more than $750 damage to railroad equipment, truck, or roadbed. A 50-percent reduction in the number of serious accidents (those resulting in more than $75,000 damage) was determined to be the maximum reduction possible.

However, the direct application of accident rate data for ordinary freight trains to special trains overlooks some very important points mentioned in certain comments on the draft version of this document. Some of these points, which should be considered in evaluating the advantages of special trains, are the following:

1. With special trains, less damage is likely if an accident does occur. Irradiated fuel casks are designed to withstand a 9.1-meter drop onto an unyielding surface; real impacts occurring in accidents involving special trains would be less severe since the speeds are less than 56 kilometers per hour and real, rather than unyielding, surfaces are involved. Crush forces would also be expected to be less than for regular trains since only a few railcars are involved and no other freight is carried. No prolonged fires would be expected since no flammable freight is transported along with the shipment.

2. A serious derailment would be less likely because of the shorter train length. Not only are there fewer cars to become derailed but the entire train may be kept under constant surveillance from both the caboose and the engine. Should one of the cars become derailed, the train crew can promptly note the occurrence and take immediate action to stop the train, probably before the car overturns or other serious damage occurs. The train can also be stopped much more quickly because of the shorter length.

3. Fewer switching mishaps would be expected because there is much less switching. No switching of the irradiated fuel car would be required and the train could proceed to its destination without intermediate switching because no other freight is carried. The reduction in the amount of switching required would also decrease the doses received by brakemen and others who carry out the switching operations.

4. Cleanup operations, should major derailment occur, might be easier if the accident involved a special train. Special railroad cranes of large capacity would be required to rerail a heavy car carrying a spent fuel cask. The crane itself would usually have to be transported to the accident site by rail, and cleanup time would probably be less than that for a major derailment of a regular freight train. For a regular train, more debris would probably have to be removed in order to reach the spent fuel car.

5. The actual transit time of the spent fuel cask is likely to be quite a bit less than it would be in regular train service. In an example cited in one of the comments to the draft version of this document, an actual special train shipment of three casks containing nuclear cores from Proviso, Illinois, to Council Bluffs, Iowa, took less than 16 hours. In a detailed accounting of the same shipment made by regular train service, the commenter estimated that the shipment would have taken more than 70 hours, most of which time is spent in holding or switch yards (Ref. 6-13)

Nevertheless, the actual reduction in both normal and accident risks in 1975, had all rail shipments of spent fuel been handled by special train service, is negligible because the shipments of spent fuel by rail in 1975 contributed only 0.08 percent of the normal risk and 0.1 percent of the accident risk. Thus, even if both risks were reduced to zero, there were so few irradiated fuel shipments by rail in 1975 that the risk reduction would have been insignificant.

In 1985, however, 652 shipments of irradiated fuel by rail are expected. Assume that, under special train service, the accident risk could be reduced to zero. The accident risk from spent fuel shipments by regular train in the 1985 baseline is 2.5×10^{-4} LCFs per year. Thus, under the assumption of no accidents with special trains, the total accident risk would be reduced by 2.5×10^{-4} LCFs per year. Now consider the cost effectiveness of this alternative by comparing the additional cost for special train service to savings in cleanup costs following an accident with regular train service and to the radiological benefits.

An irradiated fuel cask for rail shipments is estimated to carry 3.2 MT of irradiated fuel (Ref. 6-3) and to contain the following amounts of releasable radioactivity, as discussed in Appendix A: 11,000-Ci Kr-85, 0.14-Ci I-131, and 1280 Ci of other fission products. Using the release fraction model and accident probabilities discussed in Chapter 5, it is estimated that accidents of severity greater than or equal to category V would result in 100 percent release of these quantities and that the probability of such a rail accident with regular train service is about 1.86×10^{-9} per kilometer. For the 1985 level of irradiated fuel shipping activity by rail (652 shipments per year at 750 miles per shipment), the annual probability of an irradiated fuel accident of sufficient severity to release 100 percent of the releasable contents would be such that one accident might be expected about every 700 years. A category IV irradiated fuel railcar accident might be expected once every 76 years but with a release of only 10 percent of the releasable contents. A category III accident might be expected once every 7.6 years with a release of only 1 percent of the releasable contents. The decontamination costs for cleanup of the fission products only for these accidents are determined from Figure 5-13 and listed in Table 6-4.

It is estimated (Ref. 6-14) that each accident involving a release, regardless of its severity, results in a loss of the use of mainline track during cleanup for 5 days. At an estimated cost of $2000 per hour, this amounts to $240,000 per occurrence. Amortizing this figure over the average occurrence periods in Table 6-4 for each accident category and summing all accident categories involving a release result in an average annual cost of $35,000 per year.

Thus, assuming that all rail shipments of irradiated fuel in 1985 were made by special train and that special train service did, in fact, reduce to zero the probability of an accident of sufficient severity to release radioactivity or cause partial loss of shielding, the annual savings would be the sum of the amortized annual decontamination cost, the annual cost for loss of mainline track, and the accident LCF dollar equivalent ($2000 per year) for a total of $\$6.6 \times 10^5$ per year. Assume, in addition, that the use of special trains also reduced to zero the normal dose (0.036 LCF per year) resulting from irradiated fuel rail shipments in 1985 because of reduced handling and storage time. An additional saving of 0.036 LCF per year, or equivalently, $300,000 per year would result. The total savings would be about $\$1 \times 10^6$ per year.

The extra cost to transport spent fuel by special train rather than regular train is computed by using the cost estimates made in the ERDA study (Ref. 6-12): $15.60 per kilogram of spent fuel by regular train and $24.80 per kilogram of spent fuel by special trains. These figures are for a 1740-kilometer shipment and assume two casks per shipment in the case of special trains for optimum cost effectiveness. The cost for shipping a cask carrying 3.2 metric tons of irradiated fuel is $49,920 by regular train and $79,360 by special train. The annual additional cost for the 652 rail casks to be transported by special train in 1985 is

$(\$79,360 - \$49,920) \times 652 = \$19.2 \times 10^6$

TABLE 6-4

ESTIMATED FREQUENCIES OF OCCURRENCE AND DECONTAMINATION COSTS FOR RAILCAR ACCIDENTS INVOLVING IRRADIATED FUEL SHIPMENTS BY REGULAR TRAIN SERVICE IN 1985*

Accident Severity Category	Average Frequency of Occurrence (1 accident per)	Fission Product Release (curies)	Decontamination Cost ($$10^6$)**	Average Decontamination Cost per year ($)
I, II	1.7 years	0	0	0
III	7.6 years	12.8	1.1	$1.45 x 10^5
IV	76 years	128	20	$2.63 x 10^5
V,VI,VII,VIII	700 years	1280	150	$2.14 x 10^5
TOTAL				$6.22 x 10^5

*652 shipments per year at 1200 kilometers per shipment.

**Assuming all accidents occur in suburban zone.

When this cost is compared to the annual savings calculated under the assumption that special train service completely eliminates the accident risk and normal population dose, it does not appear to be a cost-effective alternative. The annual additional cost is about 19 times the annual savings.

The calculation for annual decontamination costs with regular train service is made under the assumption that all accidents would occur in suburban areas. An examination of Figure 5-13 reveals that the decontamination costs for urban areas would be approximately the same. If all accidents occurred in rural areas, the decontamination costs would be substantially reduced and make the use of special trains still less cost effective. Furthermore, since special trains probably would not completely eliminate the normal dose and accident risk of spent fuel shipments by rail, the 19:1 cost-benefit ratio is probably a minimum; the actual ratio is probably even greater.

6.3.7 ENVIRONMENTAL PROTECTION AGENCY RECOMMENDATIONS OF 0.5 MREM PER HOUR MAXIMUM RADIATION AT SEAT LEVEL IN PASSENGER AIRCRAFT

The analysis of maximum radiation dose to passengers performed in Chapter 4 was based on a maximum average dose rate of 1.3 mrem per hour in the rear third of a fully loaded passenger aircraft. The U.S. Environmental Protection Agency has recommended that the maximum radiation dose at seat level in the passenger compartment be limited to 0.5 mrem per hour (Ref. 6-15) in order to minimize individual radiation dose. Three approaches for achieving this goal were suggested: (1) additional shielding of packages, (2) placement options on aircraft, and (3) modified shipping procedures. While any of the three approaches would reduce the maximum individual dose, only additional shielding that resulted in a reduction in the total TI transported annually would be effective also in reducing the annual normal population dose. Spacing of packages or reducing the TI allowed on passenger aircraft would not reduce the total TI transported and would therefore result in no change in the normal population dose.

In Chapter 4, it was estimated that an individual who flies 500 hours per year could receive 108 mrem per year from the radioactive material on board. If the radiation level were limited to 0.5 mrem per hour, his annual dose would be reduced by the factor 1.3/0.5 = 2.6 to a dose of 42 mrem per year.

6.3.8 AIRPORT PACKAGE MONITORING

The effects of abnormal transport occurrences within normal transport, i.e., those occurrences that resulted in release of radioactive material or excessive exposure but that were not the result of a vehicular accident, were discussed in Chapter 4. The Federal Aviation Administration has proposed that airline personnel be required to monitor radioactive material packages presented to them for shipment before they are loaded onto the aircraft. It is suggested that this procedure might eliminate unnecessary exposure of passengers, attendants, and crew resulting from damaged, defective, or improperly packaged materials.

Airport package monitoring would probably have prevented only one of the 12 releases reported to the Department of Transportation during the period 1971-1975 in incidents involving aircraft shipments of radioactive materials. In this one incident, a source was improperly positioned in its container, and the shipper's monitoring system failed to detect the error. Most of the other incidents involved packages damaged by handling operations during transit.

Most aircraft incidents involve Type A packages and, if such a package were to completely lose its shielding, the radiation level at 3 meters from the package would be less than 1 rem per hour since this is one basis upon which Type A limits are determined (see Chapter 2). Assuming that such a package were inadvertently placed on an aircraft carrying 60 passengers for a 2-hour flight, the total population dose would be 120 person-rem if the average dose rate in the cabin were 1 rem per hour. Assuming such incidents occurred only once every 5 years, as the limited experience would indicate, the average additional population dose would be about 25 person-rem per year or less than 0.1 percent of the total annual dose in 1985. At $1000 per person-rem, the dollar equivalent would be $25,000 per year. If the monitoring of the estimated 1.7×10^6 packages in 1985 were to be handled by freight handlers in addition to their other work, if each monitoring required approximately 30 seconds, and if freight handlers were paid $3 per hour, the additional cost would be $42,000. The monitoring procedure itself would add about 30 person-rem per year to the normal dose, assuming 30 seconds to monitor one package and an average radiation level of 2 mrem per hour experienced by the person monitoring the package. Thus, this alternative does not appear to be cost effective.

6.4 RESTRICTIONS ON MATERIAL FORM, QUANTITY SHIPPED, OR PACKAGING

The physical and chemical form of the radionuclides transported can strongly influence the amount of material released in an accident and the pathway to eventual radiation exposure of man. Restricting the maximum quantities of radioactivity allowed on a vehicle limits the amount of material available for release in an accident and hence the magnitude of the consequences.

6.4.1 RESTRICTING THE PHYSICAL AND/OR CHEMICAL FORM OF SHIPPED MATERIAL

As noted in Chapter 5, the release of dispersible alpha-emitting isotopes in an accident presents an inhalation hazard since lung deposition may occur for particles having aerodynamic diameters of less than 10 micrometers. Larger-diameter particles have a much smaller probability of pulmonary deposition and, consequently, do not constitute as severe a health hazard to man. The consequences of an accident are directly proportional to the respirable fraction of the material released.

A fabrication technique for production of fuel containing plutonium to be used in reactors involves precipitation of the oxalate and calcination to produce PuO_2 powder. The effect of calcining temperature on particle size distribution is shown in Figure 6-1. It should be possible to control the respirable fraction by controlling the calcining temperature. Another possible method of reducing the quantity of respirable material available for release in an accident is pelletizing the PuO_2 powder prior to shipment. It might be possible by either technique to reduce the respirable fraction of particles released in an accident to 1 percent of the total quantity shipped. These techniques might also be applied to other high-hazard materials such as polonium.

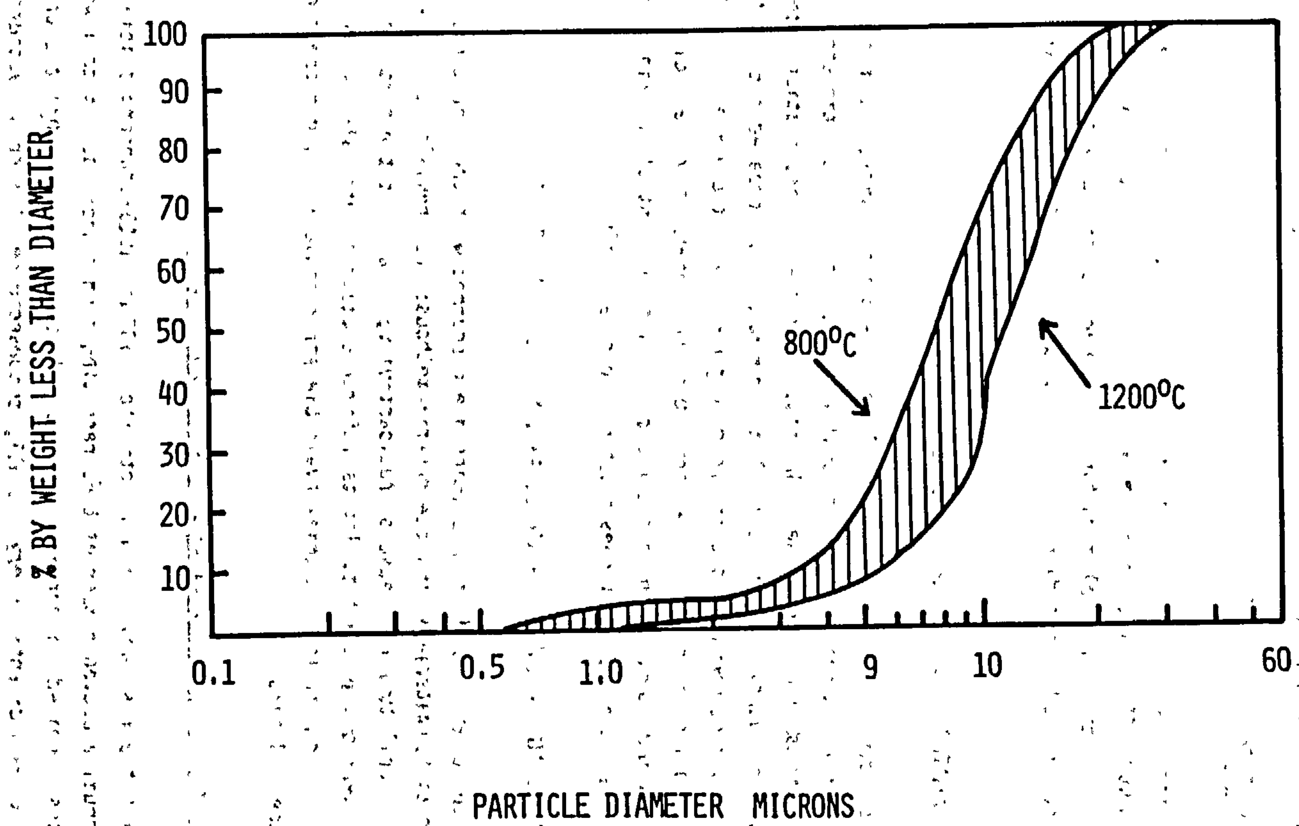

FIGURE 6-1. VARIATION IN PLUTONIUM DIOXIDE PARTICLE SIZE DISTRIBUTION FOR A RANGE OF CALCINING TEMPERATURE BETWEEN 800°C AND 1200°C (Ref. 6-16).

Assuming the respirable fractions for high-hazard dispersible materials (as defined in Section 6.2.4) are limited to 1 percent (as opposed to 20 percent in the baseline case), the annual radiological effects are as follows:

Annual normal population dose	25,360 person-rem (3.07 LCF)
Annual LCFs from accidents	0.012 LCF
Annual probability of one or more early fatalities	8.88×10^{-4}

The annual normal dose is unchanged from the baseline case (Table 6-1) by this alternative. However, the accident LCF is reduced by 0.005 LCF per year or, equivalently, $41,000 per year. In addition, there is a substantial reduction in the worst-case accident consequence for the large shipments considered. Depending on process modification costs, this alternative may be cost effective.

6.4.2 RESTRICTING MATERIAL SHIPPED PER VEHICLE

Assuming the same amount of material would be transported anyway, the reduction of the amount allowed on any given vehicle would result in more shipments and therefore in the possibility of more accidents involving those shipments. Increased transportation costs and, for shipments of strategic quantities of special nuclear material, increased security costs would result from this restriction without a corresponding reduction in the annual population dose or in the risk resulting from accidents. However, the consequence of any one accident, should it occur, would be reduced in proportion to the reduction of the amount of material on the vehicle. From a risk viewpoint, the alternative does not appear cost effective.

6.4.3 REVISING PACKAGING STANDARDS, PACKAGE QUANTITY LIMITS, AND TI LIMITS

The alternatives considered in this section are concerned with the reduction in the risk of transporting radioactive materials by three general methods: (1) revising the packaging standards to ensure survivability (no release of radioactivity) in all but the most extreme accident conditions, (2) lowering the quantity limits for radioactive materials packages and thereby limiting the amount of radioactive material available for release in any given accident, and (3) lowering the package TI limits.

6.4.3.1 Revising the Packaging Standards for Type B Containers

The results of the risk analysis for both the 1975 and 1985 standard shipments models showed that the annual expected number of LCFs resulting from accidents is much lower than that expected from doses received in normal transport. However, even though the probability of occurrence of a severe accident is very small, the consequence of such an accident could be large. For this reason, alternatives that reduce the amount of radioactive material dispersed in an accident are considered.

Since it is generally acknowledged that current packagings are better than the regulatory standards require, new packaging standards could be introduced that would, in effect, require that all new packaging designs be at least as good as those currently in use. Such an action would not result in a decrease in risk due to accidents but would ensure that the risk would not increase as a result of the introduction of new packagings inferior to present ones.

To see the effect of packaging standards revisions, a different release fraction model is considered. It postulates that all Type B packagings are constructed to match the 1985 plutonium packaging criteria discussed in Chapter 5, i.e., only a 1-percent release would occur in a class VII accident and only a 10-percent release would occur in a class VIII accident.

The annual radiological risks if this alternative were implemented are as follows:

Annual normal population dose	25,360 person-rem (3.07 LCF)
Annual LCFs from accidents	0.010 LCF
Annual probability of one or more early fatalities	1.05×10^{-8}

Both the accident LCF figure and the annual early fatality probability are reduced significantly from the baseline case (Table 6-1).

The reduction in annual accident LCFs is equivalent to $58,000 per year. Recent tests of plutonium shipping containers (Refs. 6-17 and 6-18) indicate that presently used plutonium packagings may already have the required level of accident resistance called for in this alternative. Further consideration of this alternative would require an assessment of the level of accident resistance of the designs of all Type B packagings now in use.

6.4.3.2 Lowering the Package Quantity Limits

A second possible method of risk reduction considered in this section is lowering the package quantity limits. Such action would reduce the amount of radioactive material per package available for release, and, if the same amount of shielding were used, the TI per package would also be reduced. However, unless a package TI reduction were required along with the quantity reduction, it would probably be more cost effective to reduce the amount of shielding in order to lighten and reduce the cost of transporting an individual package. Consequently, the same total amount of material would continue to be transported, but in a larger number of packages. Thus, there would be an increase in the annual expected number of LCFs. However, the risk of early fatalities might be reduced.

With the TI per package remaining the same but a larger number of packages transported, the number of TI transported annually would be increased, and the routine exposure due to normal transport would be increased accordingly. Since normal transport accounts for over 90 percent of the risk in the 1985 baseline, the total risk would be substantially increased over the baseline case (Table 6-1).

If the action lowering the quantity limits were accompanied by a corresponding requirement to reduce the package TI by the same proportion, the total TI transported annually would be unchanged. In this case, there would be no change in either the accident or normal contribution to the risk, assuming, as before, that the total quantity of radioactive material transported annually remains the same. The net effect would be to transport the same quantity of radioactive material per shipment and per vehicle, except in a larger number of packages. In either case, shipping costs would be higher, particularly in the case where the action is accompanied by a required reduction in TI because the total weight transported annually would be significantly higher. Higher costs with no change in annual LCFs indicate an unfavorable cost-benefit ratio.

6.4.3.3 Lowering the Package TI Limits

The final possible risk-reduction method considered in this section is lowering the package TI limits. Current standards allow up to 10 TI for packages with a Radioactive Yellow III label. The reduction of the package TI can be accomplished by either or both of the following methods·

1. A reduction of the quantity of material per package.

2. An increase in the amount of shielding used per package.

The first method was discussed in the preceding paragraphs and was shown to produce, at best, no change in the total annual risk. The second method, an increase in the amount of shielding per package without reducing the quantity of material per package, could result in a reduction in the number of TI shipped annually and in a corresponding reduction in the routine risk in normal transport. The effect of reduction in the maximum allowable package TI on the annual risk of normal transport would depend on the amount of the reduction and on detailed information concerning current TI per package values. The current effective radiopharmaceutical industry limit is 3 TI per package (Ref. 6-19). Radiopharmaceuticals constitute a large portion of the radioactive material shipments and, as a result, make a significant contribution to the annual risk. A reduction in the 10-TI package limit by a factor of two or three is estimated to have very little, if any, effect on the overall risk since it appears that most package TIs for other than exclusive-use shipments are already at or below that level.

A previous study (Ref. 6-19) has compared the effects of package limits of 10, 5, and 1 TI with the effective present limit of 3 TI for transporting radiopharmaceuticals by passenger aircraft. The results showed that when the cost-benefit ratios are considered, the 5-TI limit is most cost effective, and a TI limit of 3 exceeds the point of cost effectiveness by a substantial margin. However, a TI limit of 1 was found to result in costs exceeding benefits by a factor of four.

Therefore, just as currently used packagings are much better than the standards require, the effective TI package limits are lower than required by the regulations. The TI limits could be lowered to the cost-effective level of 5, for example, without affecting current shipping practice significantly and with no change in the overall risk. The result of such an action would be to ensure that the present voluntary package limits are maintained. Unlike introducing new standards for packaging durability, lowering the TI limits from 10 to 5 would not require expensive container-qualification tests. A reduction of the TI limits to less than 3, however, may not be cost effective.

6.5 SUMMARY OF COST-EFFECTIVE ALTERNATIVES

A summary of the various alternatives considered in this chapter that appear to be cost effective is presented in Table 6-5. The alternative of shipping spent fuel by barge, where feasible, appears to be the most cost effective.

The analysis of alternatives performed in this chapter was done to determine which, if any, may be cost effective and therefore merit further study. A considerable number of alternatives were considered but none in the depth required for an environmental impact statement prior to actual implementation of the specific alternative.

TABLE 6-5

SUMMARY OF COST-EFFECTIVE ALTERNATIVES

Alternative	Applicable Paragraph	Annual Savings
All air shipments by truck	6.2.1	$\$18 \times 10^{6}$
All all-cargo air shipments by truck	6.2.3	$\$8.3 \times 10^{6}$
All spent fuel by rail	6.2.6	$\$11 \times 10^{6}$
All feasible spent fuel by barge (remainder by rail)	6.2.7	$\$3 \times 10^{6}$
Route trucks on turnpikes	6.3.2	$\$1.1 \times 10^{6}$
Restrict respirable fraction of high-hazard dispersible materials to 1.0%	6.4.1	*
Revise packaging standards for Type B containers	6.4.3.1	**
Lower package TI limits	6.4.3.3	***

*May be cost effective depending on the cost of process modifications.

**May be cost effective depending on development costs for new containers.

***May be cost effective depending on level of reduction.

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CHAPTER 7
SECURITY AND SAFEGUARDS

7.1 INTRODUCTION

The rapid growth of the nuclear power industry coupled with an increase in terrorist activities have increased concern over theft of nuclear materials, sabotage of nuclear facilities, and other associated acts of terrorism. The possibilities of illegal acts and the nature and extent of potential threats have been and are continuing to be examined by the NRC as part of the overall safeguards program described in Section 7.3. Countermeasures have been established to protect both fixed sites and nuclear material in transit.*

Two categories of material have been examined relative to the in-transit protection of the material against theft and sabotage: (1) special nuclear material (SNM) such as enriched uranium and plutonium and (2) radioactive isotopes and wastes such as cobalt-60 and spent fuel.

7.2 RADIOACTIVE MATERIALS - POTENTIAL FOR MISUSE

7.2.1 LOW ENRICHED URANIUM

Low enriched uranium, the fuel used in light-water-cooled power reactors, cannot be used directly to fabricate a nuclear explosive. Furthermore, the radioactivity of this material is so low that dispersal by manual means or acts of sabotage would not produce a significant radiological hazard.

Requirements for physical protection of shipments of low enriched uranium in transit are not specified in NRC regulations.

7.2.2 IRRADIATED (SPENT) FUEL

Irradiated fuel removed from light-water-cooled power reactors contains low enriched uranium, fission products, and plutonium and other transuranics. It is highly radioactive and requires heavy shielding for safe handling. Massive, durable containers (casks) weighing 25 to 100 tons are used for transport of the spent fuel assemblies (both by road and rail). The contained plutonium is not readily separable from the other radioactive materials.

*In March of 1974, specific requirements for the protection of significant quantities of strategic special nuclear material (SSNM) in transit in 10 CFR Part 73 became effective. In May of 1976, licensees were directed to provide additional protection for road shipments through the use of a separate escort vehicle and improved communications. In February of 1977, in order to formalize security measures currently being employed, license conditions were issued requiring the use of an armored transporter plus an escort vehicle and a minimum of five armed guards for the protection of road shipments.

The design features that enable the shipping container to withstand severe transportation accidents (e.g., multiplicity of heavy steel shells, thick dense shields, and neutron-absorbing jackets) also enable the containers to withstand attack by small arms fire and explosives. A massive rupture of the containers by mechanical means or high explosives that would result in the radioactive contents being ejected or removed is considered to be essentially impossible. Although unlikely, the possibility exists that the container could be breached to the extent that the gaseous inventory and a small portion of the solids would be dispersed into the atmosphere. For a release from a truck cask containing three PWR elements, the effects in a population density of 2000 people per square mile are calculated to be about 1 early death and about 220 latent cancer fatalities (Ref. 7-1).*

Spent fuel in transit is considered to be neither an attractive nor a practical target for theft or sabotage and is specifically exempt from the physical protection requirements of 10 CFR Part 73.

7.2.3 LOW-LEVEL WASTES

Soft waste material generated at nuclear reactors and associated fuel cycle facilities, e.g., contaminated paper and clothing, are compacted and placed (typically) in 55-gallon drums for shipment. Each drum may contain 500 pounds of compacted material with up to one curie of activation and fission products.

The low specific activity and low radiation levels allow the contaminated trash to be shipped without shielding. Because the radioactive contamination is bound on the compacted material, it is unlikely to be released in the event the drums are broken open by accident or criminal acts. Even if an entire truckload of 50 drums were to be consumed by fire, the amount of radionuclides that would become widely dispersed would be quite small. It has been estimated that as much as 99 percent of the 50-curie inventory would remain in the ashes, and only 1 percent or 0.5 curie (primarily cesium-137) would become airborne (Ref. 7-2).

Liquid fuel cycle and reactor wastes such as contaminated resins and sludges are dewatered, consolidated by mixing with concrete (or other solidifying agents), and placed (typically) in 55-gallon drums.

The majority of these drums contain less than 20 curies and are shipped as Type A packages. A small percentage contain up to 100 curies (average of 20 curies) and are shipped as Type B packages. The cemented, solidified form of the waste materials contributes significantly to the retention of the radioactive inventory in case of container failure.

If each container of a 50-drum Type A shipment of cemented wastes were broken open by acts of sabotage, the total activity released to the atmosphere would be quite small. (Reference 7-2 indicates that approximately 2×10^{-3} curies of gaseous and volatile fission products would become airborne.)

*For different population densities the effects would vary proportionately. However, no credit is given in the calculations to evacuation of downwind areas that could reduce these consequences by a factor of 10.

It would be extremely difficult to breach the Type B package to the extent of breaking open the inner container and exposing the solidified wastes. In the unlikely event this were to occur, approximately 0.2 curie of fission products (primarily cesium-134 and -137) would be released to the atmosphere for each 55-gallon drum ruptured (Ref. 7-2). For a 42-drum load, which would probably be the limit for a Type B truck shipment, the total activity released would be 8.4 curies. Because of the form of the material, it is unlikely that the presence of an open fire would significantly increase the activity that would become airborne.

The breach of the Type B package and the exposure of the cemented wastes would contaminate the transport vehicle and nearby ground and produce a radiation field. However, the hazard would be limited to the vicinity of the vehicle.

Because of the form of the materials and the relatively low levels of radioactivity, low-level wastes are considered unlikely targets for sabotage. Even if subjected to criminal acts, no major hazard would result.

7.2.4 HIGH-LEVEL WASTES

High-level wastes (HLW) generated from the reprocessing of spent reactor fuel, even though cooled for many years before shipment, have many of the same fission products found in the spent fuel but little plutonium. These wastes are intended to be solidified (e.g., in the form of a dense glass) for shipment and storage. They are highly radioactive and will require heavy shielding for safe handling.

HLW shipping casks would be similar in design to a spent fuel shipping cask and would have many of the same features (steel liners, lead or depleted uranium gamma shielding, a cooling system, neutron shields, and sacrificial impact limiters). The resistance to sabotage would be essentially the same as for a spent fuel cask; if either were breached by criminal acts, the consequences are estimated to be of the same order of magnitude.

High-level waste shipments are considered to be neither an attractive nor a practical target for theft or sabotage. (There are currently no HLW shipments and few if any are anticipated by 1985.)

7.2.5 NON-FISSILE RADIOISOTOPES (SMALL SOURCE)

Small-quantity shipments (less than 20 curies) have little potential for harm to the general public through misuse. Dispersal of the contents of a shipping container following a theft or by sabotage would result in a relatively minor localized contamination. (The radiation from an unshielded 20-curie source of cobalt-60 would be only about 25 R/hr at 1 meter. On the other hand, the radiation would be extemely hazardous to a terrorist who directly handled the source without intervening shielding.)

7.2.6 NON-FISSILE RADIOISOTOPES (LARGE SOURCE)

Large-quantity shipments (10 to 10^6 curies) may have a limited potential for endangering the public health and safety through misuse.

Containers used for the shipment of these amounts of material must meet DOT and NRC regulatory requirements for Type B or large-quantity packages. These packages are designed to prevent the loss or dispersal of the contents, to retain shielding efficiency, and to provide for heat dissipation under both normal transport conditions and specific accident damage test conditions.

The size, weight (which varies from hundreds of pounds to forty tons for a 500,000-Ci Co-60 source), and construction of these containers make theft a difficult endeavor and dispersal of the contents an impractical event. In addition, the high level of radiation associated with the isotopes prevents handling without mass shielding. If a shipping container were diverted, it would be almost impossible to use the contents to cause any significant harm other than through explosive breaching and subsequent dispersal of the contents.

If sufficient amounts of explosives are used, the possibility exists that the radioisotopes could be dispersed to the atmosphere (for gases or volatiles) or locally dispersed on the ground (for solids). Tables 5-12, 5-13, and 5-14 show the consequences of worst-case accidents for several large-quantity shipments of Po-210 and Co-60. It is believed that these results are representative of the possible effects of worst-case credible criminal acts during transport.

Although terrorists might perceive large-quantity shipments of non-fissile radioisotopes to be attractive weapons, the protection afforded by the shipping container and the high level of radioactivity of the contents make theft and dispersal difficult and deliberate manipulation very difficult. The consequences associated with worst-case acts of sabotage would not constitute a significant radiological hazard.

7.2.7 URANIUM HIGHLY ENRICHED IN U-235

Highly enriched uranium (uranium enriched to 20 percent or more in the U-235 isotope) could be used to fabricate a nuclear explosive and therefore has significant potential for misuse. Depending on their form, these materials could be used directly (e.g., U metal) or after processing (e.g., HTGR fuel).

Because of its low radioactivity, sabotage of U-235 would not, in general, constitute a threat to the general public. Conceivably, it might be possible to bring about criticality by actions involving both removal of neutron absorbers and rearrangement of the uranium materials. It certainly would be a dangerous task and probably would irradiate the perpetrator. If successful, the hazard, although dangerous, would be restricted to the general vicinity of the nuclear materials.

NRC regulations require that highly enriched uranium in quantities of 5 kilograms or more be protected against theft and sabotage in accordance with the physical security requirements of 10 CFR Part 73. Additional requirements have been established for fixed site and transport protection by license conditions. (These include requirements for the use of an armored transport vehicle that has a cargo compartment with barriers or containers that deter or delay penetration, a separate escort vehicle, and a minimum of five armed guards for road shipments.) Physical security requirements are not specified for quantities smaller than this amount.

7.2.8 PLUTONIUM AND URANIUM-233

Reactor grade plutonium and U-233* (like U-235) could be used to fabricate a crude nuclear explosive. Depending on their form, the plutonium or U-233 could be used directly (e.g., Pu or U metal) or after processing (e.g., Pu nitrate). In addition, because of their radioactivity, plutonium and U-233 are potentially hazardous, particularly when in the form of respirable aerosols. Therefore, for significant quantities of these materials, the potential exists for misuse both as illicit explosives and as dispersal weapons.

Plutonium and U-233 in quantities of 2 kilograms or more are protected against theft and sabotage in accordance with the physical security requirements of 10 CFR Part 73. Additional protection has been required at both fixed sites and in transit by specific license conditions as in the case of highly enriched uranium discussed earlier.

7.3 SAFEGUARDS OBJECTIVES AND PROGRAM

Safeguards are defined as those measures employed to deter, prevent, or respond to (1) the unauthorized possession or use of significant quantities of nuclear materials through theft of diversion and (2) the sabotage of nuclear materials and facilities. The NRC safeguards program has the general objective of providing a level of protection against such acts that will ensure against significant increase in the overall risk of death, injury, and property damage to the public from other causes beyond the control of the individual. To be acceptable, safeguards must take realistic account of the risks involved and of burdens on the public in terms of impacts on civil liberties, institutions, the economy, and the environment.

The following functional elements are utilized by the NRC to ensure effective protection of the radiological health and safety of the public and protection of the environment:

1. Consideration of the nature and dimensions of the postulated threat in the development of regulatory requirements

2. Imposition of safeguards requirements on the industry directed toward countering the postulated threat.

3. Licensing activities, including review of safeguards procedures proposed by industry, as required by regulations.

4. Inspection of safeguards implementation to ensure adequacy.

5. Enforcement of requirements through administrative, civil, or criminal penalties.

6. Administrative and technical support for response and recovery.

*There are currently no strategic quantities of privately owned U-233, and no shipments are expected in the next several years.

7. Confirmatory research related to the development and testing of methods, techniques, and equipment necessary to the effective implementation of safeguards.

8. Frequent program review in the light of industrial/technical or social/political changes to ensure that any needed revisions are made to the elements above.

Current programs are directed at protecting against theft or diversion of certain types and quantities of nuclear materials that could be used for nuclear explosives or contaminants and protecting against the sabotage of nuclear facilities and materials.

The Commission's regulations in 10 CFR Part 70 require a license in order to own, acquire, deliver, receive, possess, use, transport, import, or export special nuclear materials. The NRC publishes specific safeguards requirements for materials and plant protection in 10 CFR Parts 70 and 73 and carries out the following activities to ensure compliance:

1. Prelicensing evaluation of applicants' proposed nuclear activities, including safeguards procedures in the case of applicants for significant quantities of special nuclear material;

2. Issuance of a license to authorize activities subject to specific safeguards requirements; and

3. Inspection and enforcement to ensure that applicable safeguards requirements are met by implementation of approved plans.

The provisions in 10 CFR Part 73 include specific physical protection requirements that apply to licensees who ship 5 kilograms of U-235 (contained in uranium enriched to 20% or more), 2 kilograms of plutonium or U-233, or a weighted combination of these.

The NRC conducts inspections of a licensed plant and its related transportation links to ensure continued effective implementation of material control and physical protection requirements. Each licensee is required to afford the NRC opportunity to inspect the nuclear materials, to perform or permit the NRC to perform necessary tests of materials and equipment, and to make available any records pertaining to possession, use, or transfer of nuclear material.

If items of noncompliance or deficiencies are found in the implementation of safeguards requirements by the licensee, the licensee is instructed to take prompt corrective action and to inform the NRC of the results. The NRC has the authority to modify, suspend, or revoke licenses and to impose civil penalties on licensees for noncompliance with the items and conditions of the license.

Early in 1976, the NRC established an Information Assessment Team (IAT) for the purpose of determining in a timely fashion the credibility, seriousness, and immediacy of hazards associated with threats to nuclear facilities or transportation. This team is charged with the responsibility for receiving and reviewing all incoming threat notifications, performing multi-source correlation, assessing the validity of sources and data, judging the degree of seriousness, and recommending options for alternative courses of action. In the event that a threat escalates into an attempt to steal SNM or sabotage nuclear facilities or transportation, the IAT forms the nucleus of the NRC Incident Response Action Coordination Team (IRACT). This team is responsible for initiating, planning, and coordinating incident response actions.

7.4 PHYSICAL PROTECTION OF HIGHLY ENRICHED URANIUM AND PLUTONIUM DURING TRANSIT

7.4.1 INTRODUCTION

As noted in Section 7.2, the only radioactive materials that require physical protection against theft and sabotage during transit are strategically significant quantities of uranium enriched to 20% or more in the U-235 isotope, U-233, and plutonium. The potential for misuse of shipments of other radioisotopes is sufficiently low that no additional protection is presently believed necessary.

It is estimated that during calendar years 1977 and 1978 there will be less than 30 shipments per year of strategic quantities of uranium and plutonium in the commercial sector. Most of these will be transfers of UF_6 from Piketon, Ohio, and Oak Ridge, Tennessee, to O'Hare airport for export overseas.

The following paragraphs contain a description of current requirements (both regulations and specific license conditions) for physical protection during transit and an assessment of the adequacy of these requirements relative to a postulated threat consisting of an internal threat of one employee occupying any position and an external threat of a determined violent assault by several well-armed, well-trained persons who might possess inside knowledge or assistance.*

7.4.2 ROAD SHIPMENTS

Shipments are required to be made in a vehicle that has an armored cab with a crew of three armed guards and a cargo compartment that is constructed to resist penetration and delay entry. A separate vehicle with two additional armed guards must escort the transporter.

Communication requirements include radiotelephones in both vehicles for communication to the licensee, his agent, or the police, radios for intervehicle communication, and citizen band radios in both vehicles for use in emergencies.

Shipments are required to be made on primary roads during daylight hours. (If a trip is to extend into the night, a second escort vehicle with two additional guards is required.) Transfers from vehicle to storage, from one vehicle to another, and from storage to vehicle as well as material in storage must be monitored by guards who are equipped with communications to local police and who must keep the shipment under continuous visual surveillance.

*On the basis of intelligence and other relevant information available to the NRC, there are no known groups in this country having the combination of motivation, skill, and resources required to carry out an assault against a protected shipment or facility.

Many other specific requirements, such as requirements for vehicle markings, scheduled calls, guard training, route selection, notification of shipment, are contained in NRC regulations and license conditions.

The combination of five well-trained armed guards, armor protection, and penetration-resistant cargo compartments is considered adequate to withstand an assault by a small group for a prolonged period of time. The requirements for multiple means of communication and the restriction of travel to daylight hours on well-traveled roads are designed to ensure that local police forces would be notified and would be able to respond in time to seal off and neutralize the threat. (As noted above a second escort vehicle is required if travel extends into the night.)

The protection system does not necessarily fail even if the attack is conducted by a large force that outnumbers the guards. The margin of safety might be less and casualties perhaps higher. However, the capabilities of the local and state police relative to communication networks, area isolation, response force numbers, armament, and transportation provide protection against threats larger than that postulated.

The penetration-resistant transport vehicle provides resistance to penetration and containment against acts of sabotage directed at dispersal of the plutonium. It is estimated that, for a wide range of assaults, including road mines, gunfire, hand-carried explosives, and vehicle-to-vehicle and other crash environments, this type of vehicle would prevent wide-scale dispersal of the plutonium cargo. There is, of course, a practical limit to the protection against unlimited amounts of explosives. A trailer truckload of TNT (40,000 lb) detonated next to the transporter would cause massive damage to the vehicle and to the surrounding environment. The consequence of such a blast might exceed the consequences of the plutonium contamination.

Transfers or material stored while awaiting transfer (24 hours or less) are protected by armed guards. In addition, all U.S. airports and sea terminals used for transfer of SNM have security systems that provide control of access and a reserve of armed individuals that could respond to a security emergency.

Plutonium shipments in quantities less than 2 kilograms do not fall within the physical protection requirements of 10 CFR Part 73. The cutoff point was established at this level in order to provide a substantial margin of safety below the quantity of plutonium generally accepted as being required to construct an improvised nuclear explosive.

While this level is not directly related to risks associated with dispersal weapons, it can be shown that the possible consequences from dispersal of such quantities would be of the same order as malevolent use of chemical explosives and small compared to a nuclear explosion. (It has been estimated in Reference 7-3 that plutonium dispersed in a city having a high population density could result in one fatality for each 15 grams dispersed.)

The protection afforded to road shipment and storage in transit is considered to be as effective as that provided by ERDA (now DOE) during the transport of government-owned SNM.

7.4.3 RAIL SHIPMENTS

At present, no physical protection plans have been approved by the NRC for rail shipments, and no shipments of NRC-licensed SNM are being made using this mode of transport. In order for a security plan utilizing this mode to be approved, protection comparable to that currently afforded road shipments would have to be provided. Such features of the plan as guard strength and deployment, communications, armor, penetration resistance of the cargo compartment, and route selection would be assessed to ensure that the escort force could withstand an attack by a small group until police response was ensured. For plutonium shipments, the resistance to penetration or sabotage of the cargo compartment would be evaluated to ensure a level equivalent to that for road shipments.

7.4.4 SHIPMENT BY INLAND WATERWAYS

No physical protection plans have been approved by the NRC for shipment by inland waterway, and no shipments of NRC licensed SNM are currently being made using this mode of transport. A security plan for shipment by inland waterway would be approved only if the protection against assault and sabotage were equal to that presently applied to road shipments.

7.4.5 AIR SHIPMENTS

Shipments of strategically significant quantities of SNM are required to be made in cargo-only aircraft. SNM being transferred to or from such aircraft (including periods while in storage) must be protected by guards equipped with a capability for radio communications to either a local law enforcement agency or an air terminal guard force. Preplanned in-transit storage may not exceed 24 hours. Guard surveillance of the cargo compartment whenever the compartment containing SNM is open and observation of the aircraft until it departs are required.

The combination of assigned guards, communications to local police, and a reserve of armed airport security personnel stationed at the flight lines at major commercial airports provide significant protection against an assault or covert attempts by unauthorized personnel to board the plane. (The only air shipments currently being made or projected through 1978 are imports and exports at O'Hare airport. These flights are escorted by an unarmed employee or agent of the licensee. U.S. safeguards responsibilities in the transportation of nuclear materials for export end when the shipment is unloaded at a foreign terminal. The NRC regional offices inspect every import and export shipment for compliance with requirements.) The surveillance of the transfer onto the aircraft plus the normal preflight check of the cargo compartment by the flight crew make it unlikely a stowaway could board and occupy the aircraft undetected. An attempt at diversion of the aircraft by a member of the flight crew once airborne is considered to be unlikely.

Transport of plutonium by air presents a unique problem. If both the aircraft were damaged and the shipping container were breached during flight, the altitude and velocity of the aircraft might aid in the plutonium dispersal. Similarly, a high velocity crash of an aircraft might cause or contribute to the rupture of a shipping container and the scattering of the contents.

However, no shipments of plutonium by air will be licensed by the NRC (except for individual medical applications) until the Nuclear Regulatory Commission has certified to the Joint Committee on Atomic Energy of the Congress, as required by law, that a safe container that will not rupture under crash and blast-testing equivalent to the crash and explosion of a high-flying aircraft has been developed and tested.

7.4.6 SEA SHIPMENTS

Shipments of SNM by sea are conducted in accordance with physical protection provisions similar to those applied to air shipments. Guards equipped with radio equipment capable of communicating with local police or a nearby commercial guard force maintain surveillance over the SNM during transfer operations. Vessels are observed by these guards until they depart the harbor. Sea shipments are escorted by an unarmed employee or agent of the licensee. Ship-to-shore contact is made at least every 24 hours to relay position information and status of the shipment. It is considered unlikely that a shipment, while at sea, could be successfully diverted or sabotaged to the extent that a significant radiological hazard would result.

7.5 ALTERNATIVES

The present in-transit physical security requirements provide protection, at a minimum, against theft or sabotage by a postulated threat consisting of an internal threat of one employee occupying any position and an external threat of a determined violent assault by several well-armed, well-trained persons who might possess inside knowledge or assistance. This protection is the responsibility of and is supplied by the licensee or his agent and consists of privately owned facilities and equipment under the control of private guard forces.

Consideration has been given to using such other means of protecting SNM in transit as a Federal guard force, the ERDA transport system, Department of Defense escorts, and systems designed to withstand a larger, more violent assault. These alternatives are discussed below.

7.5.1 FEDERAL GUARD FORCE

The need for and feasibility of an NRC security agency to assume operating responsibility for security forces to protect the nuclear industry was the subject of a special review by the NRC in 1975-76 (Security Agency Study, Ref. 7-4). The principal conclusion was:

> "The study has found that creation of a Federal guard force for maintaining security in the nuclear industry would not result in a higher degree of guard force effectiveness than can be achieved by the use of private guards, properly qualified, trained and certified (by NRC). Analysis of the existing regulatory structure indicates that NRC can fulfill its responsibilities to assure adequate physical protection of licensed facilities and materials through stringently enforced regulations."

7.5.2 THE ERDA (DOE) TRANSPORT SYSTEM

The Security Agency Study also addressed the question of whether a Federal transport system was necessary for privately owned strategic special nuclear material. The study concluded:

> "With regard to shipping containers and transportation vehicles, the private sector can provide a level of security equivalent to that provided by the ERDA system which is responsible for transport of government-owned special nuclear material. Equivalent security can be provided by the private sector using drivers, guards and operating techniques under stringent standards now being established by NRC. Reliable and effective communications can be provided by a system such as the ERDA communication system if commercial carriers are required to use it."

The present level of transport protection provided by the licensed industry is considered to be comparable to that required by ERDA (now DOE). While the licensee (or transport company) does not always have the capability of communicating directly to a command and control center while in transit (as does the ERDA system), the use of radiotelephone, intervehicle radio, and citizens band radio combined with restrictions that normally limit travel to daylight hours on primary highways is considered adequate to provide timely notification of local police of a security emergency.

7.5.3 DEPARTMENT OF DEFENSE ESCORTS

The Posse Comitatus Act prohibits the use of Armed Forces for civil law enforcement, which would include protection of private property, unless expressly authorized by the Constitution or by statutes. None of the present authorizations would permit the use of Armed Forces personnel except in emergencies caused by civil disorder, calamity, or disturbance or when State authority has broken down or there is armed insurrection. Even if this legal impediment did not exist, there is no need or justification for using military forces and equipment to protect against the postulated threat. The physical protection deemed necessary to defeat this threat can and is being provided by the private sector.

7.5.4 PROTECTION AGAINST A HIGHER THREAT LEVEL

The NRC is continuously evaluating the nature and extent of potential threats against nuclear materials and facilities. The threat assessment program has developed the following information:

- The intelligence community has no evidence that there are groups in this country having the motivation, skill, and resources to attack either a fuel facility or a fuel shipment.
- There have been no assaults in this country against facilities or shipments with the specific intent to cause a radiological release or to steal nuclear material.
- To date, there is no evidence to indicate any loss by theft or diversion to unauthorized use of significant quantities of special nuclear materials.
- An examination of over 1200 acts of violence characterized as terrorism occurring in the decade 1965-1975 revealed that 97% were carried out by 6 or less people and 86% by 3 or less.

Since there is no identifiable threat, the decision as to the level or protection to be applied (or the magnitude of the postulated threat against which defenses are to be established) demands the use of subjective judgment.

Based on the above threat assessment, it is believed that the requirements placed on the licensees by NRC provide a capability to protect against the postulated threat and are in the public interest. For purposes of a planned review in a public rulemaking proceeding, NRC has under preparation proposed new regulations that have as their objective the achievement of safeguards that would counter hypothetical threats more severe than those postulated in evaluating the adequacy of current safeguards for licensed operations, including transportation activities. In addition, consideration is being given to the protection of material during anomalous occurrences such as unscheduled emergency stops enroute.

7.5.5 RESTRICTING TRANSPORT TO A PARTICULAR MODE

Regardless of the mode of transportation, adequate protection against theft and acts of sabotage that would result in a significant radiological hazard can be provided. For example, while it might be argued that air shipments (fixed wing or helicopter) made from secure terminal to secure terminal are better protected than are road-air-road or all-road shipments (the evidence is not conclusive that this argument is correct), this is not sufficient justification to prohibit transport by these latter two methods when it can be shown that they have sufficient physical protection.

7.6 CONCLUSIONS

- Existing physical security requirements are adequate to protect, at a minimum, against theft or sabotage of strategic special nuclear materials (uranium enriched to 20% or more in the U-235 isotope, U-233, and plutonium) in transit by a postulated threat consisting of an internal threat of one employee occupying any position and an external threat of a determined violent assault by several well-armed, well-trained persons who might possess inside knowledge or assistance.

- The level of protection provided by these requirements reasonably ensures that transportation of strategic special nuclear material does not endanger the public health and safety or common defense and security. However, prudence dictates that safeguards policy be subject to close and continuing review. Thus, the NRC is conducting a public rulemaking proceeding to consider upgraded interim requirements and longer-term upgrading actions. The objective of the rulemaking proceeding is to consider additional safeguards measures to counter the hypothetical threats of internal conspiracies among licensee employees and determined violent assaults that would be more severe than those postulated in evaluating the adequacy of current safeguards.

- The use of the ERDA (now DOE) transport system is not, at this time, considered to be necessary for the protection of privately owned strategic special nuclear material because the present level of transport protection provided by the licensed industry is considered to be comparable to that presently required by ERDA (DOE). Similarly, the use of Department of Defense escorts is not presently needed to protect domestic shipments against the postulated threat because the physical protection deemed necessary to defeat this threat can and is being provided by the private sector.

- Shipments of radioactive materials not now covered by NRC physical protection requirements, such as spent fuel and large source nonfissile radioisotopes, do not constitute a threat to the public health and safety either because of their limited potential for misuse (due in part to the hazardous radiation levels which preclude direct handling) or because of the protection afforded by safety considerations, e.g., shipping containers.

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APPENDIX A
STANDARD SHIPMENTS MODEL

A.1 INTRODUCTION

The transportation of radioactive materials involves such a diversity of isotopes, package types, quantities of material, package radiation levels, and transport modes that a detailed consideration of every shipment becomes impractical. In order to realistically assess the radiological risk associated with the transportation of radioactive materials, it is necessary to select a finite number of shipment types that dominate the radiological risk.

The standard shipments model used in the draft version of this document was based on a 1972 shipper survey (Ref. A-1) extrapolated to 1975 and on interviews with a few major shippers. The results of a detailed 1975 shipper survey (Ref. A-2) were not available in time to be included in the draft document. The standard shipments model used in this document is much more extensive than the previous one and is based on the 1975 survey data. The purpose of this appendix is to illustrate the methods used to derive the various standard shipments models. In the remainder of this appendix, "the survey report" refers to the report of the survey data listed as Reference A-2.

In the 1975 survey, certain shippers completed "detailed questionnaires" while others completed "summary questionnaires." The detailed questionnaires requested information based on actual shipping records while the summary questionnaires requested information based on shipper estimates. Most major shippers, i.e., those known to ship large numbers of packages annually, and all special nuclear material licensees completed detailed questionnaires, although a few were missed and were sent summary questionnaires. Summary questionnaires sent to a cross section of licensees were intended to represent the entire licensee population on a sampling basis. Thus, the summary questionnaire data base was divided into two separate groups: one for minor shippers and the other for apparent major shippers. There exist, therefore, three data bases: one from the detailed questionnaires, one from the summary questionnaires completed by minor shippers, and one from the summary questionnaires completed by apparent major shippers. Each data base was extrapolated differently to include the entire shipper population. The set of standard shipments on which this risk assessment is based was determined from these three data bases.

Each standard shipment is specified by the isotope or material being shipped, the package type, the number of packages shipped per year, the average number of packages per shipment, the average quantity of material per package, the average transport index (TI) per package, the average distance traveled per shipment, and the primary and secondary transport modes.

A.2 COMPILATION OF STANDARD SHIPMENTS LIST

The selection of standard shipments was made as follows. First, groups of isotopes and materials were selected from Reports X.H,* XIII.H,* and XIV.H* of Reference A-2. The isotopes selected accounted for 97.9% of the total packages, 99.1% of the total kilometers, 97% of the total TI, and over 99% of the total curies or grams, as determined from the detailed questionnaires. All uranium-plutonium mixtures were combined into a single group with an average reactor grade plutonium content of 25% by weight.

Having selected the isotopes and materials that accounted for the vast majority of packages, curies or grams, TI, and kilometers in the detailed questionnaire data, it was necessary to determine the distribution of shipments according to package type and transport mode for each material. For example, one needs to know how many Type B packages of Co-60 were transported by truck. Such information was not directly obtainable from the survey report. Certain of the computer reports (I.D and II.D) gave the breakdown for each isotope according to package type, but not by transport mode, while others (X.A-G and XI.A-G) listed the breakdown by transport mode but not by package type.

In order to obtain a breakdown by both package type and transport mode, two tabulations were made. First, the number of packages of each isotope was listed by package type, independent of transport mode, using Reports I.D and II.D. Next, the number of packages of each isotope was tabulated according to primary transport mode, independent of package type, using Reports X.A-G and XI.A-G. Then, the two tabulations were combined to form a composite distribution of numbers of packages (extrapolated to account for the unsurveyed shipper population) as a function of both package type and primary transport mode. The results are shown in Table A-1. The primary uses of each isotope (M = medical, I = industrial, FC = fuel cycle, W = waste) are also included in the table.

Implicit in the tabulation of data in Table A-1 is the assumption that all packages of a given isotope have the same transport mode split, regardless of package type. This assumption was necessary in order to combine the package data and transport mode data. Thus, Table A-1 constitutes a first approximation to the breakdown according to package type and transport mode. An exception was made for Co-60 when it was noted that there were no reported aircraft shipments of Co-60 greater than 20 curies in the detailed questionnaire data. Thus, Type B and large-quantity Co-60 shipments were assumed to be transported by truck.

Entries listed as "Blank Entry" in Reports I.D and II.D or "unknown" in the transport mode breakdown of Reports X and XI were added to the category containing the largest percentage of packages for that isotope. Certain obvious discrepancies (such as very massive shipments by aircraft) were adjusted prior to tabulating the results in Table A-1. Two large shipment types, Co-60 LQ-2 and Pu-239 LQ, were not listed in the survey data, but shipment data were obtained from other sources.

*The raw data for Reference A-2 are contained in a series of computer reports specified by a Roman numeral combined with an alphabetic character.

TABLE A-1

TOTAL PACKAGES* EXTRAPOLATED FROM DETAILED QUESTIONNAIRE (NON-URANIUM)

Material	Major Use**	Package Type	Air Freight	Passenger Aircraft	Truck	Mail	Rail	Ship	Total
Am-241	I	A	2172	254	4548	63	0	14	7052
		B	48	6	100	1	0	0	155
Au-198	M	A	192	1568	2299	0	0	0	4059
Co-57	M	A	1907	7063	5474	0	0	0	14444
		LSA	7	28	21	0	0	0	56
Co-60	I,M	A	114	62	1763	0	0	0	1940
		B	19	11	299	0	0	0	329
		LSA	259	141	3995	0	0	0	4395
		LQ1	4	2	67	0	0	0	73
		LQ2	0	0	4	0	0	0	4
Cs-137	I	A	81	190	3771	0	0	0	4042
		B	1	1	23	0	0	0	25
		LSA	2	4	79	0	0	0	85
C-14	M	A	6356	7415	4865	981	0	0	19617
Ga-67	M	A	1390	5720	12750	0	0	0	19860
H-3	I	A	7996	11820	8227	956	0	0	28970
		B	112	166	115	13	0	0	406
		LSA	14	20	14	2	0	0	49
Ir-192	I	A	627	22	432	0	0	0	1081
		B	2819	97	1944	0	0	0	4861
I-131 + I-125	M	A	30714	209442	86587	0	0	0	326743
		B	83	568	235	0	0	0	886
		LSA	6	44	18	0	0	0	68
Kr-85	I	A	243	126	640	0	0	66	1075
		B	54	28	143	0	0	15	241
		LSA	5	3	13	0	0	1	22
MC+MF	FC	A	0	0	20154	0	0	0	20154
		B	0	0	4687	0	0	0	4687

TABLE A-1 (continued)

Material	Major Use**	Package Type	Air Freight	Passenger Aircraft	Truck	Mail	Rail	Ship	Total
MC+MF	FC	LQ	0	0	11	0	0	0	11
		LSA	0	0	31191	0	0	0	31191
Mo-99	M	A	25460	56421	46058	0	0	0	127939
		B	869	1927	1573	0	0	0	4369
Po-210	I	A	72	1	68	35	8	0	184
		LQ	7	0	6	3	1	0	17
P-32	M	A	2014	5634	3558	0	0	0	11206
Ra-226	I	A	12	5	104	0	0	0	122
		B	66	27	555	0	0	0	648
Tc-99m	M	A	10090	20649	203910	0	0	0	234649
Waste	W	A	0	0	12877	0	0	0	12877
		B	0	0	806	0	0	0	806
		LSA	0	0	19736	0	0	0	19736
Xe-133	I	A	6844	6154	12538	0	0	0	25536
Mixed	M	A	930	1445	21842	269	0	0	24486
		B	3	5	83	1	0	0	92
		LSA	211	328	4963	61	0	0	5564
Pu-238	M	A	12	75	139	0	0	0	226
		B	15	93	174	0	0	0	282
		LQ	0	3	5	0	0	0	8
		LSA	2	12	22	0	0	0	36
Pu-239	FC	A	2	1	63	0	0	0	66
		B	135	40	3804	0	0	0	3979
		LQ	1	0	22	0	0	0	23
Pu	FC	A	0	0	1	0	0	0	1
		B	5	1	132	0	0	0	138
U-Pu	FC	A	4	0	17	0	0	0	21
		B	62	9	303	0	0	0	374
		LQ	0	0	1	0	0	0	1
Spent fuel	FC	Cask	0	0	254	0	17	0	271

*Limited quantity shipments in limited packagings are listed as "various" isotopes in Table A-3.

**I - industrial; M - medical, FC - fuel cycle; W - waste material.

Uranium shipment data are tabulated separately in Table A-2 because they were determined differently. It was recognized that most of the uranium transported is for use in the nuclear fuel cycle for the production of power in nuclear reactors. Two previous studies (Refs. A-3 and A-4) have addressed the environmental effects of transport of uranium and identified the shipment types listed in Table A-2. The amounts per package, the numbers of packages per shipment, and the average distances per package shown in the table were taken from these two previous studies.

The first two shipment types in Table A-2 involve natural uranium. The total grams of natural uranium transported were determined from the survey data, from both the summary and detailed questionnaires. Natural uranium shipments were considered to be those listed in the survey data as "U-238," "U-235 Z," "U-235 A, B, and C," and "U." A total of 9.1×10^{10} grams of natural and depleted uranium was transported in 1 year, as determined from the survey data. Half of this was assumed to be shipment type 1 and half shipment type 2, since the two shipments are sequential and the total amount of uranium must be conserved. The total packages per year of each shipment type were determined by dividing the total grams transported by the amount per package. The number of packages of enriched uranium for each of the remaining three shipment types was determined in the same way from the total grams of enriched uranium transported (3.9×10^9 grams total).

All entries in the survey tables listed as "U-235 D-Y" or "U-235" were considered as enriched uranium.* The total amount of material in grams was determined by dividing the amount shown (amount of U-235 only) in the tables by the fractional enrichment. Thus, the total amounts of enriched uranium are considerably greater than those determined from Report XIV.H, for example, since Report XIV.H shows only the amount of U-235 contained in the U-235/U-238 mixture.

The total number of packages of uranium determined in this way does not agree with the total number determined from the survey, but the total number of grams, of course, does agree. Since it is only the total amount of material shipped (not the total packages) that determines the risk in the accident case, this simplified model is considered adequate in determining the accident risk.

The average TI per package assigned to each uranium shipment was computed by first determining the total TI for both natural and enriched uranium from the survey data, distributing the natural uranium TI equally among packages of shipment types 1 and 2 (as defined in Table A-2), and distributing the enriched uranium TI equally among packages of shipment types 3, 4, and 5. The result is an average TI of 2.6 each for types 1 and 2 and 1.4 each for types 3, 4, and 5. Since the normal dose depends upon the total TI transported annually, it is unimportant how the TI are distributed among packages, as long as the total TI is accounted for. The normal dose computed for the enriched uranium shipments is an overestimate, since the TI reported in the survey data was most likely fissile TI rather than radiation TI. In the section of Chapter 4 where maximum individual doses are considered, a dose rate value from Reference A-4 was used in place of the TI per package computed here.

The summary questionnaire data for numbers of packages were added to those from the detailed questionnaires. The resulting package totals are shown in Table A-3, listed by isotope, package

*The letters A-Y following the symbol U-235 in the survey data indicate the percentage enrichment in the isotope U-235.

TABLE A-2

URANIUM SHIPMENTS USED IN THE STANDARD SHIPMENTS

Ship. Type	Material	From	To	Form/ Package*	Amount per Pkg (grams)	Pkgs per shipment	Total pkgs. per yr	Avg. Distance (km)
1	U_3O_8	Mill	UF_6 Prod.	LSA	3.8×10^5	40	1.2×10^5	1600
2	UF_6	UF_6 Prod.	Enrich Pl.	LSA	1×10^7	2	4550	800
3	UF_6(enr)	Enrich Pl.	UO_2 Pl.	AF	2.2×10^6	5	591	1200
4	UO_2(enr)	UO_2 Pl	Fuel Fab.	AF	1.1×10^5	40	11818	1200
5	UO_2(enr)	Fuel Fab.	Reactors	SF	8.3×10^5	6	1566	1600

*LSA = low specific activity; AF = Type A - fissile; SF = special form.

TABLE A-3

COMPILATION OF TOTAL PACKAGES SHIPPED PER YEAR

Material	Package Type	Mode*	Packages per Year
Various	limited**	AF	138508
		PAC	172992
		T	391008
Am-241	A	AF	4201
		PAC	491
		T	20330
		M	73
		S	16
	B	AF	55
		PAC	7
		T	115
		M	1
Au-198	A	AF	201
		PAC	1644
		T	2411
Co-57	A	AF	2146
		PAC	7947
		T	6183
	LSA	AF	8
		PAC	31
		T	24
Co-60	A	AF	158
		PAC	86
		T	17447
	B	AF	37
		PAC	21
		T	1397
	LQ	AF	6
		PAC	3
		T	92
	LSA	AF	359
		PAC	195
		T	5535
Cs-137	A	AF	333
		PAC	792
		T	31023
	B	AF	2
		PAC	3
		T	69
Cs-137	LSA	AF	5
		PAC	12
		T	233
C-14	A	AF	8691
		PAC	10140
		T	6655
		M	1341
Ga-167	A	AF	1407
		PAC	5789
		T	12904
H-3	A	AF	10510
		PAC	15536
		T	10984
		M	1256
	B	AF	147
		PAC	218
		T	151
		M	17

TABLE A-3 (continued)

Material	Package Type	Mode	Packages per Year
H-3	LSA	AF	18
		PAC	27
		T	18
		M	2
Ir-192	A	AF	2788
		PAC	97
		T	1922
	B	AF	12751
		PAC	440
		T	13654
I-131+I-125	A	AF	38133
		PAC	260034
		T	107817
	B	AF	103
		PAC	220
		T	292
	LSA	AF	8
		PAC	54
		T	22
Kr-85	A	AF	1079
		PAC	559
		T	3446
		S	291
	B	AF	241
		PAC	125
		T	634
		S	65
	LSA	AF	22
		PAC	12
		T	58
		S	6
MF+MC	A	T	21517
	B	T	5004
	LQ	T	12
	LSA	T	33301
Mo-99	A	AF	25838
		PAC	57008
		T	54929
		M	109
	B	AF	882
		PAC	1947
		T	1876
		M	4
Po-210	A	AF	86
		PAC	1
		T	81
		M	42
		R	10
	LQ	AF	9
		T	7
		M	3
		R	1
P-32	A	AF	2164
		PAC	6052
		T	3823
Ra-226	A	AF	58
		PAC	24
		T	25893
	B	AF	312
		PAC	128
		T	2620

TABLE A-3 (continued)

Material	Package Type	Mode	Package per Year
Tc-99m	A	AF	10329
		PAC	21138
		T	208740
Waste	A	T	131120
	B	T	821
	LSA	T	20097
Xe-133	A	AF	7058
		PAC	6347
		T	12930
Mixed	A	AF	930
		PAC	1445
		T	26773
		M	269
	B	AF	3
		PAC	5
		T	100
		M	1
	LSA	AF	211
		PAC	328
		T	5970
		M	61
Pu-238	A	AF	272
		PAC	1724
		T	3230
	B	AF	15
		PAC	93
		T	174
	LSA	AF	2
		PAC	12
		T	22
	LQ	PAC	3
		T	5
Pu-239	A	AF	2
		PAC	1
		T	63
	B	AF	135
		PAC	40
		T	3804
	LQ	AF	1
		T	22
Pu	A	T	1
	B	AF	5
		PAC	1
		T	132
U-Pu mix	A	AF	4
		T	17
	B	AF	62
		PAC	9
		T	303
	LQ	T	1
Spent fuel	Cask	T	254
		R	17
U_3O_8 (nat)	LSA	T	54000
		R	66000
UF_6 (nat)	A	T	2048
		R	2502
UF_6 (enr)	B	T	485
		S	106
UO_2 (enr)	B	T	9691
		S	2127
UO_2 (fuel)	B	T	1284
		S	282

*AF = air freight; PAC = passenger aircraft; T = truck; S = ship; R = rail; M = mail.

**All limited shipments have been grouped together.

type, and transport mode. Data from apparent major shippers were obtained from Table 4.8 of Reference A-2. The air/land transport mode splits listed in Table 4.8 were used. Further subdivision of packages between passenger and cargo for air transport and between truck and rail for land transport was made using the corresponding mode splits in the detailed questionnaire data. The minor shipper summary questionnaire data were obtained from Summary Questionnaire Report I.D. Since this report presented only package totals for each isotope, the package type split and transport mode split were taken to be the same as for the detailed questionnaire data.

A.3 SIMPLIFICATION OF STANDARD SHIPMENTS LIST

All shipments in limited (exempt) packagings were grouped together in Table A-3, with the transport mode split preserved. In Table A-4, limited quantities shipped in other packagings were combined with other limited shipments, using the limited mode split. In order to minimize the number of scenarios (isotope - transport mode - package type combinations), scenarios with fewer than 1% of the total packages of that isotope and package type were combined in the transport mode with the largest number of packages.

The total of all packages (except limited) transported by airfreight in Table A-3 was 7.32×10^5 However, for the 12-month period ending in June 1975, CAB data (Ref. A-5) indicate a total of 31,000 all-cargo aircraft departures. If all airfreight packages were transported by all-cargo aircraft, there would be about 100 packages per flight, assuming an RTF of 1/24. This does not appear to be reasonable. Many respondents to the 1975 survey probably entered the symbol AF (freight-only aircraft) under the heading "transport mode" for all airfreight shipments. However, the CAB data indicate that only 12.4% of the total domestic airfreight tonnage goes by cargo-only aircraft, the majority being shipped by passenger aircraft. To account for this, 87.6% of the packages of each isotope and package type transported by airfreight in Table A-3 were transferred to the passenger aircraft category, with the exception of the large-quantity shipments.

The transfer of packages from cargo aircraft to passenger aircraft results in a total of 5.12×10^5 nonlimited packages by passenger aircraft. The total number of passenger aircraft departures in 1975 was about 4.5×10^6. Assuming only one package per flight, approximately 10% of all passenger aircraft flights, on the average, carried radioactive material. Since many materials are shipped in multipackage consignments, these data appear to be compatible with the RTFs of 1/10-1/30 discussed in Chapter 4.

The actual split between all-cargo aircraft and passenger aircraft probably lies somewhere between these extremes, i.e., some of the respondents to the 1975 survey probably did interpret the symbol "AF" to mean all-cargo flights as was intended. However, since there is no way of determining how many responded correctly, the latter more conservative approach (transferring a large number of packages from all-cargo aircraft to passenger aircraft) was taken in this assessment.

The net result of these simplifications is shown in Table A-4. This table serves as the basis for the analysis in the body of the report.

TABLE A-4

PACKAGE TOTALS FOR STANDARD SHIPMENTS - 1975 (PACKAGES PER YEAR)

Material	Package Type	Air Freight	Passenger Aircraft	Truck	Rail	Ship
Various	Limited	1.72E+4	2.95E+5	3.91E+5	-	-
Am-241	A	521	4170	2.04E+4	-	-
	B	7	55	116	-	-
Au-198	A	25	1820	2410	-	-
Co-57	A	267	9860	6180	-	-
Co-60	A	-	-	1.77E+4	-	-
	B	5	53	1400	-	-
	LQ1	-	-	101	-	-
	LQ2	-	-	4	-	-
	LSA	45	509	5540	-	-
C-14	A	1080	1.91E+4	6660	-	-
Cs-137	A	41	1080	3.10E+4	-	-
	B	5	-	69	-	-
Ga-67	A	175	7030	1.29E+4	-	-
H-3	A	1300	2.6E+4	1.10E+4	-	-
	B	18	364	151	-	-
	LSA	2	45	18	-	-
Ir-192	A	346	2540	1920	-	-
	B	1590	1.17E+4	1.37E+4	-	-
I-131+I-125	A	4720	2.93E+5	1.08E+5	-	-
	B	13	310	292	-	-
Kr-85	A	136	1530	3500	-	297
	B	30	336	634	-	-
MF+MC	A	-	-	2.15E+4	-	-
	B	-	-	5000	-	-
	LQ	-	-	12	-	-
	LSA	-	-	3.33E+4	-	-
Mo-99	A	3200	7.97E+4	5.49E+4	-	-
	B	109	2720	1880	-	-
Po-210	A	16	113	81	10	-
	LQ	1	11	7	1	-
P-32	A	268	7940	3820	-	-
Ra-226	A	-	-	2.60E+4	-	-
	B	39	401	2620	-	-
Tc-99m	A	1280	3.01E+4	2.09E+5	-	-
Waste	A	-	-	1.31E+5	-	-
	B	-	-	821	-	-
	LSA	-	-	2.03E+4	-	-
Xe-133	A	875	1.22E+4	1.29E+4	-	-
Mixed	A	115	2260	2.70E+4	-	-
	B	-	8	101	-	-
	LSA	26	513	5830	-	-
Pu-238	A	34	1980	3250	-	-
	B	2	109	179	-	-
Pu-239	B	17	165	4030	-	-
	LQ	1	-	-	-	-
U-Pu	B	8	58	330	-	-
Spent Fuel(T)	Cask	-	-	254	-	-
Spent Fuel(R)	Cask	-	-	-	17	-
U_3O_8 (Nat)	LSA	-	-	5.40E+4	6.60E+4	-
UF_6 (Nat)	A	-	-	2050	2500	-
UF_6 (Enr)	B	-	-	485	-	106
UO_2 (Enr)	B	-	-	9690	-	2130
UO_2 Fuel	B	-	-	1280	-	282

In addition to the number of packages per year for each isotope and transport mode combination, four other parameters are required to characterize each shipment: average distance per shipment, average number of packages per shipment, average number of curies per package, and average TI per package. These parameters were determined by averaging values given in Reports I.D and II.D in the 1975 survey for each isotope and package type. Values for uranium shipments were determined from Reference A-3 as discussed earlier. The results for all shipments are summarized in Table A-5. The TI value of 1.0 assigned for spent fuel shipments is an artifact, which, when combined with a K value of 1000, produces a dose-rate factor of 90 mrem-m^2/hr (1000 mrem-ft^2/hr), as discussed in Appendix D.

The average distances per shipment were determined for each isotope and package type by dividing the TI miles for each entry in Reports I.D and II.D by the TI for that entry and then summing over all entries for that isotope and package type. Distances for uranium shipments were taken directly from References A-3 and A-4.

Certain shipments, such as large irradiator sources or truck shipments of irradiated fuel, are loaded directly onto the primary mode vehicle and transported directly to the receiver with no secondary link. However, most other shipments involve a secondary mode link such as a van or courier vehicle to move the material from the shipper to the primary mode terminal (e.g., airport, freight dock) and to take the material from another primary mode terminal to the consignee at the end of the trip. For shipments by passenger aircraft, truck, and rail, the secondary mode distance is assumed to be 40 kilometers at each end or 80 kilometers per shipment. For shipments by all-cargo aircraft, which do not service all major airports, the assumed distance is 80 kilometers at each end for a total of 160 kilometers per shipment. In the case of transport by ship, the distance from the port to the user may be still larger; a value of 320 kilometers per shipment is assumed (not necessarily the case for barge shipments, as discussed in Chapter 6).

In the absence of data to the contrary, one package per shipment was assumed. Data do exist for some uranium fuel cycle and some waste shipments (Ref. A-3), and these data were incorporated into the model. These data are reflected in the numbers of packages per shipment for the materials listed in Table A-5.

A.4 DOSIMETRIC PARAMETERS FOR STANDARD SHIPMENTS

The consequences of an accident involving a release of radioactive material depend on certain dosimetric parameters, including the rem-per-curie value, the particular organ or organs affected, the fraction aerosolized, and the resuspension factor. Each of these is discussed below.

A.4.1 REM-PER-CURIE VALUES AND AFFECTED ORGANS

For dispersible materials (gases, liquids, and volatile or dispersible solids), the rem-per-curie value used in this analysis is the dose in rem received by an individual per curie of radioactive material inhaled.[a] The inhalation of a radionuclide primarily affects one or more critical organs characteristic of that nuclide. For example, inhaled plutonium may cause biological damage to bone and lung tissue. Table A-6 lists the rem-per-curie values and critical

TABLE A-5

SHIPMENT PARAMETERS FOR STANDARD SHIPMENTS

Material	Package Type	Curies per Package	TI per Package	Kilometers per Shipment	Packages per Shipment
Various	Limited	.003	.01	1600 [1]	1
Am-241	A	3.51	2.1	633	1
	B	107	0.9	2450	1
Au-198	A	.84	2.6	958	1
Co-57	A	.003	.08	2420	1
Co-60	A	7.9	4.6	1480	1
	B	1760	1.5	1280	1
	LQ1	40000	.14	2010	1
	LQ2	$3.2x10^5$	1.0 [2]	3200	1
	LSA	.16	4.8	898	1
C-14	A	.02	.02	2140	1
Cs-137	A	.67	2.7	346	1
	B	1350	2.0	950	1
Ga-67	A	.16	.2	700	1
H-3	A	8.6	.002	1770	1
	B	134	0	1600 [1]	1
	LSA	1.7	2.6	800	1
Ir-192	A	64	1.3	1820	1
	B	157	2.1	2030	1
I-131 +	A	.01	.7	1430	1
I-125	B	9.7	0.6	1340	1
Mixed	A	.332	.4	544	1
	B	146	3.8	850	1
	LSA	1.3	.73	980	1
MF+MC	A	.48	5.9	889	50
	B	.23	.07	794	50
	LQ	392	3.0	2330	1
	LSA	.59	1.9	692	50
Mo-99	A	1.2	1.9	1690	1
	B	94	4.4	3230	1
Po-210	A	.007	.04	1210	1
	LQ	144	1.95	2330	1
P-32	A	.24	.25	1600	1
Xe-133	A	1.6	.14	1850	1
Waste	A	.33	22.4	1090	50
	B	273	6.5	725	50
	LSA	.32	2.0	879	50
Ra-226	A	.002	.07	839	1
	B	.04	.3	253	1
Kr-85	A	16	.8	2420,13500 [3]	1
	B	91	.04	2010	1
Pu-238	A	13.3	.02	594	1
	B	2630	.82	1930	1
Pu-239	B	1169	.98	1660	1
Plutonium	LQ	$1.23x10^6$	2.0	1600	1
Spent Fuel	Cask	$1.4x10^6$ [4]	1.0 [2]	2530 [5]	1
	Cask	$9.1x10^6$ [4]	1.0 [2]	1210 [5]	1
U (nat depl) (U_3O_8)	LSA	.13 [6]	2.6	1600	40
U (nat depl) (UF_6)	LSA	3.5 [7]	2.6	800	2
U (enr) (UF_6)	A	.85	1.4	1210,9660 [8] [9]	5
U (enr) (UO_2)	B	.042	1.4	1210,9660 [9]	40

TABLE A-5 (continued)

Material	Package Type	Curies per Package	TI per Package	Kilometer per Shipment	Packages per Shipment
UO_2 (enr) (fuel rods)	B	.32	.5	1600,9660 [9]	6
U-Pu mix	B	38,300	3.3	2750	1
Tc-99m	A	1.03	.16	209	1
Tl-201[10]	A	8.2	.37	2690	1
Recycle Pu [10]	ICV	6.2×10^6	2.0	1600	1

Assumptions

[1] Certain isotopes with TI's of zero were assigned primary mode distances of 1600 kilometers.

[2] Large casks are assigned a TI of 1 to force a dose rate factor of 90 mrem-m^2/hr (1000 mrem-ft^2/hr) - see Appendix D.

[3] Kr-85 Type A goes 2420 kilometers in domestic traffic and 13500 kilometers by ship overseas.

[4] The spent fuel curies are divided into releasable material (Kr-85, I-131, and volatile fission products) and exposure-source materials. The curie breakdown is as follows:

	Curies			
	Kr-85	I-131	Volatile Fission Products	Exposable
Truck cask	1,700	.022	200	1.4×10^6
Rail cask	10,900	.138	1280	9.1×10^6

[5] Spent fuel when shipped by truck goes 2530 kilometers and when shipped by rail goes 1210 kilometers.

[6] Shipped in 40-package lots.

[7] Shipped in 2-package lots.

[8] Shipped in 5-package lots.

[9] Overseas uranium shipments go 9660 kilometers by ship. Domestic shipments go 1210 kilometers by truck.

[10] These shipments occur in 1985 only.

TABLE A-6

REM-PER-CURIE (INHALED) VALUES FOR STANDARD SHIPMENTS

Material	Physical Form	Rem/Ci Inhaled	Organ	Time Period	Ref.
Limited [1]	liquid	1.1×10^{6}	thyroid	60 d	A-6
AM-241	special form	3.1×10^{-2}*	WB	1 hr	A-7, A-8
Au-198	liquid	1.4×10^{4}	LLI	168 hr/wk	A-9
Co-57	liquid	1.4×10^{3}	LLI	168 hr/wk	A-9
Co-60	dispersible solid	1.3×10^{6}	lung	50 y	A-6
	special form	1.34*	WB	1 hr	A-7, A-8
C-14	liquid	700	WB	168 hr/wk	A-9
Cs-137	liquid	3.7×10^{4}	WB	50 y	A-6
	special form	3.4×10^{-1}*	WB	1 hr	A-7, A-8
Ga-67	special form	9.0×10^{-2}*	WB	1 hr	A-7, A-8
H-3 [2]	liquid/gas	64	WB	70 d	A-10
Ir-192	special form	4.0×10^{-1}*	WB	1 hr	A-7, A-8
I-131+I-125	liquid	1.1×10^{6}	thyroid	60 d	A-6
Mixed [3]	liquid	1.1×10^{6}	thyroid	60 d	A-6
MC+MF [4]	dispersible solid	1.3×10^{6}	lung	50 y	A-6
Mo-99	liquid	2.1×10^{4}	LLI	60 d	A-6
Tl-201	liquid	2280	LLI	168 hr/wk	A-9
Po-210	dispersible solid	7.1×10^{7}	lung	168 hr/wk	A-9
P-32	liquid	7.1×10^{4}	bone	168 hr/wk	A-9
Xe-133	gas	476	WB	168 hr/wk	A-9
Waste [5]	dispersible solid	3.7×10^{4}	WB	50 y	A-6, A-9
Ra-226 [6]	special form	7.0×10^{-1}*	WB	1 hr	A-7, A-8

TABLE A-6 (continued)

Material	Physical Form	Rem/Ci Inhaled	Organ	Time Period	Ref.
Kr-85	gas	0.61	WB	50 y	A-6
Tc-99m	liquid	89	lung	2 d	A-6
Pu-238	dispersible solid	1.2×10^{8}	lung	1 y	A-6
		3.1×10^{8}	lung	50 y	A-6
		7.6×10^{8}	bone	50 y	A-6
	special form	-	-	-	A-7, A-8
Spent fuel					
I-131	gaseous fission product	1.1×10^{6}	thyroid	60 d	A-6
Kr-85	gaseous fission product	0.61	WB	50 y	A-6
Mixed fission prod. [7]	volatile fission product	3.7×10^{4}	WB	50 y	A-6
Exposure [8]	special form	1.2×10^{-1}*	WB	1 hr	A-6, A-7, A-8
U (nat & depl) [9]	dispersible solid, volatile solid	1.94×10^{7}	bone	50 y	A-11
		4.73×10^{7}	lung	50 y	A-11
	special form	5.7×10^{-3}*	WB	1 hr	A-7, A-8
U (enr) [10]	dispersible solid	1.94×10^{7}	bone	50 y	A-11
		4.74×10^{7}	lung	50 y	A-11
	special form	5.2×10^{-2}*	WB	1 hr	A-7, A-8
plutonium [11]	dispersible solid	3.99×10^{6}	lung	1 y	A-6, A-12
		1.06×10^{7}	lung	50 y	A-6, A-12
		3.74×10^{7}	bone	50 y	A-6, A-12
	special form	2.9×10^{-5}	WB	1 hr	A-7, A-8

*Rem/hr/Ci for nondispersible materials.

TABLE A-6 (continued)

Notes:

1. Modeled as I-131.
2. Taken for individuals older than 10-15 years and for a body half-time of 10 days.
3. Modeled as I-131 since most of this material is radiopharmaceutical byproduct material.
4. Modeled as Co-60 since that isotope is both a fission product and corrosion product.
5. Modeled as Cs-137.
6. The radiation comes from the decay of Bi-214.
7. Modeled as Cs-137.
8. The gamma source for irradiated fuel was derived from isotopic mixture in Reference A-8, allowing for 150-day cooling. The principal contributors are Zr-95 and Ru-106.
9. 99.3 percent U-238/.007 percent U-235.
10. 3 percent enrichment assumed.
11. The calculation for rem-per-curie for recycle plutonium is detailed in Appendix C.

organs for each material in the standard shipments list, including special form and other nondispersible materials. Critical organs were determined from rem-per-curie values from References A-6, A-10, and A-11, and from the list of critical organs in the ICRP/NRCP tabulation of maximum permissible concentrations.

For materials whose rem-per-curie values are not specifically tabulated, values were computed based on the ICRP/NCRP maximum permissible concentrations in air for chronic exposure at 168 hours per week as follows:

$$D = \frac{10^6 \times D_o}{K(BR)(MPC_a)} \qquad \text{(A-1)}$$

where D_o = statutory organ dose limit (15 rem/year for internal organs)

BR = breathing rate

MPC_a = maximum permissible concentration in air

K = unit conversion factor

For breathing rate of 20 liters per minute, this becomes:

$$\text{Rem/curie (inhaled)} = \frac{1.427 \times 10^{-3}}{MPC_a} \qquad \text{(A-2)}$$

Nondispersible materials present only a direct radiation hazard in the accident case (as well as the normal case); therefore, the dose received is a whole-body dose. The computational method of determining whole-body doses from direct external exposure sources is discussed in Appendix G. For nondispersible materials, the gamma-ray doses delivered in 1 hour at a distance of 1 meter from a 1-curie source are listed in Table A-6.

A.4.2 RESPIRABLE FRACTION

The fraction of material that is respirable (able to be inhaled and deposited in the pulmonary region of the lungs) was chosen conservatively to be 1.0 unless data were available to the contrary. A respirable fraction of unity is probably a reasonable choice for gases and liquids, but it is probably very conservative for most dispersible solids. Specific data (Refs. A-13 and A-14) were available for plutonium and for U_3O_8 and were used in the calculation. The respirable fractions used for each standard shipment are listed in Table A-7.

A.4.3 AEROSOLIZED FRACTION

The aerosolized fraction of material released in an accident depends on the accident environment. A container may be crushed beneath a truck, in which case very little material is aerosolized, or it may bounce into the air following the impact and disperse its entire contents. The aerosolized fraction estimated for each standard shipment is listed in Table A-7. For most packages, the aerosolized fraction was assumed to be 1.0. However, certain shipments, notably uranium, involve large quantities of material (10^5 to 10^6 grams per package). An assumption of

TABLE A-7

ADDITIONAL DOSIMETRIC FACTORS

Material	Respirable Fraction	Aerosolized Fraction	Resuspension Dose Factor
"Limited" [1]	1.0	1.0	1.0
Am-241 [2]	0.0	0.0	0.0
Au-198	1.0	1.0	1.03
Co-57	1.0	1.0	1.0
Co-60 [2]	0.0,1.0	0.0,1.0	0.0,1.6
C-14	1.0	1.0	1.0
Cs-137	0.0,1.0	0.0,1.0	0.0,1.62
Ga-67 [2]	0.0	0.0	0.0
H-3	1.0	1.0	1.0
Ir-192	0.0	0.0	0.0
MF+MC	1.0	1.0	1.6
I-131 + I-125	1.0	1.0	1.09
Mixed	1.0	1.0	1.09
Mo-99	1.0	1.0	1.0
Po-210	1.0	1.0	1.5
Ra-226 [2]	0.0	0.0	0.0
P-32	1.0	1.0	1.1
Xe-133	1.0	1.0	1.0
Waste	1.0	1.0	1.62
Kr-85	1.0	1.0	1.0
Pu-238 [2]	0.0	0.0	0.0
Pu [2,3]	0.0,0.2	0.0,1.0	0.0,1.60
Pu [4]	0.2	.05	1.6
Spent fuel-I-131	1.0	1.0	1.09
Kr-85	1.0	1.0	1.0
FP	1.0	1.0	1.62
U_3O_8	0.06	.05	1.63
UF_6	1.0	.01	1.63
U-Pu	0.2	1.0	1.6
Tc-99m	1.0	1.0	1.0
UO_2 [2]	0.0,0.2	0.0,.05	0.0,1.63

[1] "Limited" is modeled as I-131.

[2] Special form materials are assigned value of 0.0. If a material appears both in special and normal form, both sets of values are shown.

[3] Small plutonium shipments.

[4] Large plutonium shipments.

unity aerosolized fraction for such shipments should be excessively conservative, since complete aerosolization of such large amounts of material would be quite difficult.

The mechanisms of aerosolization can be divided into four principal categories: wind resuspension of spilled contents, impact or fire-driven pressure rupture, fire entrainment of spilled contents, and explosion. By examination of potential accident environments, it was determined that the pressure-rupture accident is the only mechanism that occurs in a significant proportion of accidents and with a significant potential release. Even when it does occur, not all of the material ejected from the container would be aerosolized. The situation would be analogous to throwing a handful of sand into the air; most of it would fall back down, with only a small portion of it becoming aerosolized. Based on these considerations, it was estimated that, on the average, no more than 5% of the released material is aerosolized.

A 1% aerosolized fraction was selected for UF_6. Since UF_6 is a solid up to a temperature of 64°C, it was considered to remain essentially non-aerosolized except when involved in a fire, in which case it was considered 100% aerosolized. Since UF_6 is transported principally by truck or rail and since fires occur in only about 1% of all truck or rail accidents, an average aerosolized fraction of 1% was considered appropriate.

A.4.4 RESUSPENSION FACTOR

The resuspension dose factors take into account the doses received by individuals after the initial debris cloud passes. The dose results from radioactive particles deposited on the ground during the cloud passage which are resuspended and inhaled. A discussion of the methods used to estimate resuspension factors is provided in Chapter 5 and will not be repeated here. The resuspension factors for each shipment considered are listed in Table A-7.

A.5 1985 STANDARD SHIPMENTS

The numbers of radioactive material packages expected to be shipped in 1985 are listed in Table A-8. All industrial and most radiopharmaceutical (non-SNM, nonsource material) shipments and all Pu-238 packages were scaled upward by a factor of 2.6 from their 1975 values. This corresponds to an average increase of 10% per year during the 10-year period 1975 to 1985.

Pu-239 shipments were estimated to be unchanged from their 1975 values since these involve principally research reactors and weapon-production facilities. However, a new type of plutonium shipment, "recycle Pu," was added to account for the recycling of plutonium recovered from spent fuel and the fabricating of mixed oxide (MOX) fuel by 1980. For an estimated (Ref. A-12) 20,535 kg per year transported in 1985, 41 packages per year will be shipped in integrated container vehicles (ICV) in 504-kg quantities. This plutonium is considered as "once-through" plutonium, and the average number of curies per package is determined from the isotopic content discussed in Appendix C.

Spent fuel shipments for 1985 are based on an estimated total amount of 2,849 tonnes per year (Ref. A-12). Each truck shipment is estimated to contain 0.5 tonne, and each rail shipment 3.2 tonnes (Ref. A-3). The transport mode split between truck and rail is taken to be the same

TABLE A-8

STANDARD SHIPMENTS - 1985 (PACKAGES PER YEAR)

Material	Package Type	AF	P A/C	Truck	Rail	Ship
Limited	Ex	4.47×10^4	7.67×10^5	1.02×10^6	-	-
Am-241	A	1.22×10^4	-	5.30×10^4	-	-
	B	161	-	302	-	-
Au-198	A	25	1820	2410	-	-
Co-57	A	694	2.56×10^4	1.61×10^4	-	-
Co-60	A	-	-	4.60×10^4	-	-
	B	-	-	3800	-	-
	LQ1	-	-	262	-	-
	LQ2	-	-	10	-	-
	LSA	1440	-	1.44×10^4	-	-
C-14	A	2810	4.97×10^4	1.73×10^4	-	-
Cs-137	A	2920	-	8.06×10^4	-	-
	B	13	-	179	-	-
Ga-67	A	455	5.18×10^4	-	-	-
H-3	A	3380	6.76×10^4	2.86×10^4	-	-
	B	47	946	393	-	-
	LSA	5	117	47	-	-
Ir-192	A	7500	-	4990	-	-
	B	3.45×10^4	-	3.56×10^4	-	-
I-131+I-125	A	4720	2.93×10^5	1.08×10^5	-	-
	B	13	310	292		
Kr-85	A	354	3980	9100	-	772
	B	78	874	1650	-	-
MF+MC	A	-	-	8.9×10^4	-	-
	B	-	-	2.07×10^4	-	-
	LQ	-	-	50	-	-
	LSA	-	-	1.38×10^5	-	-

TABLE A-8 (continued)

Material	Package Type	AF	P A/C	Truck	Rail	Ship
Mo-99	A	8320	2.07×10^5	1.43×10^5	-	-
	B	283	7070	4890	-	-
Po-210	A	336	-	211	260	-
	LQ	32	-	18	3	-
P-32	A	697	2.06×10^4	9930	-	-
Ra-226	A	-	-	2.6×10^4	-	-
	B	440	-	2620	-	-
Tc-99m	A	3330	7.83×10^4	5.43×10^5	-	-
Tl-201	A	-	7500	4.25×10^4	-	-
Waste	A	-	-	5.4×10^5	-	-
	B	-	-	3300	-	-
	LSA	-	-	8.4×10^4	-	-
Xe-133	A	2280	3.17×10^4	3.35×10^4	-	-
Mixed	A	299	5880	7.02×10^4	-	-
	B	-	21	263	-	-
	LSA	68	1330	1.52×10^4	-	-
Pu-238	A	88	5150	8450	-	-
	B	288	-	465	-	-
Pu-239	B	182	-	4030	-	-
	LQ	1	-	-	-	-
Spent fuel	Cask	-	-	1530	652	-
U_3O_8	LSA	-	-	2.24×10^5	2.73×10^5	-
UF_6 Nat.	A	-	-	8440	1.04×10^4	-
UF_6 Enr.	B	-	-	2010	-	439
UO_2 Enr	B	-	-	4.01×10^4	-	8820
UO_2 Fuel	B	-	-	5300	-	1170
U-Pu Mix	B	33	240	1370	-	-
Recycle Pu	ICV	-	-	41	-	-

as that predicted by Blomeke et al. (Ref. A-15). The results are 1,530 truck shipments and 652 rail shipments.

Uranium fuel cycle shipments for 1985 were determined using an estimated 5,383 tonnes of enriched uranium produced in 1985 (Ref. A-12). When compared to the 1300 tonnes determined from the 1975 survey, an industry growth factor of 4.14 was determined. All uranium and uranium-plutonium-mixture shipments were scaled upward by this factor from their 1975 values. Only the total numbers of packages were scaled; the average number of curies per package (or shipment), the TI per package, and the distance per package were assumed to be the same as in 1975.

The projected package totals for certain of the 1985 standard shipments were not obtained in any of the above ways. An executive of a major U.S. radioisotope supplier estimated that:

1. The use of I-131, Ra-226, and Au-198 is not expected to expand by 10% per year as suggested for other radioisotopes.

2. Several isotopes are not expected to be transported by passenger aircraft in the future. The isotopes Am-241, Co-60, Ir-192, Po-210, Ra-226, Pu-238, and Pu-239 were transferred to air-freight mode.

3. Ga-67 will be shipped by air instead of truck.

4. Tl-201 is expected to be significant in 1985.

A.6 EXPORT-IMPORT MODEL

The standard shipment list in Table A-4 was determined from information contained in the 1975 survey report. In order to determine the impacts of export shipments explicitly, a standard shipment list similar to that of Table A-4 was compiled from the detailed questionnaire survey data for exports only. Imports are discussed in Section A.6.2.

A.6.1 EXPORT STANDARD SHIPMENTS LIST

A list of total packages by package type and transport mode and corresponding package parameters for export shipments is shown in Table A-9. The data were obtained by sorting the export-shipments data in the 1975 survey by isotope, package type, and transport mode and determining the total number of packages (extrapolated), the average number of curies or grams per package, the average TI per package, and the average distance traveled per package.

Materials included in the standard shipments list used in the total impact calculation were included in the export standard shipments list. These materials accounted for more than 99% of the total packages, curies, and TI exported, as indicated in the 1975 survey data.

Exports account for about 5×10^6 curies, or about 1% of the total number of curies transported in the United States. About 95% of the number of curies exported are Co-60, Ir-192,

TABLE A-9

1975 STANDARD SHIPMENTS MODEL FOR EXPORT SHIPMENTS - TOTAL PACKAGES PER YEAR BY PACKAGE TYPE, TRANSPORT MODE, AVERAGE CURIES/PACKAGE, AVERAGE TI/PACKAGE, AND AVERAGE MILES/PACKAGE

					Extrapolated Total Packages								
					Air Freight		Pass. A/C		Ship		Truck		
Material	Package Type	Ci Package	TI Package	Form	Package	Km/Pkg	Package	Km/Pkg	Package	Km/Pkg	Package	Km/Pkg	Total Package
Am-241	A	2.8	2.2	SF	14	6440	18	4990	7	11500	14	1450	53
Am-241	B	13.1	0.4	SF	6	8050	1	8050	-	-	-	-	7
Au-198	A	16.0	6.0	L	1	2090	-	-	-	-	-	-	1
Co-57	A	.086	0.5	L	3	644	17	1210	-	-	-	-	20
Co-60	A	7.3	0.5	SF	4	6120	-	-	-	-	-	-	4
Co-60	B	2670	1.0	SF	-	-	-	-	-	-	13	2450	13
Co-60	LSA	.0001	0	L	1	11300	-	-	-	-	-	-	1
Cs-137	A	2.0	5.0	SF	-	-	-	-	-	-	3	1770	3
C-14	A	0.27	3.1	L	32	9340	64	4030	-	-	-	-	96
H-3A	A	.06	0	L	53	12900	119	11900	-	-	-	-	172
H-3T	A	50	0	G	-	-	-	-	-	-	1	1260	1
Ir-192	A	66	1.0	NS	10	4830	-	-	-	-	-	-	10
	B	126	2.3	NS	64	1240	-	-	-	-	-	-	64
I-131	A	.09	.48	L	14	3010	146	4030	-	-	-	-	160
Kr-85	A	2.2	.28	G	78	10400	11	11900	42	13500	4	1380	135
MF	A	9.6	3.1	G	36	3880	-	-	-	-	-	-	36
Mo-99	A	2.64	3.3	L	125	6730	70	5230	-	-	22	2430	217
	B	76.7	3.0	L	7	11700	11	7570	-	-	-	-	18
Pu-238	B	359	0.84	SF	10	8050	1	6600	-	-	1	1830	12
Pu-239	B	1.45	0.0	SF	12	8050	4	96[illegible]	-	-	-	-	16
P-32	A	0.13	0.43	L	7	5430	21	3380	-	-	-	-	28
Ra-226	A	0.004	1.6	SF	10	3860	-	-	-	-	-	-	10
Xe-133	A	5.4	0.28	G	3	9660	24	4380	-	-	1	1260	28
Mixed	A	0.016	0.1	L	.1	403	13	1290	-	-	-	-	14
Limited	Lim	6×10^{-5}	0	L	10	12600	8	7570	-	-	-	-	18
U-Pu	B	0.11	0	L	41	4030	-	-	-	-	-	-	41
UO_2 (enr)	B	0.013	.26	DS	18	9140	29	10500	1.24×10^{4}	14000	18	7580	1.25x10
UF_6 (enr)	B	0.34	3.4	DS	117	9660	-	-	261	760	27	869	405
UO_2-Rx	B	1.48×10^{-6}	3.5	SF	34	9820	-	-	-	-	-	-	34
U-238	A	.0044	.27	SF	3	8050	-	-	81	16100	9	483	93

Mo-99, and Pu-238. Over 80% of the approximately 15,000 packages exported are enriched UO_2, although these represent only a small number of the total curies.

Enriched UO_2 and UF_6 account for about 72% of the approximately 6,500 annual TI exported. The total TI exported is about 0.1% of the total TI transported annually.

A.6.2 IMPORT MODEL

An examination of the import shipments reported in the 1975 shipper survey indicated the following unextrapolated totals:

19 packages
7.2×10^6 curies
40 TI (estimated)

Virtually all the curies were contained in the four special-form Co-60 packages averaging 1.83×10^5 curies per package. Thus, the accident risk is evaluated in Chapter 5 for these four truck shipments only. The normal risk is discussed in Chapter 4 based on the total TI transported. Although the packages arrived in the U.S. by passenger and cargo aircraft, mail, ship, and truck, the environmental impacts of these shipments (evaluated only from the time the shipments enter the U.S. until they reach their U.S. destination) were made by assuming they traveled by truck from their port of entry to their destination. The reported imports included Type A packages of I-125, Yb-169, Cf-252, and C-14, exempt packages of enriched UO_2 and natural uranium metal, one Type B package of Pu-239, one Type B (fissile) package of enriched UO_2, and four Type B packages of Co-60.

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APPENDIX B

EXCERPTS FROM FEDERAL REGULATIONS

B.1 NUCLEAR REGULATORY COMMISSION REGULATIONS

B.1.1 10 CFR Part 71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material under Certain Conditions

UNITED STATES NUCLEAR REGULATORY COMMISSION

RULES and REGULATIONS

TITLE 10, CHAPTER 1, CODE OF FEDERAL REGULATIONS—ENERGY

PART 71 — PACKAGING OF RADIOACTIVE MATERIAL FOR TRANSPORT AND TRANSPORTATION OF RADIOACTIVE MATERIAL UNDER CERTAIN CONDITIONS*

AUTHORITY. The provisions of this Part 71 issued under secs 53, 63, 81, 161, 182, 183, 68 Stat 930, 933, 935, 948, 953, 954, as amended, 42 U.S.C. 2073, 2093, 2111, 2201, 2232, 2233, unless otherwise noted. For the purposes of sec 223, 68 Stat 958, as amended, 42 U.S.C. 2273, §§ 71.61—71.63 issued under sec. 1610, 68 Stat 950, as amended, 42 U.S.C. 2201(o) Secs 202, 206, Pub. L. 93-438, 88 Stat 1244, 1246, 42 U.S.C. 5842, 5846

§ 71.1 Purpose.

(a) This part establishes requirements for transportation and for preparation for shipment of licensed material and prescribes procedures and standards for approval by the Nuclear Regulatory Commission of packaging and shipping procedures for fissile material (uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241) and for quantities of licensed materials in excess of type A quantities, as defined in § 71.4(q), and prescribes certain requirements governing such packaging and shipping. [38 FR 10437]

(b) The packaging and transport of these materials are also subject to other parts of this chapter and to the regulations of other agencies having jurisdiction over means of transport. The requirements of this part are in addition to, and not in substitution for, other requirements.

§ 71.2 Scope.

The regulations in this part apply to each person authorized by specific license issued by the Commission to receive, possess, use or transfer licensed materials, if he delivers such materials to a carrier for transport or transports such material outside the confines of his plant or other place of use. [37 FR 3985]

§ 71.3 Requirement for license.

No licensee subject to the regulations in this part shall (a) deliver any licensed materials to a carrier for transport or (b) transport licensed material except as authorized in a general license or specific license issued by the Commission, or as exempted in this part.

§ 71.4 Definitions.

As used in this part:

(a) "Carrier" means any person engaged in the transportation of passengers or property, as common, contract, or private carrier, or freight forwarder, as those terms are used in the Interstate Commerce Act, as amended, or the U.S. Post Office; [31 FR 9941]

(b) "Close reflection by water" means immediate contact by water of sufficient thickness to reflect a maximum number of neutrons;

(c) "Containment vessel" means the receptacle on which principal reliance is placed to retain the radioactive material during transport;

(d) "Fissile classification" means classification of a package or shipment of fissile materials according to the controls needed to provide nuclear cri-

*Amended 37 FR 3985

ticality safety during transportation as follows:

(1) Fissile Class I: Packages which may be transported in unlimited numbers and in any arrangement, and which require no nuclear criticality safety controls during transportation. For purposes of nuclear criticality safety control, a transportation index is not assigned to Fissile Class I packages. However, the external radiation levels may require a transport index number.

(2) Fissile Class II: Packages which may be transported together in any arrangement but in numbers which do not exceed an aggregate transport index of 50. For purposes of nuclear criticality safety control, individual packages may have a transport index of not less than 0.1 and not more than 10. However, the external radiation levels may require a higher transport index number but not to exceed 10. Such shipments require no nuclear criticality safety control by the shipper during transportation.

(3) Fissile Class III: Shipments of packages which do not meet the requirements of Fissile Classes I or II and which are controlled in transportation by special arrangements between the shipper and the carrier to provide nuclear criticality safety.

33 FR 17621

(e) "Fissile materials" means uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241;

(f) "Large quantity" means a quantity of radioactive material, the aggregate radioactivity of which exceeds any one of the following:

(1) For transport groups as defined in paragraph (p) of this section:

(i) Group I or II radionuclides: 20 curies;

(ii) Group III or IV radionuclides: 200 curies;

(iii) Group V radionuclides: 5,000 curies;

(iv) Group VI or VII radionuclides: 50,000 curies;

and

(2) For special form material, as defined in paragraph (o) of this section: 5,000 curies.

(g) "Low specific activity material" means any of the following:

(1) Uranium or thorium ores and physical or chemical concentrates of those ores;

(2) Unirradiated natural or depleted uranium or unirradiated natural thorium;

(3) Tritium oxide in aqueous solutions provided the concentration does not exceed 5.0 millicuries per milliliter;

(4) Material in which the activity is essentially uniformly distributed and in which the estimated average concentration per gram of contents does not exceed:

(i) 0.0001 millicurie of Group I radionuclides; or

(ii) 0.005 millicurie of Group II radionuclides; or

(iii) 0.3 millicurie of Groups III or IV radionuclides.

NOTE This includes, but is not limited to, materials of low radioactivity concentration such as residues or solutions from chemical processing, wastes such as building rubble, metal, wood, and fabric scrap, glassware, paper, and cardboard, solid or liquid plant waste, sludges, and ashes.

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(5) Objects of nonradioactive material externally contaminated with radioactive material, provided that the radioactive material is not readily dispersible and the surface contamination, when averaged over an area of 1 square meter, does not exceed 0.0001 millicurie (220,000 disintegrations per minute) per square centimeter of Group I radionuclides or 0.001 millicurie (2,200,000 disintegrations per minute) per square centimeter of other radionuclides.

(h) "Maximum normal operating pressure" means the maximum gauge pressure which is expected to develop in the containment vessel under the normal conditions of transport specified in Appendix A of this part;

(i) "Moderator" means a material used to reduce, by scattering collisions and without appreciable capture, the kinetic energy of neutrons;

(j) "Optimum interspersed hydrogenous moderation" means the occurrence of hydrogenous material between containment vessels to such an extent that the maximum nuclear reactivity results;

(k) "Package" means packaging and its radioactive contents;

31 FR 9941

(l) "Packaging" means one or more receptacles and wrappers and their contents excluding fissile material and other radioactive material, but including absorbent material, spacing structures, thermal insulation, radiation shielding, devices for cooling and for absorbing mechanical shock, external fittings, neutron moderators, nonfissile neutron absorbers, and other supplementary equipment;

(m) "Primary coolant" means a gas, liquid, or solid, or combination of them, in contact with the radioactive material or, if the material is in special form, in contact with its capsule, and used to remove decay heat;

(n) "Sample package" means a package which is fabricated, packed, and closed to fairly represent the proposed package as it would be presented for transport, simulating the material to be transported, as to weight and physical and chemical form;

(o) "Special form" means any of the following physical forms of licensed material of any transport group:

(1) The material is in solid form having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters; does not melt, sublime, or ignite in air at a temperature of 1,000° F.; will not shatter or crumble if subjected to the percussion test described in Appendix D of this part; and is not dissolved or converted into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.; or

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(2) The material is securely contained in a capsule having no dimension less than 0.5 millimeter or at least one dimension greater than five millimeters, which will retain its contents if subjected to the tests prescribed in Appendix D of this part; and which is constructed of materials which do not melt, sublime, or ignite in air at 1,475° F., and do not dissolve or convert into dispersible form to the extent of more than 0.005 percent by weight by immersion for 1 week in water at 68° F. or in air at 86° F.

(p) "Transport group" means any one of seven groups into which radionuclides in normal form are classified, according to their toxicity and their relative potential hazard in transport, in Appendix C of this part.

(1) Any radionuclide not specifically listed in one of the groups in Appendix C shall be assigned to one of the Groups in accordance with the following table:

	Radioactive half-life		
Radionuclide	0 to 1000 days	1000 days to 10^4 years	Over 10^4 years
Atomic number 1-81.	Group III	Group II	Group III.
Atomic number 82 and over	Group I	Group I	Group III.

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(2) For mixtures of radionuclides the following shall apply:

(i) If the identity and respective activity of each radionuclide are known, the permissible activity of each radionuclide shall be such that the sum, for all groups present, of the ratio between the total activity for each group to the permissible activity for each group will not be greater than unity.

(ii) If the groups of the radionuclides are known but the amount in each group cannot be reasonably determined, the mixture shall be assigned to the most restrictive group present.

(iii) If the identity of all or some of the radionuclides cannot be reasonably determined, each of those unidentified radionuclides shall be considered as belonging to the most restrictive group which cannot be positively excluded.

(iv) Mixtures consisting of a single radioactive decay chain where the radionuclides are in the naturally occurring proportions shall be considered as consisting of a single radionuclide. The group and activity shall be that of the first member present in the chain, except that if a radionuclide "x" has a half-life longer than that of that first member and an activity greater than that of any other member, including the first, at any time during transportation, the transport group of the nuclide "x" and the activity of the mixture shall be the maximum activity of that nuclide "x" during transportation.

Terms defined in Parts 20, 30 to 36 inclusive, and 70 of this chapter have the same meaning when used in this part.

(q) "Type A quantity" and "type B quantity" means a quantity of radioactive material the aggregate radioactivity of which does not exceed that specified in the following table:

Transport groups see § 71.4(p)	Type A quantity (in curies)	Type B quantity (in curies)
I	0 001	20
II	0 05	20
III	3	200
IV	20	200
V	20	5,000
VI and VII	1,000	50,000
Special form	[1] 20	5,000

§ 71.5 Transportation of licensed material.

(a) No licensee shall transport any licensed material outside of the confines of his plant or other place of use, or deliver any licensed material to a carrier for transport, unless the licensee complies with the applicable requirements of the regulations appropriate to the mode of transport, of the Department of Transportation in 49 CFR Parts 170-189, 14 CFR Part 103 and 46 Part 146, and the U.S. Postal Service in 39 CFR Parts 14 and 15 insofar as such regulations relate to the packaging of byproduct, source, or special nuclear material, marking and labeling of the packages, loading and storage of packages, placarding of the transportation vehicle, monitoring requirements and accident reporting.

(b) When Department of Transportation regulations are not applicable to shipments of licensed material by rail, highway, or water because the shipment or the transportation of the shipment is not in interstate or foreign commerce, or to shipments of licensed material by air because the shipment is not transported in civil aircraft, the licensee shall conform to the standards and requirements of the Department of Transportation specified in paragraph (a) of this section, to the same extent as if the shipment or transportation were in interstate or foreign commerce or in civil aircraft. Any requests for modifications, waivers, or exemptions from those requirements, and any notifications referred to in those requirements shall be filed with or made to, the Nuclear Regulatory Commission.

(c) Paragraph (a) of this section shall not apply to the transportation of licensed material, or to the delivery of licensed material to a carrier for transport, where such transportation is subject to the regulations of the Department of Transportation or the U.S Postal Service.

EXEMPTIONS

*§ 71.6 Specific exemptions.

On application of any interested person or on its own initiative, the Commission may grant such exemptions from the requirements of the regulations in this part as it determines are authorized by law and will not endanger life or property or the common defense and security.

*§ 71.7 Exemption for no more than Type A quantities.†

A licensee is exempt from all the requirements of this part to the extent that he delivers to a carrier for transport:

(a) Packages each of which contains no licensed material having a specific activity in excess of 0.002 microcurie/gram; or

(b) Shipments subject to the regulations of the Department of Transportation in 49 CFR parts 170—189, 14 CFR part 103, or 46 CFR part 146 or the U.S. Postal Service in 39 CFR parts 14 and 15 of packages each of which contains no more than a type A quantity of radioactive material, as defined in § 71.4(q), which may include one of the following:

(1) Not more than 15 grams of fissile material; or

(2) Thorium, or uranium containing not more than 0.72 percent by weight of fissile material; or

(3) Uranium compounds, other than metal (e.g., UF_4 UF_6, or uranium oxide in bulk form, not pelletted or fabricated into shapes) or aqueous[1] solutions of uranium, in which the total amount of uranium-233 and plutonium present does not exceed 1.0‡ percent by weight of the uranium-235 content, and the total fissile content does not exceed 1.00‡ percent by weight of the total uranium content; or

(4) Homogenous hydrogenous[2] solutions or mixtures containing not more than:

(i) 500 grams of any fissile material, provided the atomic ratio of hydrogen to fissile material is greater than 7,600, or

(ii) 800 grams of uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of other fissile material is not more than 1 percent by weight of the total uranium-235 content; or

(iii) 500 grams of uranium-233 and uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of plutonium is not more than 1 percent by weight of the total uranium-233 and uranium-235 content; or

(5) Less than 350 grams of fissile material: *Provided*, That there is not more than 5 grams of fissile material in any cubic foot within the package.

*§ 71.8 Exemption of physicians.

Physicians, as defined in § 35.3(b) of this chapter, are exempt from the regulations in this part to the extent that they transport licensed material for use in the practice of medicine.

§ 71.9 Exemption for fissile material.

A licensee is exempt from requirements in §§ 71.33, 71.35(b), 71.36(b), 71.37, 71.38, 71.39, and 71.40 to the extent that he delivers to a carrier for transport packages each of which contains one of the following:

(a) Not more than 15 grams of fissile material; or

(b) Thorium, or uranium containing not more than 0 72 percent by weight of fissile material; or

(c) Uranium compounds, other than metal (e.g., UF_4, UF_6, or uranium oxide

[1] Except that for californium-252, the limit is 2 Ci

*Redesignated by 38 FR 10437.

†Amended 38 FR 10437.

[1] This applies to light water and does not apply to heavy water.

[2] This applies to light hydrogen and does not apply to heavy hydrogen (i.e., deuterium or tritium).

‡ Amended 38 FR 16347

in bulk form, not pelletted or fabricated into shapes) or aqueous[1] solutions of uranium, in which the total amount of uranium-233 and plutonium present does not exceed 1.0‡ percent by weight of the uranium-235 content, and the total fissile content does not exceed 1.00‡ percent by weight of the total uranium content; or

[38 FR 10437] (d) Homogeneous hydrogenous[2] solutions or mixtures containing not more than:

(1) 500 grams of any fissile material, provided the atomic ratio of hydrogen to fissile material is greater than 7,600; or

(2) 800 grams of uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of other fissile material is not more than 1 percent by weight of the total uranium-235 content; or

(3) 500 grams of uranium-233 and uranium-235: *Provided*, That the atomic ratio of hydrogen to fissile material is greater than 5,200, and the content of plutonium is not more than 1 percent by weight of the total uranium-233 and uranium-235 content; or

(e) Less than 350 grams of fissile material: *Provided*, That there is not more than 5 grams of fissile material in any cubic foot within the package.

§ 71.10 Limited exemption for shipment of type B quantities of radioactive material.

A person delivering a type B quantity of radioactive material, as defined in § 71.4(q), to a carrier for transport in accordance with the provisions of a special permit, which has been issued by the Department of Transportation and is in effect on June 30, 1973, is exempt from the requirements in this part with respect to such shipments. The exemption granted by this section shall terminate on December 31, 1973, or on the date on which the DOT special permit expires, whichever is later, except as to activities described both in the special permit and in an application for a license which the person has, prior to the termination date of the exemption, filed with the Commission. If the person has filed such an application, the exemption granted by this section shall continue until the application has been finally determined by the Commission.

GENERAL LICENSES**

[1] This applies to light water and does not apply to heavy water.

[2] This applies to light hydrogen and does not apply to heavy hydrogen (i.e., deuterium or tritium).

**Added 38 FR 10437.

‡Amended 38 FR 16347.

[31 FR 9941] ***§ 71.11 General license for shipment of licensed material.**

A general license is hereby issued, to persons holding specific licenses issued pursuant to this chapter, to deliver licensed material to a carrier for transport, without complying with the package standards of Subpart C of this part, when either:

(a) The material is shipped as a Fissile Class III shipment with the following limitations on its contents:

[38 FR 10437] (1) No single package contains more than a type A quantity of radioactive material, as defined in § 71.4(q); and

(2) The fissile material contents of the shipment do not exceed:

(i) 500 grams of uranium-235; or

(ii) 300 grams total of uranium-233, plutonium-238, plutonium-239, and plutonium-241; or

[31 FR 9941] (iii) Any combination of uranium-233, uranium-235, and plutonium in such quantities that the sum of the ratios of the quantity of each of them to the quantity specified in subdivisions (i) and (ii) of this subparagraph does not exceed unity; or

(iv) 2500 grams of plutonium-238, plutonium-239, and plutonium-241 encapsulated as plutonium-beryllium neutron sources, with no one package containing in excess of 400 grams of plutonium-238, plutonium-239, and plutonium-241; or

(b) The material is shipped as Fissile Class II packages with the following limitations on the contents of each package:

[38 FR 10437] (1) No single package contains more than a type A quantity of radioactive material, as defined in § 71.4(q); and

(2) No package contains fissile material in excess of the amounts specified in the following table, and each package is labeled with the corresponding transport index:

Maximum quantity of fissile material in a single package: U 235 (grams)	U-233 (grams)	Plutonium (grams)	Plutonium as Pu Be neutron sources (grams)	Corresponding transport index
35-40	27-30	23-25	320-400	10
30 35	24 27	21-23	240-320	8
25 30	21-24	19 21	160-240	6
20-25	18-21	17-19	80-160	4
15 20	15-18	15-17	15-80	2

NOTE. Combinations of fissile materials are authorized. For combinations of fissile materials, the transport index is the sum of the individual corresponding transport indexes. The total transport index shall not exceed 10.

*Redesignated 38 FR 10437.

[39 FR 22131] **§ 71.12 General license for shipment in DOT specification containers, in packages approved for use by another person, and in packages approved by a foreign national competent authority.**

[35 FR 6271] A general license is hereby issued, to persons holding a general or specific license issued pursuant to this chapter, to deliver licensed material to a carrier for transport:

[38 FR 10437] (a) In a specification container for fissile material as specified in § 173.396 (b) or (c) or for a type B quantity of radioactive material as specified in § 173.394(b) or § 173.395(b), or for a large quantity of radioactive material as specified in § 173.394(c) or § 173.395(c) of the regulations of the Department of Transportation, 49 CFR part 173; or

[39 FR 32929] (b) In a package for which a license, certificate of compliance or other approval has been issued by the Commission's Director of Nuclear Material Safety and Safeguards or the Atomic Energy Commission, provided that:

(1) The person using a package pursuant to the general license provided by this paragraph:

(i) Has a copy of the specific license, certificate of compliance, or other approval authorizing use of the package and all documents referred to in the license, certificate, or other approval, as applicable;

(ii) Complies with the terms and conditions of the license, certificate, or other approval, as applicable, and the applicable requirements of this part; and

(iii) Prior to first use of the package submits in writing to the Director of Nuclear Material Safety and Safeguards or the Atomic Energy Commission, his name and license number, the name and license or certificate number of the person to whom the package approval has been issued, and the package identification number specified in the package approval

(2) The package approval authorizes use of the package under general license provided in this paragraph.

[38 FR 10437] (c) In a package which meets the pertinent requirements in the 1967 regulations of the International Atomic Energy Agency and the use of which has been approved in a foreign national competent authority certificate which has been revalidated by the Department of Transportation, *Provided*, That the person using a package pursuant to the general license provided by this paragraph:

(1) Has and complies with the applicable certificate, the revalidation, and the documents referenced in the certificate relative to the use and maintenance of the packaging, and the actions to be taken prior to shipment, and

(2) Complies with the applicable requirements of this part, and the Department of Transportation regulations in 49 CFR part 173, 14 CFR part 103, and 46 CFR part 146

38 FR 10437

§ 71.13 Communications.

All communications concerning the regulations in this part should be addressed to the Nuclear Regulatory Commission, Washington, D C 20555, Attention. Director of Nuclear Material Safety and Safeguards, or may be delivered in person at the Commission's offices at 1717 H Street NW., Washington, D.C. or at 7920 Norfolk Avenue, Bethesda, Maryland.

40 FR 8774

*§ 71.14 Interpretations.

Except as specifically authorized by the Commission in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of the Commission other than a written interpretation by the General Counsel will be recognized to be binding on the Commission.

*§ 71.15 Additional requirements.

The Commission may by rule, regulation, or order impose upon any licensee such requirements, in addition to those established in this part, as it deems necessary or appropriate to protect health or to minimize danger to life or property.

31 FR 9941

***§ 71.16 Amendment of existing licenses.

(a) Licenses issued pursuant to this part and in effect on October 4, 1968, which authorize Fissile Class II packages are hereby amended by increasing the minimum number of units specified for each Fissile Class II package by a factor of 1.25. The new number, shall be rounded up to the first decimal. In addition, the term "radiation units" is changed to "transport index" wherever used in the license.

(b) The reference to § 71.7(b) in licenses issued pursuant to this part prior to March 26, 1972,** is changed to § 71.9(b).

37 FR 3985

(c) The reference to § 71.9(b) in licenses issued pursuant to this part prior to June 30, 1973, is changed to 71.12(b)

38 FR 10437

*Redesignated by FR 10437.
***Amended 37 FR 3985

Subpart B—License Applications

§ 71.21 Contents of application.

An application for a specific license under this part may be submitted as an application for a license or license amendment under this chapter and shall include, for each proposed packaging design and method of transport, the following information in addition to any otherwise required:

(a) A package description as required by § 71.22;

(b) A package evaluation as required by § 71.23,

(c) A description of proposed procedural controls as required by § 71.24;

(d) In the case of fissile material, an identification of the proposed fissile class

§ 71.22 Package description.

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

(a) With respect to the packaging:

(1) Gross weight,

(2) Model number;

(3) Specific materials of construction, weights, dimensions, and fabrication methods of.

(i) Receptacles, identifying the one which is considered to be the containment vessel;

(ii) Materials specifically used as nonfissile neutron absorbers or moderators;

(iii) Internal and external structures supporting or protecting receptacles;

(iv) Valves, sampling ports, lifting devices, and tie-down devices;

(v) Structural and mechanical means for the transfer and dissipation of heat; and

(4) Identification and volumes of any coolants and of receptacles containing coolant.

(b) With respect to the contents of the package:

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**Effective date of this amendment.

(1) Identification and maximum radioactivity of radioactive constituents;

(2) Identification and maximum quantities of fissile constituents;

(3) Chemical and physical form;

(4) Extent of reflection, the amount and identity of non-fissile neutron absorbers in the fissile constituents, and the atomic ratio of moderator to fissile constituents;

(5) Maximum weight; and

(6) Maximum amount of decay heat

§ 71.23 Package evaluation.

The applicant shall:

(a) Demonstrate that the package satisfies the standards specified in Subpart C;

(b) For a Fissile Class II package, ascertain and specify the number of similar packages which may be transported together in accordance with § 71.39, and

(c) For a Fissile Class III shipment, describe any proposed special controls and precautions to be exercised during transport, loading, unloading, and handling, and in the event of accident or delay.

31 FR 9941

§ 71.24 Procedural controls.

The applicant shall describe the regular and periodic inspection procedures proposed to comply with § 71.51(c).

37 FR 3985

§ 71.25 Additional information.

The Commission may at any time require further information in order to enable it to determine whether a license, certificate of compliance, or other approval should be granted, denied, modified, suspended, or revoked.

39 FR 22131

Subpart C—Package Standards

§ 71.31 General standards for all packaging.

(a) Packaging shall be of such materials and construction that there will be no significant chemical, galvanic, or other reaction among the packaging components, or between the packaging components and the package contents.

(b) Packaging shall be equipped with a positive closure which will prevent inadvertent opening.

(c) Lifting devices:

(1) If there is a system of lifting devices which is a structural part of the package, the system shall be capable of supporting three times the weight of the loaded package without generating stress in any material of the packaging in excess of its yield strength.

(2) If there is a system of lifting

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devices which is a structural part only of the lid, the system shall be capable of supporting three times the weight of the lid and any attachments without generating stress in any material of the lid in excess of its yield strength.

(3) If there is a structural part of the package which could be employed to lift the package and which does not comply with subparagraph (1) of this paragraph, the part shall be securely covered or locked during transport in such a manner as to prevent its use for that purpose.

(4) Each lifting device which is a structural part of the package shall be so designed that failure of the device under excessive load would not impair the containment or shielding properties of the package.

(d) Tie-down devices:

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(1) If there is a system of tie-down devices which is a structural part of the package, the system shall be capable of withstanding, without generating stress in any material of the package in excess of its yield strength, a static force applied to the center of gravity of the package having a vertical component of two times the weight of the package with its contents, a horizontal component along the direction in which the vehicle travels of 10 times the weight of the package with its contents, and a horizontal component in the transverse direction of 5 times the weight of the package with its contents.

(2) If there is a structural part of the package which could be employed to tie the package down and which does not comply with subparagraph (1) of this paragraph, the part shall be securely covered or locked during transport in such a manner as to prevent its use for that purpose.

(3) Each tie-down device which is a structural part of the package shall be so designed that failure of the device under excessive load would not impair the ability of the package to meet other requirements of this subpart.

§ 71.32 Structural standards for type B and large quantity packaging.

38 FR 10437

Packaging used to ship a type B or a large quantity of radioactive material, as defined in § 71.4 (q) and (f), shall be designed and constructed in accordance with the structural standards of this section.

31 FR 9941

Standards different from those specified in this section may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment.

(a) *Load resistance.* Regarded as a simple beam supported at its ends along any major axis, packaging shall be capable of withstanding a static load, normal to and uniformly distributed along its length, equal to 5 times its fully loaded weight, without generating stress in any material of the packaging in excess of its yield strength.

(b) *External pressure.* Packaging shall be adequate to assure that the containment vessel will suffer no loss of contents if subjected to an external pressure of 25 pounds per square inch gauge.

§ 71.33 Criticality standards for fissile material packages.

(a) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that it would be subcritical if it is assumed that water leaks into the containment vessel, and:

(1) Water moderation of the contents occurs to the most reactive credible extent consistent with the chemical and physical form of the contents; and

(2) The containment vessel is fully reflected on all sides by water.

31 FR 9941

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that it would be subcritical if it is assumed that any contents of the package which are liquid during normal transport leak out of the containment vessel, and that the fissile material is then:

(1) In the most reactive credible configuration consistent with the chemical and physical form of the material;

(2) Moderated by water outside of the containment vessel to the most reactive credible extent; and

(3) Fully reflected on all sides by water.

(c) The Commission may approve exceptions to the requirements of this section where the containment vessel incorporates special design features which would preclude leakage of liquids in spite of any single packaging error and appropriate measures are taken before each shipment to verify the leak tightness of each containment vessel.

§ 71.34 Evaluation of a single package.

(a) The effect of the transport environment on the safety of any single package of radioactive material shall be evaluated as follows:

(1) The ability of a package to withstand conditions likely to occur in normal transport shall be assessed by subjecting a sample package or scale model, by test or other assessment, to the normal conditions of transport as specified in § 71.35; and

(2) The effect on a package of conditions likely to occur in an accident shall be assessed by subjecting a sample package or scale model, by test or other assessment, to the hypothetical accident conditions as specified in § 71.36.

31 FR 9941

(b) Taking into account controls to be exercised by the shipper, the Commission may permit the shipment to be evaluated together with or without the transporting vehicle, for the purpose of one or more tests.

(c) Normal conditions of transport and hypothetical accident conditions different from those specified in § 71.35 and § 71.36 may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment.

§ 71.35 Standards for normal conditions of transport for a single package.

38 FR 10437

(a) A package used for the shipment of fissile material or more than a type A quantity of radioactive material, as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in appendix A of this part:

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(1) There will be no release of radioactive material from the containment vessel;

(2) The effectiveness of the packaging will not be substantially reduced;

(3) There will be no mixture of gases or vapors in the package which could, through any credible increase of pressure or an explosion, significantly reduce the effectiveness of the package;

(4) Radioactive contamination of the liquid or gaseous primary coolant will not exceed 10^{-7} curies of activity of Group I radionuclides per milliliter, 5×10^{-6} curies of activity of Group II radionuclides per milliliter, 3×10^{-4} curies of activity of Group III and Group IV radionuclides per milliliter; and

(5) There will be no loss of coolant.

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in Appendix A of this part:

(1) The package will be subcritical;

(2) The geometric form of the package contents would not be substantially altered;

(3) There will be no leakage of water into the containment vessel. This requirement need not be met if, in the

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evaluation of undamaged packages under § 71.38(a), § 71.39(a)(1), or § 71.40(a), it has been assumed that moderation is present to such an extent as to cause maximum reactivity consistent with the chemical and physical form of the material; and

(4) There will be no substantial reduction in the effectiveness of the packaging, including:

31 FR 9941

(i) Reduction by more than 5 percent in the total effective volume of the packaging on which nuclear safety is assessed,

(ii) Reduction by more than 5 percent in the effective spacing on which nuclear safety is assessed, between the center of the containment vessel and the outer surface of the packaging; or

(iii) Occurrence of any aperture in the outer surface of the packaging large enough to permit the entry of a 4-inch cube.

(c) A package used for the shipment of more than a type A quantity of radioactive material as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that under the normal conditions of transport specified in appendix A of this part, the containment vessel would not be vented directly to the atmosphere.

38 FR 10437

§ 71.36 Standards for hypothetical accident conditions for a single package.

(a) A package used for the shipment of more than a type A quantity of radioactive material, as defined in § 71.4(q), shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in appendix B of this part as the free drop, puncture, thermal, and water immersion conditions in the sequence listed in appendix B, it will meet the following conditions:

33 FR 17623

(1) The reduction of shielding would not be sufficient to increase the external radiation dose rate to more than 1,000 millirems per hour at 3 feet from the external surface of the package.

(2) No radioactive material would be released from the package except for gases and contaminated coolant containing total radioactivity exceeding neither:

(i) 0.1 percent of the total radioactivity of the package contents, nor

(ii) 0.01 curie of Group I radionuclides, 0.5 curie of Group II radionuclides, 10 curies of Group III radionuclides, 10 curies of Group IV radionuclides, and 1,000 curies of inert gases irrespective of transport group.

A package need not satisfy the requirements of this paragraph if it contains only low specific activity materials, as defined in § 71.4(g), and is transported on a motor vehicle, railroad car, aircraft, inland water craft, or hold or deck of a seagoing vessel assigned for the sole use of the licensee.

33 FR 17623

(b) A package used for the shipment of fissile material shall be so designed and constructed and its contents so limited that if subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Puncture, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, the package would be subcritical. In determining whether this standard is satisfied, it shall be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package and the chemical and physical form of the contents;

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents; and

(3) There is reflection by water on all sides and as close as is consistent with the damaged condition of the package.

31 FR 9941

§ 71.37 Evaluation of an array of packages of fissile material.

(a) The effect of the transport environment on the nuclear safety of an array of packages of fissile material shall be evaluated by subjecting a sample package or a scale model, by test or other assessment, to the hypothetical accident conditions specified in § 71.38, § 71.39, or § 71.40 for the proposed fissile class, and by assuming that each package in the array is damaged to the same extent as the sample package or scale model. In this case of a Fissile Class III shipment, the Commission may, taking into account controls to be exercised by the shipper, permit the shipment to be evaluated as a whole rather than as individual packages, and either with or without the transporting vehicle, for the purpose of one or more tests.

(b) In determining whether the standards of §§ 71.38(b), 71.39(a)(2), and 71.40(b) are satisfied, it shall be assumed that:

(1) The fissile material is in the most reactive credible configuration consistent with the damaged condition of the package, the chemical and physical form of the contents, and controls exercised over the number of packages to be transported together; and

(2) Water moderation occurs to the most reactive credible extent consistent with the damaged condition of the package and the chemical and physical form of the contents.

§ 71.38 Specific standards for a Fissile Class I package.

A Fissile Class I package shall be so designed and constructed and its contents so limited that:

(a) Any number of such undamaged packages would be subcritical in any arrangement, and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case that greater amount may be considered; and

(b) Two hundred fifty such packages would be subcritical in any arrangement, if each package were subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, with close reflection by water on all sides of the array and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging in which case that greater amount may be considered. The condition of the package shall be assumed to be as described in § 71.37.

31 FR 9941

§ 71.39 Specific standards for a Fissile Class II package.

(a) A Fissile Class II package shall be so designed and constructed and its contents so limited, and the number of such packages which may be transported together so limited, that:

(1) Five times that number of such undamaged packages would be subcritical in any arrangement if closely reflected by water; and

(2) Twice that number of such packages would be subcritical in any arrangement if each package were subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, with close reflection by water on all sides of the array and with optimum interspersed hydrogenous moderation unless there is a greater amount of interspersed moderation in the packaging, in which case that greater amount may be considered. The condition of the package shall be assumed to be as described in § 71.37.

(b) The transport index for each Fissile Class II package is calculated by dividing the number 50 by the number of

[33 FR 17624] such Fissile Class II packages which may be transported together as determined under the limitations of paragraph (a) of this section. The calculated number shall be rounded up to the first decimal place.

§ 71.40 Specific standards for a Fissile Class III shipment.

[31 FR 9941] A package for Fissile Class III shipment shall be so designed and constructed and its contents so limited, and the number of packages in a Fissile Class III shipment shall be so limited, that:

(a) The undamaged shipment would be subcritical with an identical shipment in contact with it and with the two shipments closely reflected on all sides by water; and

(b) The shipment would be subcritical if each package were subjected to the hypothetical accident conditions specified in Appendix B of this part as the Free Drop, Thermal, and Water Immersion conditions, in the sequence listed in Appendix B, with close reflection by water on all sides of the array and with the packages in the most reactive arrangement and with the most reactive degree of interspersed hydrogenous moderation which would be credible considering the controls to be exercised over the shipment. The condition of the package shall be assumed to be as described in § 71.37. Hypothetical accident conditions different from those specified, in this paragraph may be approved by the Commission if the controls proposed to be exercised by the shipper are demonstrated to be adequate to assure the safety of the shipment.

§ 71.41 Previously constructed packages for irradiated solid nuclear fuel.

Notwithstanding any other provisions of this Subpart, a package, the use of which has been authorized by the Commission for the transport of irradiated solid nuclear fuel on or after September 23, 1961, and which has been completely constructed prior to January 1, 1967, shall be deemed to comply with the package standards of this subpart for that purpose.

§ 71.42 Special requirements for plutonium shipments after June 17, 1978.

[39 FR 20960] (a) Notwithstanding the exemption in § 71.9, plutonium in excess of twenty (20) curies per package shall be shipped as a solid.

(b) Plutonium in excess of twenty (20) curies per package shall be packaged in a separate inner container placed within outer packaging that meets the requirements of Subpart C for packaging of material in normal form. The separate inner container shall not release plutonium when the entire package is subjected to the normal and accident test conditions specified in Appendices A and B. Solid plutonium in the following forms is exempt from the requirements of this paragraph:

(1) Reactor fuel elements;

(2) Metal or metal alloy; or

(3) Other plutonium bearing solids that the Commission determines should be exempt from the requirements of this section.

(c) Authority in licenses issued pursuant to this part for delivery of plutonium to a carrier for transport under conditions which do not meet the limitations of paragraphs (a) and (b) of this section shall expire on June 17, 1978.

Subpart D—Operating Procedures

§ 71.51 Establishment and maintenance of procedures.

[37 FR 3985] The licensee shall establish and maintain:

(a) Operating procedures adequate to assure that the determinations and controls required by this chapter are accomplished;

(b) Procedures for opening and closing packages in which licensed material is transported to provide safety and to assure that, prior to delivery to a carrier for transport, each package is properly closed for transport; and

(c) Regular and periodic inspection procedures adequate to assure that the procedures required by paragraphs (a) and (b) of this section are followed.

§ 71.52 Assumptions as to unknown properties.

[31 FR 9941] When the isotopic abundance, mass, concentration, degree of irradiation, degree of moderation, or other pertinent property of fissile material in any package is not known, the licensee shall package the fissile material as if the unknown properties have such credible values as will cause the maximum nuclear reactivity.

§ 71.53 Preliminary determinations.

(a) Prior to the first use of any packaging for the shipment of licensed materials, the licensee shall ascertain that there are no cracks, pinholes, uncontrolled voids or other defects which could significantly reduce the effectiveness of the packaging.

(b) Prior to the first use of any packaging for the shipment of licensed materials, where the maximum normal operating pressure will exceed 5 pounds per square inch gauge, the licensee shall test the containment vessel to assure that it will not leak at an internal pressure 50 percent higher than the maximum normal operating pressure.

(c) Packaging shall be conspicuously and durably marked with its model number. Prior to applying the model number, the licensee shall determine that the packaging has been fabricated in accordance with the design approved by the Commission.

§ 71.54 Routine determinations.

[31 FR 9941] Prior to each use of a package for shipment of licensed material the licensee shall ascertain that the package with its contents satisfies the applicable requirements of Subpart C of this part and of the license, including determinations that:

(a) The packaging has not been significantly damaged;

(b) Any moderators and nonfissile neutron absorbers, if required, are present and are as authorized by the Commission;

(c) The closure of the package and any sealing gaskets are present and are free from defects;

(d) Any valve through which primary coolant can flow is protected against tampering;

(e) The internal gauge pressure of the package will not exceed, during the anticipated period of transport, the maximum normal operating pressure;

(f) Contamination of the primary coolant will not exceed, during the anticipated period of transport, the limits specified in § 71.35(a) (4).

The provisions of this section shall not be applicable for packages authorized in the general licenses granted by § 71 6. In such cases the licensee shall ascertain that the contents of the package are as authorized in the general license.

§ 71.55 Opening instructions.

[37 FR 3985] Prior to delivery of a package to a carrier for transport, the licensee shall assure that any special instruction needed to safely open the package are sent to or have been made available to the consignee.

§ 71.61 Reports.

[31 FR 9941] The licensee shall report to the Director of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, within 30 days any instance in which there is substantial reduction in the effectiveness of any authorized packaging during use.

38 FR 10437

§ 71.62 Records.

(a) The licensee shall maintain for a period of 2 years after its generation a record of each shipment of fissile material or of more than a type A quantity of radioactive material as defined in § 71.4(q), in a single package, showing, where applicable:

(1) Identification of the packaging by model number;

(2) Details of any significant defects in the packaging, with the means employed to repair the defects and prevent their recurrence;

(3) Volume and identification of coolant;

(4) Type and quantity of licensed material in each package, and the total quantity in each shipment;

(5) For each item of irrad[illegible]c material,

(i) Identification by model number;

(ii) Irradiation and decay history to the extent appropriate to demonstrate that its nuclear and thermal characteristics comply with license conditions;

(iii) Any abnormal or unusual condition relevant to radiation safety.

(6) Date of the shipment;

(7) For Fissile Class III, any special controls exercised;

(8) Name and address of the transferee;

(9) Address to which the shipment was made; and

(10) Results of the determinations required by §§ 71.53 and 71.54.

(b) The licensee shall make available to the Commission for inspection, upon reasonable notice, all records required by this part.

34 FR 9941

§ 71.63 Inspection and tests.

(a) The licensee shall permit the Commission at all reasonable times to inspect the licensed material, packaging, and premises and facilities in which the licensed material or packaging are used, produced, tested, stored or shipped.

(b) The licensee shall perform and permit the Commission to perform, such tests as the Commission deems necessary or appropriate for the administration of the regulations in this chapter.

40 FR 8774

§ 71.64 Violations.

An injunction or other court order may be obtained prohibiting any violation of any provision of the Atomic Energy Act of 1954, as amended, or Title II of the Energy Reorganization Act of 1974, or any regulation or order issued thereunder. A court order may be obtained for the payment of a civil penalty imposed pursuant to section 234 of the Act for violation of section 53, 57, 62, 63, 81, 82, 101, 103, 104, 107, or 109 of the Act, or section 206 of the Energy Reorganization Act of 1974, or any rule, regulation, or order issued thereunder, or any term, condition, or limitation of any license issued thereunder, or for any violation for which a license may be revoked under section 186 of the Act. Any person who willfully violates any provision of the Act or any regulation or order issued thereunder may be guilty of a crime and, upon conviction may be punished by fine or imprisonment or both, as provided by law.

APPLNDICLS

APPLNDIX A—NOPMAL CONDITIONS OF TRANSPORT

Each of the following normal conditions of transport is to be applied separately to determine its effect on a package

1 *Heat*—Direct sunlight at an ambient temperature of 130° F in still air

2 *Cold*—An ambient temperature of −40° F in still air and shade

3 *Pressure*—Atmospheric pressure of 0.5 times standard atmospheric pressure

4 *Vibration*—Vibration normally incident to transport

5 *Water Spray*—A water spray sufficiently heavy to keep the entire exposed surface of the package except the bottom continuously wet during a period 30 minutes

6 *Free Drop*—Between 1-1/2 and 2 1/2 hours after the conclusion of the water spray test, a free drop through the distance specified below onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

FREE FALL DISTANCE

Package weight (pounds)	*Distance (feet)*
Less than 10 000	4
10,000 to 20,000	3
20,000 to 30 000	2
More than 30,000	1

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7 *Corner Drop*—A free drop onto each corner of the package in succession, or in the case of a cylindrical package onto each quarter of each rim, from a height of 1 foot onto a flat essentially unyielding horizontal surface This test applies only to packages which are constructed primarily of wood or fiberboard, and do not exceed 110 pounds gross weight, and to all Fissile Class II packagings

8 *Penetration*—Impact of the hemispherical end of a vertical steel cylinder 1-1/4 inches in diameter and weighing 13 pounds dropped from a height of 40 inches onto the exposed surface of the package which is expected to be most vulnerable to puncture The long axis of the cylinder shall be perpendicular to the package surface

9 *Compression*—For packages not exceeding 10 000 pounds in weight, a compressive load equal to either 5 times the weight of the package or 2 pounds per square inch multiplied by the maximum horizontal cross section of the package, whichever is greater The load shall be applied during a period of 24 hours, uniformly against the top and bottom of the package in the position in which the package would normally be transported

APPENDIX B—HYPOTHETICAL ACCIDENT CONDITIONS

The following hypothetical accident conditions are to be applied sequentially, in the order indicated, to determine their cumulative effect on a package or array of packages.

1. *Free Drop*—A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.

2. *Puncture*—A free drop through a distance of 40 inches striking, in a position for which maximum damage is expected, the top end of a vertical cylindrical mild steel bar mounted on an essentially unyielding horizontal surface. The bar shall be 6 inches in diameter, with the top horizontal and its edge rounded to a radius of not more than one-quarter inch, and of such a length as to cause maximum damage to the package, but not less than 8 inches long. The long axis of the bar shall be perpendicular to the unyielding horizontal surface.

3. *Thermal*—Exposure to a thermal test in which the heat input to the package is not less than that which would result from exposure of the whole package to a radiation environment of 1,475° F. for 30 minutes with an emissivity coefficient of 0.9, assuming the surfaces of the package have an absorption coefficient of 0.8. The package shall not be cooled artificially until 3 hours after the test period unless it can be shown that the temperature on the inside of the package has begun to fall in less than 3 hours.

4. *Water Immersion* (fissile material packages only)—Immersion in water to the extent that all portions of the package to be tested are under at least 3 feet of water for a period of not less than 8 hours.

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APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES

Element*	Radionuclide***	Group
Actinium (89)	Ac 227	I
	Ac 228	I
Americium (96)	Am 241	I
	Am 243	I
Antimony (51)	Sb 122	IV
	Sb 124	III
	Sb 125	III
Argon (18)	Ar-37	VI
	Ar-41	II
	Ar-41 (uncompressed)**	V
Arsenic (33)	As 73	IV
	As 74	IV
	As 76	IV
	As 77	IV
Astatine (85)	At 211	III
Barium (56)	Ba 131	IV
	Ba-133	II
	Ba 140	III
Berkelium (97)	Bk 249	I
Beryllium (4)	Be 7	IV
Bismuth (83)	Bi 206	IV
	Bi 207	III
	Bi 210	II
	Bi 212	III
Bromine (35)	Br 82	IV
Cadmium (48)	Cd 109	IV
	Cd 115 m	III
	Cd 115	IV
Calcium (20)	Ca 45	IV
	Ca 47	IV
Californium (98)	Cf 249	I
	Cf 250	I
	Cf 252	I
Carbon (6)	C 14	IV
Cerium (58)	Ce 141	IV
	Ce 143	IV
	Ce 144	III
Cesium (55)	Cs 131	IV
	Cs 134 m	III
	Cs 134	III
	Cs 135	IV
	Cs 136	IV
	Cs 137	III
Chlorine (17)	Cl 36	III
	Cl 138	IV
Chromium (24)	Cr 51	IV
Cobalt (27)	Co 56	III
	Co 57	IV
	Co 58 m	IV
	Co 58	IV
	Co 60	III
Copper (29)	Cu 64	IV
Curium (96)	Cm 242	I
	Cm 243	I
	Cm 244	I
	Cm 245	I
	Cm 246	I
Dysprosium (66)	Dy 154	III
	Dy 165	IV
	Dy 166	IV
Erbium (68)	Er 169	IV
	Er 171	IV
Europium (63)	Eu 150	III
	Eu 152 m	IV
	Eu 152	III
	Eu 154	II
	Eu 155	IV
Fluorine (9)	F 18	IV
Gadolinium (64)	Gd 153	IV
	Gd 159	IV
Gallium (31)	Ga 67	III
	Ga 72	IV
Germanium (32)	Ge 71	IV
Gold (79)	Au 193	III
	Au 194	III
	Au 195	III

See footnotes at end of table.

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APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES—Continued

Element*	Radionuclide***	Group
	Au 196	IV
	Au 198	IV
	Au 199	IV
Hafnium (72)	Hf 181	IV
Holmium (67)	Ho 166	IV
Hydrogen (1)	H 3 (see tritium)	
Indium (49)	In 113 m	IV
	In 114 m	III
	In 115 m	IV
	In 115	IV
Iodine (53)	I 124	III
	I 125	III
	I 126	III
	I 129	III
	I 131	III
	I 132	IV
	I 133	III
	I 134	IV
	I 135	IV
Iridium (77)	Ir 190	IV
	Ir 192	III
	Ir 194	IV
Iron (26)	Fe 55	IV
	Fe 59	IV
Krypton (36)	Kr 85 m	III
	Kr 85 m (uncompressed).**	V
	Kr 85	III
	Kr 85 (uncompressed).**	VI
	Kr 87	II
	Kr 87 (uncompressed) **	V
Lanthanum (57)	La 140	IV
Lead (82)	Pb 203	IV
	Pb 210	II
	Pb 212	II
Lutecium (71)	Lu 172	III
	Lu 177	IV
Magnesium (12)	Mg 28	III
Manganese (25)	Mn 52	IV
	Mn 54	IV
	Mn 56	IV
Mercury (80)	Hg 197 m	IV
	Mn 56	IV
Mercury (80)	Hg 197 m	IV
	Hg 197	IV
	Hg 203	IV
Mixed fission products MFP.		II
Molybdenum (42)	Mo 99	IV
Neodymium (60)	Nd 147	IV
	Nd 149	IV
Neptunium (93)	Np 237	I
	Np 239	I
Nickel (28)	Ni 56	III
	Ni 59	IV
	Ni 63	IV
	Ni 65	IV
Niobium (41)	Nb 93 m	IV
	Nb 95	IV
	Nb 97	IV
Osmium (76)	Os 185	IV
	Os 191 m	IV
	Os 191	IV
	Os 193	IV
Palladium (46)	Pd 103	IV
	Pd 109	IV
Phosphorus (15)	P 32	IV
Platinum (78)	Pt 191	IV
	Pt 193	IV
	Pt 193 m	IV
	Pt 197 m	IV
	Pt 197	IV
Plutonium (94)	Pu 238 (F)	I
	Pu 239 (F)	I

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See footnotes at end of table.

APPENDIX C—TRANSPORT GROUPING OF RADIONUCLIDES—Continued

Element*	Radionuclides***	Group
	Pu 240	I
	Pu 241 (F)	I
	Pu 242	I
Polonium (84)	Po 210	I
Potassium (19)	K 42	IV
	K 43	III
Praseodymium (59)	Pr 142	IV
	Pr 143	IV
Promethium (61)	Pm 147	IV
	Pm 149	IV
Protactinium (91)	Pa 230	I
	Pa 231	I
	Pa 233	II
Radium (88)	Ra 223	II
	Ra 224	II
	Ra 236	I
	Ra 228	I
Radon (86)	Rn 220	IV
	Rn 222	II
Rhenium (75)	Re 183	IV
	Re 186	IV
	Re 187	IV
	Re 188	IV
	Re Natural	IV
Rhodium (45)	Rh 103 m	IV
	Rh 105	IV
Rubidium (37)	Rb 86	IV
	Rb 87	IV
	Rb Natural	IV
Ruthenium (44)	Ru 97	IV
	Ru 103	IV
	Ru 105	IV
	Ru 106	III
Samarium (62)	Sm 145	III
	Sm 147	III
	Sm 151	IV
	Sm 153	IV
Scandium (21)	Sc 46	III
	Sc 47	IV
	Sc 48	IV
Selenium (34)	Se 75	IV
Silicon (14)	Si 31	IV
Silver (47)x11	Ag 105	IV
	Ag 110 m	III
	Ag 111	IV
Sodium (11)	Na 22	III
	Na 24	IV
Strontium (38)	Sr 85 m	IV
	Sr 85	IV
	Sr 89	III
	Sr 90	II
	Sr 91	III
	Sr 92	IV
Sulphur (16)	S 35	IV
Tantalum (73)	Ta 182	III
Technetium (43)	Tc 96 m	IV
	Tc 96	IV
	Tc 97 m	IV
	Tc 97	IV
	Tc 99 m	IV
	Tc 99	IV
Tellurium (52)	Te 125 m	IV
	Te 127 m	IV
	Te 127	IV
	Te 129 m	III
	Te 129	IV
	Te 131 m	III
	Te 132	IV
Terbium (65)	Tb 160	III
Thallium (81)	Tl 200	IV
	Tl 201	IV
	Tl 202	IV
	Tl 204	III
Thurium (90)	Th 227	II
	Th 228	I
	Th 230	I
	Th 231	I
	Th 232	III
	Th 234	II
	Th Natural	III
Thulium (69)	Tm 168	III
	Tm 170	III
	Tm 171	IV
Tin (50)	Sn 113	IV
	Sn 117 m	III
	Sn 121	III
	Sn 125	IV
Tritium (1)	H 3	IV
	H 3 (as a gas, as luminous paint, or adsorbed on solid material)	VII
Tungsten (74)	W 181	IV
	W 185	IV
	W 187	IV
Uranium (92)	U 230	II
	U 232	I
	U 233 (F)	II
	U 234	II
	U 235 (F)	III
	U 236	II
	U 238	III
	U Natural	III
	U Enriched (F)	III
	U Depleted	III
Vanadium (23)	V 48	IV
	V 49	III
Xenon (54)	Xe 125	III
	Xe 131 m	III
	Xe 131 m (uncompressed).**	V
	Xe 133	III
	Xe 133 (uncompressed).**	VI
	Xe 135	II
	Xe 135 (uncompressed).**	V
Ytterbium (70)	Yb 175	IV
Yttrium (39)	Y 88	III
	Y 90	IV
	Y 91 m	III
	Y 91	III
	Y 92	IV
	Y 93	IV
Zinc (30)	Zn 65	IV
	Zn 69 m	IV
	Zn 69	IV
Zirconium (40)	Zr 93	IV
	Zr 95	III
	Zr 97	IV

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See footnotes at end of table.

*Atomic number shown in parentheses

**Uncompressed means at a pressure not exceeding one atmosphere

***Atomic weight shown after the radionuclide symbol.

m—Metastable state.

(F) Fissile material

APPENDIX D—TESTS FOR SPECIAL FORM LICENSED MATERIAL

1. *Free Drop*—A free drop through a distance of 30 feet onto a flat essentially unyielding horizontal surface, striking the surface in such a position as to suffer maximum damage.

2. *Percussion*—Impact of the flat circular end of a 1 inch diameter steel rod weighing 3 pounds, dropped through a distance of 40 inches. The capsule or material shall be placed on a sheet of lead, of hardness numberr 3.5 to 4.5 on the Vickers scale, and not more than 1 inch thick, supported by a smooth essentially unyielding surface.

3. *Heating*—Heating in air to a temperature of 1,475° F. and remaining at that temperature for a period of 10 minutes.

[31 FR 9941]

4. *Immersion*—Immersion for 24 hours in water at room temperature. The water shall be at pH 6–pH 8, with a maximum conductivity of 10 microrahus per centimeter.

[33 FR 17621]

The record keeping and reporting requirements contained in this part have been approved by the Bureau of the Budget in accordance with the Federal Reports Act of 1942.

[31 FR 9941]

Physical Protection of Special Nuclear Material in Transit

§ 73.30 General requirements.

(a) Except as specified in § 73.38(a) or as otherwise authorized pursuant to § 73.30(f), each licensee who transports or who delivers to a carrier for transport either uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233, or plutonium, or any combination of these materials, which is 5,000 grams or more computed by the formula, grams=(grams contained U-235)+2.5 (grams U-233+grams plutonium), shall make arrangements to assure that such special nuclear material will, if a common or contract carrier is used, be transported under the established procedures of a carrier which provides a system for the physical protection of valuable material in transit and requires an exchange of hand-to-hand receipts at origin and destination and at all points enroute where there is a transfer of custody.

(b) Transit times of shipments other than those specified in § 73.1(b)(3) shall be minimized and routes shall be selected to avoid areas of natural disaster or civil disorders. Such shipments shall be preplanned to assure that deliveries occur at a time when the receiver at the final delivery point is present to accept receipt of shipment.

(c) Special nuclear material shall be shipped in containers which are sealed by tamper indicating type seals. The container shall also be locked if it is not in another container or vehicle which is locked. If inspection of the container or vehicle is not required by State or local authorities before final destination, the outermost container or vehicle shall also be sealed by tamper indicating type seals. No container weighing 500 pounds or less shall be shipped in open trucks, railroad flat cars or box cars and ships. This paragraph does not apply to shipments of quantities specified in § 73.1(b)(3).

(d) When guards are used pursuant to §§ 73.31(c)(1), 73.31(c)(2), 73.33 and 73.35, the licensee shall not permit an individual to act as a guard unless there is documentation that the individual has been qualified by demonstrating an understanding of his duties and responsibilities. The licensee or his agent shall have documentation that guards have been requalified annually.

(e) By January 7, 1974, each licensee shall submit a plan outlining the procedures that will be used to meet the requirements of §§ 73.30 through 73.36 and 73.70(g) including a plan for the selection, qualification, and training of armed escorts, or the specification and design of a specially designed truck or trailer as appropriate. This plan shall be followed by the licensee after March 6, 1974.

(f) A licensee or applicant for a license may apply to the Commission for approval of proposed procedures for transport of special nuclear material in a manner not otherwise authorized by the regulations of this part. Such application shall include a description and quantity of the special nuclear material involved, the origin and destination, the carriers to be used, the expected time in transit, the number of transfer points, the communications to be used, the vehicle visual identification, and the cargo security and surveillance measures to be used.

(g) Paragraphs (b), (c), (d), and (f) of this section are effective March 6, 1974.

§ 73.31 Shipment by road.

(a) All shipments by road shall be made without any scheduled intermediate stops to transfer special nuclear material or other cargo between the facility from which it is shipped and the facility of the receiver.

(b) All motor vehicles used to transport special nuclear material shall be equipped with a radiotelephone which can communicate with a licensee or his agent. The licensee or agent with whom communications shall be maintained for different segments of the shipment shall be predesignated before a shipment is made. Calls to such licensee or agent shall be made at least every 2 hours when radiotelephone or conventional telephone coverage along the route is available to relay position and projected route. Call frequency may extend up to 5 hours when radiotelephone or conventional telephone coverage is not available along the preplanned route, at which time a conventional telephone call shall be made. In the event no call is received in accordance with these requirements, the licensee or his agent shall immediately notify an appropriate law enforcement authority and the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part.

(c) A shipment shall be accompanied by at least two people in the vehicle containing the shipment, which may be two drivers or one driver and an authorized individual. The vehicle containing the shipment shall be under continuous visual surveillance, or one of the drivers or authorized individuals shall be in the cab of the vehicle, awake, and not in a sleeper berth. The shipment shall be further protected by one of the following methods:

(1) An armed escort consisting of at least two guards shall accompany the shipment in a separate escort vehicle. Escorts shall maintain continuous vigilance for the presence of conditions or situations which might threaten the security of the shipment, take such action as circumstances might require to avoid interference with continuous safe passage of the cargo vehicle, provide assistance to, or summon aid for crew of cargo vehicles in case of emergency, check seals and locks at each stop where time permits, and observe the cargo vehicle and adjacent areas during stops or layovers. Continuous radio communication capability shall be provided between the cargo vehicle and the escort vehicle. Escort vehicles shall also be equipped with a radiotelephone. The licensee may use his own employees as armed escorts or he may use an agent. Only the driver is required in the vehicle containing special nuclear material for shipments involving an average of less than an hour in transportation, if communication is maintained during the course of the shipment with the licensee or agent monitoring the shipment.

(2) The shipment shall be made in a specially designed truck or trailer which reduces the vulnerability to diversion. Design features of the truck or trailer shall permit immobilization of the van and provide barriers or deterrents to physical penetration of the cargo compartment unless armed guards are also used in which case immobilization of the vehicle is not required.

(d) Transfers to and from other modes of transportation shall be in accordance with § 73.35.

(e) Vehicles shall be marked on top with identifying letters or numbers which will permit identification of the vehicle under daylight conditions from the air in clear weather at 1,000 feet above ground level. The same code of letters and numbers as those used on the top shall also be marked on the sides and rear of the vehicle to permit identification from the ground.

(f) This section is effective March 6, 1974.

§ 73.32 Shipment by air.

(a) Except as specifically approved by the Nuclear Regulatory Commission, no shipment of special nuclear material shall be made in passenger aircraft in excess of (1) 20 grams or 20 curies, whichever is less, of plutonium or uranium-233, or (2) 350 grams of uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope).

(b) In shipments on cargo aircraft of either uranium-235 (contained in uranium enriched to 20 percent or more in the U-235 isotope), uranium-233 or plutonium, or any combination of these materials which is 5,000 grams or more computed by the formula, grams=(grams contained U-235) + 2.5(grams U-233 + grams plutonium), transfers shall be in accordance with § 73.35. Transfers shall be minimized.

(c) Export shipments shall be escorted by an unarmed authorized individual, who may be a crew member, from the last terminal in the United States until the shipment is unloaded at a foreign terminal. He shall perform monitoring duties at foreign terminals as described in § 73.35.

(d) Paragraph (c) of this section is effective March 6, 1974.

§ 73.33 Shipment by rail.

(a) A shipment by rail shall be escorted by two guards, in the shipment car or an escort car of the train, who shall keep the shipment cars under observation and who shall detrain at stops when practicable and time permits to guard the shipment cars under observation, and check car or container locks and seals. Radiotelephone communication shall be maintained with a licensee or his agent to relay position every 2 hours or less, and at scheduled stops in the event that radiotelephone coverage was not available in the last 5 hours before the stop. The licensee or agent with whom communications shall be maintained for different segments of the shipment shall be predesignated before a shipment is made. In the event no call is received in accordance with these requirements, the licensee or his agent shall immediately notify an appropriate law enforcement authority and the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part.

(b) Transfers shall be in accordance with § 73.35.

(c) This section is effective March 6, 1974.

§ 73.34 Shipment by sea.

(a) Shipments shall be made on vessels making the minimum ports of call. Transfers to and from other modes of transportation shall be in accordance with § 73.35. There shall be no scheduled transfers to other ships. At domestic ports of call where other cargo is transferred, the shipments shall be protected in accordance with § 73.35(a).

(b) The shipment shall be placed in a secure compartment which is locked and sealed. Locks and seals shall be periodically inspected in transit, if accessible, by an escort or crew member.

(c) Export shipments shall be escorted by an unarmed authorized individual, who may be a crew member, from the last port in the United States until the shipment is unloaded at a foreign port. He shall perform monitoring duties at foreign ports as described in § 73.35.

(d) Ship-to-shore communications shall be available, and a ship-to-shore contact shall be made every twenty-four hours to relay position information, and the status of the shipment, which shall be determined by a daily inspection where possible. This information shall be sent, as often as it is available, to the licensee or his agent who makes the arrangements for the protection of the shipment.

(e) This section is effective March 6, 1974.

§ 73.35 Transfer of special nuclear material.

All transfers shall be monitored by a guard. An alternate guard shall be designated at all transfer points to substitute, if necessary. Monitoring of special nuclear material transfers shall be conducted as follows:

(a) At scheduled intermediate stops where special nuclear material is not scheduled for transfer, the guard shall observe the opening of the cargo compartment and assure that the shipment is not removed. The guard shall maintain continuous visual surveillance of the cargo compartment. Continuous visual surveillance of the cargo compartment shall be maintained up to the time the vehicle is ready to depart. The guard shall observe the vehicle until it has departed, and shall notify the licensee or his agent of the latest status immediately thereafter.

(b) At points where special nuclear material is transferred from a vehicle to storage, from one vehicle to another, or from storage to a vehicle, the guard shall keep the shipment under continuous visual surveillance by observing the opening of the cargo compartment of the incoming vehicle and assuring that the shipment is complete by checking locks and/or seals. Continuous visual surveillance of a shipment shall be maintained at all times it is in the terminal or in storage. Shipments shall be preplanned in order to avoid storage times in excess of 24 hours. Continuous visual surveillance of the cargo compartment shall be maintained up to the time the vehicle is ready to depart from the terminal. The guard shall observe the vehicle until it has departed, and shall notify the licensee or his agent of the latest status immediately thereafter.

(c) The guard shall be required to immediately notify the carrier and the licensee who made the arrangements for protection of special nuclear material of any deviation from or attempted interference with schedule or routing.

(d) This section is effective March 6, 1974.

§ 73.36 Miscellaneous requirements.

(a) Each licensee who takes delivery of special nuclear material free on board (f.o.b.) the point at which it is delivered to a carrier for transport shall make the arrangements to assure that such special nuclear material will be protected in transit as prescribed in §§ 73.30 through 73.35, rather than the person who delivers such shipment to the carrier for transport.

(b) Each licensee who imports special nuclear material shall make arrangements to assure that such material will be protected in transit as follows:

(1) An individual designated by the licensee or his agent, or as specified by a contract of carriage, shall confirm the container count and examine locks and/or seals for evidence of tampering, at the first place in the United States at which the shipment is discharged from the arriving carrier.

(2) The shipment shall be protected at the first terminal at which it arrives in the United States and all subsequent terminals as provided in §§ 73.30 through 73.35 and paragraphs (c) and (f) of this section.

(c)(1) Each licensee who delivers special nuclear material to a carrier for transport shall immediately notify the consignee by telephone, telegraph, or teletype, of the time of departure of the shipment, and shall notify or confirm with the consignee the method of transportation, including the names of carriers, and the estimated time of arrival of the shipment at its destination. (2) In the case of a shipment free on board (f.o.b.) the point where it is delivered to a carrier for transport, each licensee shall, before the shipment is delivered to the carrier, obtain written certification from the licensee who is to take delivery of the shipment at the f.o.b. point that the physical protection arrangements required by §§ 73.30 through 73.35 for licensed shipments have been made. When a contractor exempt from the requirements for a Commission license is the consignee of a shipment, the licensee shall, before the shipment is delivered to the carrier, obtain written certification from the contractor who is to take delivery of the shipment at the f.o.b. point that the physical protection arrangements required by ERDA Manual or NRC Manual Chapters 2401 or 2405, as appropriate, have been made.

(c)(3) Each licensee who delivers special nuclear material to a carrier for transport or releases special nuclear material f.o.b. at the point where it is delivered to a carrier for transport shall also make arrangements with the consignee to be notified immediately by telephone and telegraph or teletype, of the arrival of the shipment at its destination.

(d) In addition to complying with the requirements specified in paragraphs (c) and (f) of this section, each licensee who exports special nuclear material shall comply with the requirements specified in §§ 73.30 through 73.35, as applicable, up to the first point where the shipment is taken off the vehicle outside the United States. The licensee shall also make arrangements with the consignee to be notified immediately by telephone and telegraph, teletype, or cable, of the arrival of the shipment at its destination, or of any such shipment that is lost or unaccounted for after the estimated time of arrival at its destination.

(e) Each licensee who receives a shipment of special nuclear material shall immediately notify by telephone and telegraph or mailgram, or facsimile,† the person who delivered the material to a carrier for transport and the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the arrival of the shipment at its destination. When an Energy Research and Development Administration (ERDA) license-exempt contractor is the consignee, the licensee who is the consignor shall notify by telephone and telegraph, or mailgram, or facsimile,† the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the arrival of the shipment at its destination immediately upon being notified of the receipt of the shipment by the license-exempt contractor as arranged pursuant to paragraph (c)(3) of this section. In the event such a shipment fails to arrive at its destination at the estimated time, the consignee, if a licensee, or in the case of an export shipment, the licensee who exported the shipment, shall immediately notify by telephone and telegraph, or mailgram, or facsimile,† the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of this part, and the licensee or other person who delivered the material to a carrier for transport. The licensee who made the physical protection arrangements shall also immediately notify by telephone and telegraph, or teletype, the Director of the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office listed in Appendix A of the action being taken to trace the shipment.

(f) Each licensee who makes arrangements for physical protection of a shipment of special nuclear material as required by §§ 73.30 through 73.36 shall immediately conduct a trace investigation of any shipment that is lost or unaccounted for after the estimated arrival time and file a report with the Commission as specified in § 73.71. If the licensee who conducts the trace investigation is not the consignee, he shall also immediately report the results of his investigation by telephone and telegraph, or teletype to the consignee.

(g) Paragraphs (a), (b), (c) and (d) of this section are effective March 6, 1974.

B.1.3 10 CFR §20.205, PROCEDURES FOR PICKING UP, RECEIVING, AND OPENING PACKAGES

§ 20.205 Procedures for picking up, receiving, and opening packages.

(a)(1) Each licensee who expects to receive a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section shall:

(i) If the package is to be delivered to the licensee's facility by the carrier, make arrangements to receive the package when it is offered for delivery by the carrier; or

(ii) If the package is to be picked up by the licensee at the carrier's terminal, make arrangements to receive notification from the carrier of the arrival of the package, at the time of arrival.

(2) Each licensee who picks up a package of radioactive material from a carrier's terminal shall pick up the package expeditiously upon receipt of notification from the carrier of its arrival.

(b)(1) Each licensee, upon receipt of a package of radioactive material, shall monitor the external surfaces of the package for radioactive contamination caused by leakage of the radioactive contents, except:

(i) Packages containing no more than the exempt quantity specified in the table in this paragraph;

(ii) Packages containing no more than 10 millicuries of radioactive material consisting solely of tritium, carbon-14, sulfur-35, or iodine-125;

(iii) Packages containing only radioactive material as gases or in special form;

(iv) Packages containing only radioactive material in other than liquid form (including Mo-99/Tc-99m generators) and not exceeding the Type A quantity limit specified in the table in this paragraph; and

(v) Packages containing only radionuclides with half-lives of less than 30 days and a total quantity of no more than 100 millicuries.

The monitoring shall be performed as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or eighteen hours if received after normal working hours.

(2) If removable radioactive contamination in excess of 0.01 microcuries (22,000 disintegrations per minute) per 100 square centimeters of package surface is found on the external surfaces of the package, the licensee shall immediately notify the final delivering carrier and, by telephone and telegraph, mailgram, or facsimile,† the appropriate Nuclear Regulatory Commission Inspection and Enforcement Regional Office shown in Appendix D.

TABLE OF EXEMPT AND TYPE A QUANTITIES

Transport group[1]	Exempt quantity limit (in millicuries)	Type A quantity limit (in curies)
I	.01	0.001
II	0.1	0.050
III	1	3
IV	1	20
V	1	20
VI	1	1000
VII	25,000	1000
Special Form	1	20

(c)(1) Each licensee, upon receipt of a package containing quantities of radioactive material in excess of the Type A quantities specified in paragraph (b) of this section, other than those transported by exclusive use vehicle, shall monitor the radiation levels external to the package. The package shall be monitored as soon as practicable after receipt, but no later than three hours after the package is received at the licensee's facility if received during the licensee's normal working hours, or 18 hours if received after normal working hours.

(2) If radiation levels are found on the external surface of the package in excess of 200 millirem per hour, or at three feet from the external surface of the package in excess of 10 millirem per hour, the licensee shall immediately notify by telephone and telegraph, mailgram, or facsimile, the director of the appropriate NRC Regional Office listed in Appendix D, and the final delivering carrier.

(d) Each licensee shall establish and maintain procedures for safely opening packages in which licensed material is received, and shall assure that such procedures are followed and that due consideration is given to special instructions for the type of package being opened.

B.2 DEPARTMENT OF TRANSPORTATION REGULATIONS

B.2.1 49 CFR §173.393, GENERAL PACKAGING AND SHIPPING REQUIREMENTS

§ 173.393 General packaging and shipment requirements.

(a) Unless otherwise specified, all shipments of radioactive materials must meet all requirements of this section, and must be packaged as prescribed in §§ 173.391 through 173.396.

(b) The outside of each package must incorporate a feature such as a seal, which is not readily breakable and which, while intact, will be evidence that the package has not been illicitly opened.

(c) The smallest outside dimension of any package must be 4 inches or greater.

(d) Each radioactive material must be packaged in a packaging which has been designed to maintain shielding efficiency and leak tightness, so that, under conditions normally incident to transportation, there will be no release of radioactive material. If necessary, additional suitable inside packaging must be used. Each package must be capable of meeting the standards in §§ 173.398(b) and 173.24.

(1) Internal bracing or cushioning, where used, must be adequate to assure that, under the conditions normally incident to transportation, the distance from the inner container or radioactive material to the outside wall of the package remains within the limits for which the package design was based, and the radiation dose rate external to the package does not exceed the transport index number shown on the label. Inner shield closures must be positively secured to prevent loss of the contents.

(e) The packaging must be designed, constructed, and loaded so that during transport:

(1) The heat generated within the package because of the radioactive materials present will not, at any time during transportation, affect the efficiency of the package under the conditions normally incident to transportation, and

(2) The temperature of the accessible external surfaces of the package will not exceed 122° F. in the shade when fully loaded, assuming still air at ambient temperature. If the package is transported in a transport vehicle consigned for the sole use of the consignor, the maximum accessible external surface temperature shall be 180° F.

(f) Pyrophoric materials, in addition to the packaging prescribed in this subpart, must also meet the packaging requirements of § 173.134 or § 173.154. Pyrophoric radioactive liquids may not be shipped by air.

(g) Liquid radioactive material in Type A quantities must be packaged in or within a leak-resistant and corrosion-resistant inner containment vessel. In addition:

(1) The packaging must be adequate to prevent loss or dispersal of the radioactive contents from the inner containment vessel if the package were subjected to the 9 meter (30-foot) drop test prescribed in § 173.398(c)(2)(i); and either

(2) Enough absorbent material must be provided to absorb at least twice the volume of radioactive liquid contents. The absorbent material may be located outside the radiation shield only if it can be shown that if the radioactive liquid contents were taken up by the absorbent material the resultant dose rate at the surface of the package would not exceed 1,000 millirem per hour; or

(3) A secondary leak-resistant and corrosion-resistant containment vessel must be provided to retain the radioactive contents under the normal conditions of transport as prescribed in § 173.398(b), assuming the failure of the inner primary containment vessel.

(h) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(i) Except for shipments described in paragraph (j) of this section, all radioactive materials must be packaged in suitable packaging (shielded, if necessary) so that at any time during the normal conditions incident to transportation the radiation dose rate does not exceed 200 millirem per hour at any point on the external surface of the package, and the transport index does not exceed 10.

(j) Packages for which the radiation dose rate exceeds the limits specified in paragraph (i) of this section, but does not exceed at any time during transportation any of the limits specified in paragraphs (j)(1) through (4) of this section may be transported in a transport vehicle which has been consigned as exclusive use (except aircraft). Specific instructions for maintenance of the exclusive use (sole use) shipment controls must be provided by the shipper to the carrier. Such instructions must be included with the shipping paper information:

(1) 1,000 millirem per hour at 3 feet from the external surface of the package (closed transport vehicle only);

(2) 200 millirem per hour at any point on the external surface of the car or vehicle (closed transport vehicle only);

(3) Ten millirem per hour at any point 2 meters (six feet) from the vertical planes projected by the outer lateral surface of the car or vehicle; or if the load is transported in an open transport vehicle, at any point 2 meters (six feet) from the vertical planes projected from the outer edges of the vehicle.

(4) 2 millirem per hour in any normally occupied position in the car or vehicle, except that this provision does not apply to private motor carriers.

(k) [Reserved]

(l) Packages consigned for export are also subject to the regulations of the foreign governments involved in the shipment. See §§ 173.8, 173.9, and 173.393b. (The regulations of the International Atomic Energy Agency (IAEA) are used by most foreign governments.)

(m) Prior to the first shipment of any package, the shipper shall determine by examination or appropriate test that:

(1) The packaging meets the specified quality of design and construction; and

(2) The effectiveness of the shielding and containment, and, where necessary, the heat transfer characteristics of the package are within the limits applicable to or specified for the package design.

(n) Prior to each shipment of any package, the shipper shall insure by examination or appropriate test that:

(1) The package is proper for the contents to be shipped;

(2) The packaging is in unimpaired physical condition except for superficial marks;

(3) Each closure device of the packaging, including any required gasket, is properly installed and secured and free of defects;

(4) For a fissile material, any moderator and neutron absorber, if required, is present in proper condition;

(5) Any special instructions for filling, closing, and preparation of the package for shipment have been followed;

(6) Each closure, valve, and any other opening of the containment system through which the radioactive content might escape is properly closed and sealed;

(7) Each package containing liquid in excess of a Type A quantity and destined for air shipment is tested to demonstrate that it is leak tight under an ambient atmospheric pressure differential of at least 0.5 atmosphere (absolute) (7.3 p.s.i.a. or 0.5 kg./cm.^{2}); the test may be conducted on the entire containment system or on any receptacle or vessel within the containment system, as appropriate to determine compliance with the requirement;

(8) If the maximum normal operating pressure of a package is likely to exceed 0.35 kg./cm.^{2} (gage), the internal pressure of the containment system will not exceed the design pressure during transportation; and

(9) External radiation and contamination levels are within the allowable limits.

(o) No person may offer for transportation a package of radioactive materials until the temperature of the packaging system has reached equilibrium (see also paragraph (e) of this section) unless, for the specific contents, he has ascertained that the maximum applicable surface temperature limits cannot be exceeded.

(p) No person may offer for transportation aboard a passenger carrying aircraft any radioactive material unless that material is intended for use in, or incident to, research, or medical diagnosis or treatment, or is excepted under the provisions of § 175.10 of this subchapter.

[Amdt 173-3, 33 FR 14926, Oct. 4, 1968, as amended by Amdt. 173-6, 34 FR 7162, May 1, 1969, Amdt. No 173-66, FR 17970, Sept. 2, 1972; Amdt. 173-90, 39 FR 45241, Dec. 31, 1974; Amdt. 173-94A, 41 FR 40684, Sept. 20, 1976]

§ 173.391 Limited quantities of radioactive materials and radioactive devices.

(a) Limited quantities of radioactive materials in normal form not exceeding 0.01 millicurie of Group I radionuclides; 0.1 millicurie of Group II radionuclides; 1 millicurie of Groups III, IV, V, or VI radionuclides; 25 curies of Group VII radionuclides; tritium oxide in aqueous solution with a concentration not exceeding 0.5 millicuries per milliliter and with a total activity per package of not more than 3 curies; or 1 millicurie of radioactive material in special form; and not containing more than 15 grams of uranium-235 are excepted from specification packaging, marking, and labeling, and are excepted from the provisions of § 173.393, if the following conditions are met:

(1) The materials are packaged in strong tight packages such that there will be no leakage of radioactive materials under conditions normally incident to transportation.

(2) The package must be such that the radiation dose rate at any point on the external surface of the package does not exceed 0.5 millirem per hour.

(3) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(4) The outside of the inner container must bear the marking "Radioactive."

(b) Manufactured articles such as instruments, clocks, electronic tubes or apparatus, or other similar devices, having limited quantities of radioactive materials (other than liquids) in a nondispersible form as a component part, are excepted from specification packaging, marking, and labeling, and are excepted from the provisions of § 173.393, if the following conditions are met:

NOTE 1: For radioactive gases, the requirement for the radioactive material to be in a nondispersible form does not apply.

(1) Radioactive materials are securely contained within the devices, or are securely packaged in strong, tight packages, so that there will be no leakage of radioactive materials under conditions normally incident to transportation.

(2) The radiation dose rate at four inches from any unpackaged device does not exceed 10 millirem per hour.

(3) The radiation dose rate at any point on the external surface of the outside of the package may not exceed 0.5 millirem per hour. However, for exclusive use shipments only, the radiation at the external surface of the package or the item may exceed 0.5 millirem per hour, but must not exceed 2 millirem per hour.

(4) There must be no significant removable radioactive surface contamination on the exterior of the package (see § 173.397).

(5) The total radioactivity content of a package containing radioactive devices must not exceed the quantities shown in the following table:

Transport group	Quantity in curies	
	Per device	Per package
I	0.0001	0.001
II	0.001	0.05
III	0.01	3
IV	0.05	3
V or VI	1	1
VII	25	200
Special form	0.05	20

(6) No package may contain more than 15 grams of fissile material.

(c) A manufactured article, other than a reactor fuel element, in which the only radioactive material is metallic natural or depleted uranium or natural thorium or alloys thereof, is excepted from specification packaging, marking, and labeling, and is excepted from the provisions of § 173.393, if the following conditions are met:

(1) The radiation dose rate at any point on the external surface of the outside container does not exceed 0.5 millirem per hour;

(2) There must be no significant radioactive surface contamination on the exterior of the package. To determine whether "significant," the standard in § 173.397 must be used.

(3) The total radioactivity content of each article must not exceed 3 curies.

(4) The outer surface of the uranium or thorium is enclosed in a non-radioactive, sealed, metallic sheath.

NOTE: Such articles may be packagings for the transportation of radioactive materials.

(d) Shipments made under this section for transportation are not subject to Subpart F of Part 172 of this subchapter, to Part 174 of this subchapter except § 174.24 and to Part 177 of this subchapter except § 177.817.

APPENDIX C
PLUTONIUM

C.1 HISTORICAL BACKGROUND (Refs. C-1 and C-2)

The element plutonium was first artificially formed by deuteron bombardment of uranium oxide:

$$_{92}U^{238} + {}_1H^2 \longrightarrow {}_{93}Np^{238} + 2n$$

$$_{93}Np^{238} \xrightarrow[\text{(2.1 days)}]{\beta-} {}_{94}Pu^{238}$$

This was performed in February 1941 by Arthur Wall, Glenn T. Seaborg, and Joseph Kennedy at the University of California at Berkeley using a 152 cm (60-inch) cyclotron. When an isotope (Pu-239) of the new element was shown to be fissionable in March 1941, continuing research became shrouded in the secrecy of the Manhattan Project.

The initial focus of plutonium research was aimed at production of enough Pu-239 to manufacture a nuclear weapon. The only practical means of accomplishing this task was through the use of thermal reactors with sufficient neutron flux to produce significant quantities of the material through the following capture/decay chain:

$$_{92}U^{238} + n \longrightarrow {}_{92}U^{239} \xrightarrow[\text{(23.5 min)}]{\beta-} {}_{93}Np^{239} \xrightarrow[\text{(2.33 days)}]{\beta-} {}_{94}Pu^{239}$$

With the advent of the Atoms for Peace program, the thrust of the plutonium research program was directed toward the possibilities of using Pu-239 as a reactor fuel as well as exploiting the useful aspects of other plutonium isotopes.

In the 35 years since its initial manufacture, plutonium has become one of the most studied and best understood heavy elements in the periodic table.

C.2 CHEMISTRY AND METALLURGY

Plutonium is the fifth element in the actinide series. It is a reactive silvery-white metal that can exist in four valence states (+3, +4, +5, +6), with the +4 state being the most stable under physiological conditions (Ref. C-3). It rapidly oxidizes in moist air, forming mixtures of oxides and hydrides. Plutonium reacts with all common gases at elevated temperatures, is soluble in most dilute acids and in most mineral acids, and forms numerous organic and inorganic compounds (Ref. C-4).

Metallurgically, plutonium is very unusual. It exhibits six distinct allotropic phases and is a very dense metal (19.86 g/cm^3 in the most dense form) with a low melting point (640°C). It has a very low latent heat of fusion (2856 Joule/g-atom) and is second only to manganese in the magnitude of its electrical resistivity (1.45 microohm-m at room temperature).

C.3 NUCLEAR PROPERTIES (Refs. C-4 and C-5)

Fifteen isotopes of plutonium, Pu-232 to Pu-246, have been identified. The most common isotope, Pu-239, has a 24,390 year half-life and decays by energetic alpha emission (4.64 to 5.16 meV (Ref. C-6)). This isotope is used in nuclear weapons and is a potential fuel for nuclear reactors because of its high thermal neutron fission cross-section and high neutron yield.

Pu-238 is another important plutonium isotope. Because of its energetic alpha particles (4.7 to 5.5 MeV (Ref. C-6)) and relatively short half-life (86.4 years), it has been used as an isotopic heat source for cardiac pacemakers and for thermoelectric power generation devices such as the SNAP systems used in lunar missions.

The isotopes Pu-240, Pu-241, and Pu-242 are formed from Pu-239 by successive neutron capture. Of these three, Pu-241 is a relatively short-lived (13 years) beta emitter whose daughter product, americium-241, is used in neutron sources. Am-241 is a relatively long-lived (458 years) alpha emitter that constitutes a radiological health hazard comparable to Pu-239 on a dose per curie basis.

In this study, three types of plutonium shipments are considered: shipments of pure isotopic material (i.e., Pu-238 or Pu-239), shipments of uranium-plutonium mixtures, and shipments of light-water-reactor-produced plutonium. Table C-1 lists the specific activitity (curies per gram) and the biological hazard from inhalation (rem per curie inhaled) for some isotopes of plutonium, americium, and curium. Clearly, the biological hazard of a shipment of plutonium is highly dependent on its isotopic makeup. In the case of plutonium associated with the nuclear fuel cycle, the isotopic content and dosimetric impact predicted in Reference C-10 (see Table C-2) were used.

C.4 PHYSIOLOGICAL ASPECTS

The data base for conclusions concerning the physiological effect of plutonium exposure in man is quite limited. It consists of five principal sources:

1. A group of 25 Los Alamos Scientific Laboratory personnel who were exposed to plutonium during the early 1940s (Ref. C-11),

2. A group of 18 critically ill people who were injected with plutonium in the late 1940s (Ref. C-12),

3. 452 members of the United States Transuranium Registry (Ref. C-13),

TABLE C-1

SPECIFIC ACTIVITY AND DOSE COMMITMENT FROM

SOME ISOTOPES OF PLUTONIUM, AMERICIUM, AND CURIUM (Refs. C-7, C-9)

Isotope	Specific Activity (ci/gm)	Type of Radiation	50-Year Bone Dose (rem/ci inhaled)	50-Year Lung Dose (rem/ci inhaled)
Pu-238*	17.1	α	7.6×10^{8}	3.1×10^{8}
Pu-239*	0.06	α	8.7×10^{8}	2.9×10^{8}
Pu-240*	0.228	α	8.7×10^{8}	2.9×10^{8}
Pu-241*	98.98	β	1.7×10^{7}	5.9×10^{5}
Pu-242**	0.00382	α	5.5×10^{8}	4.6×10^{8}
Am-241*	3.43	α	9.0×10^{8}	3.2×10^{8}
Cm-243**	46.0	α	2.8×10^{8}	5.3×10^{8}
Cm-244*	83.3	α n	4.2×10^{8}	3.1×10^{8}
Cm-246*	0.26	α	4.1×10^{8}	5.1×10^{8}

*Dose from Reference C-7 with 1 μ median diameter.

**Dose from Reference C-9 with 1 μ median diameter.

ISOTOPIC CONTENT (WEIGHT PERCENT) AND DOSIMETRIC IMPACT OF VARIOUS MIXTURES OF PLUTONIUM ASSOCIATED WITH LIGHT-WATER REACTORS (Refs. C-8, C-10)

Isotope	High-Burnup LWR Fuel*	Predicted 1990 Industry Average	Predicted Equilibrium Recycle
Pu-238	1.9	1.2	3.4
Pu-239	63.0	53.0	41.7
Pu-240	19.0	25.8	27.1
Pu-241	12.0	13.5	15.4
Pu-242	3.8	6.0	11.7
Am-241	0.6	0.7	0.7
Specific Activity (ci/gm)**	12.3 (0.4)	13.68 (0.32)	15.93 (0.69)
50 year lung dose (rem/ci)***	1.06×10^7	7.13×10^6	1.85×10^7
50 year bone dose (rem/ci)***	3.47×10^7	3.5×10^7	5.03×10^7

*35,000 MWD/tonne Yankee fuel
**Values for the alpha component of activity are shown in parentheses
***Including both α and β components.

4. A group of 25 Rocky Flats workers exposed to aerosolized plutonium during a fire in October 1965 (Ref. C-14), and

5. Approximately 200 accidental exposure cases among other government contractors (Ref. C-15).

Because of the nature of these exposures (largely accidental), detailed and accurate dosimetry is not possible. However, there has been no evidence of cancer, other illnesses, or death that can be attributed unequivocably to plutonium exposure in human beings. A large amount of experimental data has been gathered concerning the behavior of various chemical and physical forms of plutonium in several species of animals (dogs, rats, pigs, sheep, and primates), and inferences concerning man can be drawn from these data.

Under the circumstances of an accidental exposure, the plutonium will be deposited on the skin, in a wound, in the gastrointestinal tract, or in the respiratory tract. After this deposition, plutonium may be transported by the blood or lymphatic system to other organs or tissues of the body or it may be eliminated directly. The rate and amount of translocation and the eventual destination are strongly dependent on the site of deposition and the physical and chemical properties of the plutonium compound (Ref. C-16) to which the person was exposed.

C.4.1 SKIN DEPOSITION

Animal data on systemic uptake of plutonium through intact or abraded skin show wide variations. The largest observed uptake in animals was 1-2% with $Pu(NO_3)_4$ in 10M HNO_3 through rat skin. The degree of absorption seems to be strongly influenced by the area of skin exposed, the mass of plutonium applied, and the pathological effects of the solvent on the skin (Refs. C-3 and C-16). Plutonium appears to be less extensively absorbed through human skin. In two cases where humans have been exposed to plutonium-bearing solutions with significant plutonium concentrations, absorption (as determined from urinalysis data) was less than 2×10^{-7} of the incident amount (Refs. C-4 and C-16). If plutonium is introduced into a puncture wound, abrasion, or cut, a higher percentage (0.3% to 2.7%) may be absorbed (Ref. C-4). The remainder is sloughed from the wound by normal healing and drainage processes. Using the very limited data base, it appears that most of the material absorbed from wounds translocates to bone or liver tissue (Ref. C-16).

C.4.2 GASTROINTESTINAL TRACT DEPOSITION

The presence of large amounts of plutonium in the gastrointestinal (GI) tract following an accident would not normally be expected. The two routes to the GI tract are consumption of contaminated foodstuffs and passage from the nasopharyngeal or tracheobronchial regions of the respiratory tract. The presence of significant quantities of plutonium in food is unlikely because of its very low uptake by plant roots. Under ideal conditions for plant uptake, only .0002 of the concentration in soil appeared in the plants growing there (Ref. C-17). Even if soluble plutonium enters the GI tract, only a small fraction is absorbed. This low absorption is a result of the hydrolysis of the soluble salt to form insoluble species (Ref. C-3). Experimental values for rats and pigs range from 7×10^{-7} for PuO_2 to 1.9×10^{-2} for $Pu(NO_3)_4$ (Refs. C-3 and C-16). The material absorbed is translocated mostly to skeletal structure and, to a lesser extent, to the liver. The amount of absorption appears to be strongly dependent on the valence of available Pu ions and on the pH of the administered solution. In fact, the maximum value of 2% was for a highly acid nitrate that man would not normally encounter (Ref. C-17). The maximum permissible concentration (MPC) for Pu in water set by the ICRP is based on 0.003% absorption, which is conservative based on the pH data.

C.4.3 RESPIRATORY DEPOSITION

Because of the chemical nature of plutonium, deposition of insoluble particles, probably oxides, in the respiratory tract is considered the most likely route to man (Ref. C-18). Once the particles enter the respiratory tract, their behavior is very dependent upon the particle size and solubility. The various pathways that may be taken are shown in Figure C-1. The effect of particle size on deposition location is illustrated in Figure C-2 and discussed in greater detail below.

Large particles (>10 microns in equivalent aerodynamic diameter) are filtered out of the inspired air by the cilia in the nasopharyngeal passages. They are captured in the mucoid lining of the passages, transported with the mucus drainage, and eventually swallowed (pathway b on Figure C-1). Intermediate sized particles (1 to 10 microns in equivalent aerodynamic diameter) are deposited principally in the pulmonary or nasopharyngeal region with a small fraction depositing in the tracheobronchial region (Refs. C-7 and C-8). Some of these particles also become entrained in the mucoid lining and are moved upward towards the pharynx by mucociliary action for eventual deposition into the upper GI tract (pathway d in Figure C-1). In addition, a small number of these particles are dissolved in blood (pathway c on Figure C-1). Small particles (<1 micron in equivalent aerodynamic diameter) are preferentially deposited in the pulmonary region. They come in direct contact with the alveoli and are rapidly phagocytized* and localized in the reticuloendothelial cells of the alveoli (Ref. C-16).

Soluble plutonium readily diffuses from the reticuloendothelial cells of the alveoli into the blood and lymphatic systems and is translocated into skeletal and liver tissue with a clearance half-time of 150-200 days (Ref. C-16).

Insoluble plutonium, notably PuO_2, has much longer lung clearance half-time (200-1000 days). Clearance mechanisms include tracheobronchial mucociliary action (pathways f and k on Figure C-1), some dissolution (pathway e on Figure C-1), and lymphatic absorption (pathway g on Figure C-1). The overall pattern of the plutonium translocation (in beagles) is shown on Figure C-3. The buildup in the thoracic lymph nodes appears to be an endpoint in that there is very little movement of the plutonium from the thoracic lymph nodes to systemic blood (pathway h on Figure C-1).

Studies indicate that different isotopes of plutonium may exhibit different biological behavior. For instance, Pu-238 appears to translocate faster than other plutonium isotopes,

*Phagocytosis is a process by which special cells, such as white blood cells, rid the body of bacteria and unwanted debris in the tissue. During phagocytosis, the foreign matter is actually surrounded and ingested by the cell (Ref. C-19).

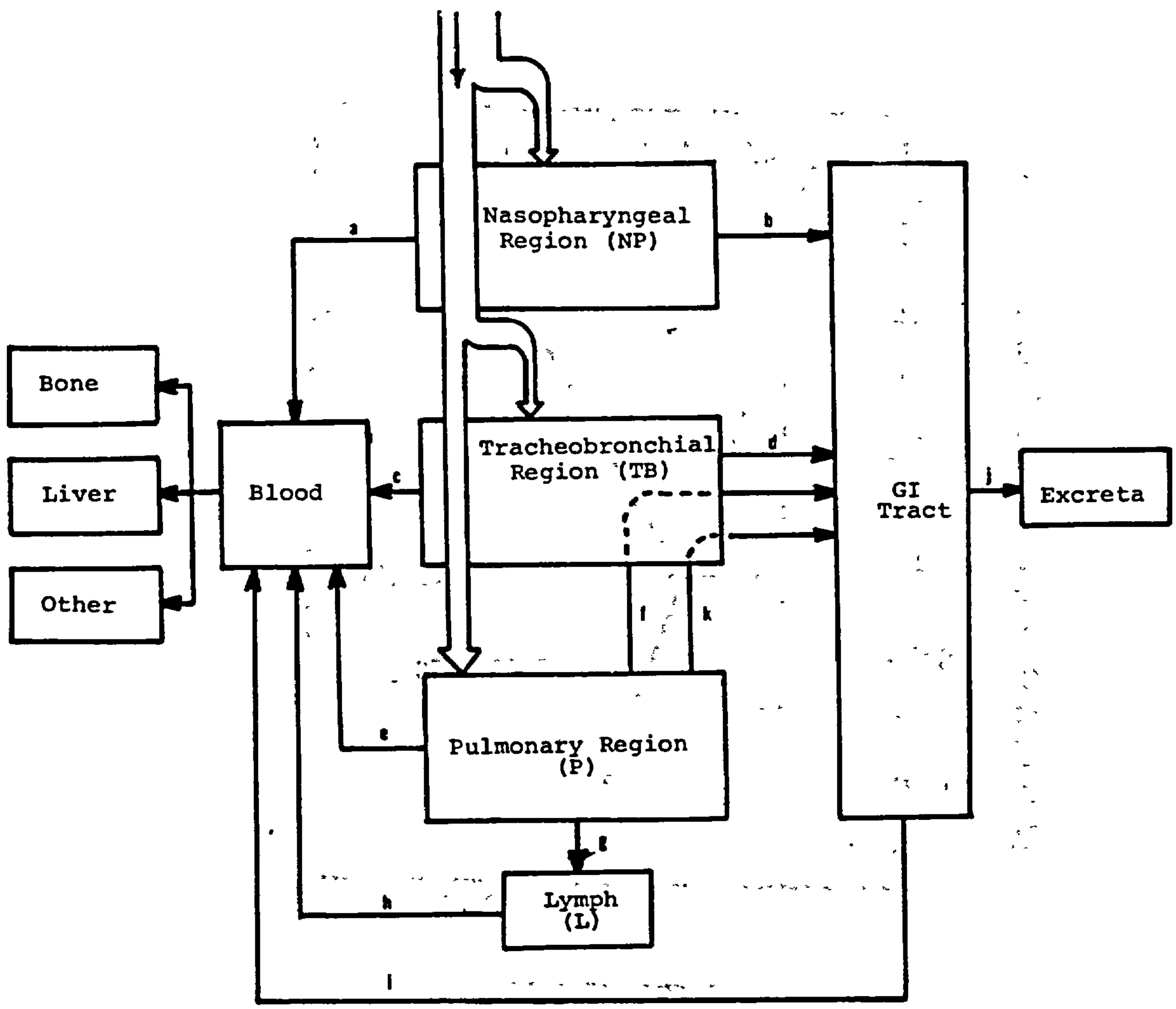

FIGURE C-1. BIOLOGICAL PATHWAYS FOR INHALED MATERIAL (Refs. C-3, C-7, C-19, C-20)

(a) Nasopharyngeal absorption in blood

(b) and (d) Mucociliary translocation to upper GI tract

(c) Tracheobronchial absorption in blood

(e) Alveolar diffusion

(f) Short-term and (k) long-term mucociliary translocation of phagocytized material to tracheobronchial region

(g) Absorption into lymphatic system

(h) Transfer to venous system

(i) Gastrointestinal absorption in blood

(j) Excretion from GI tract as feces or absorption from GI tract and excretion as urine

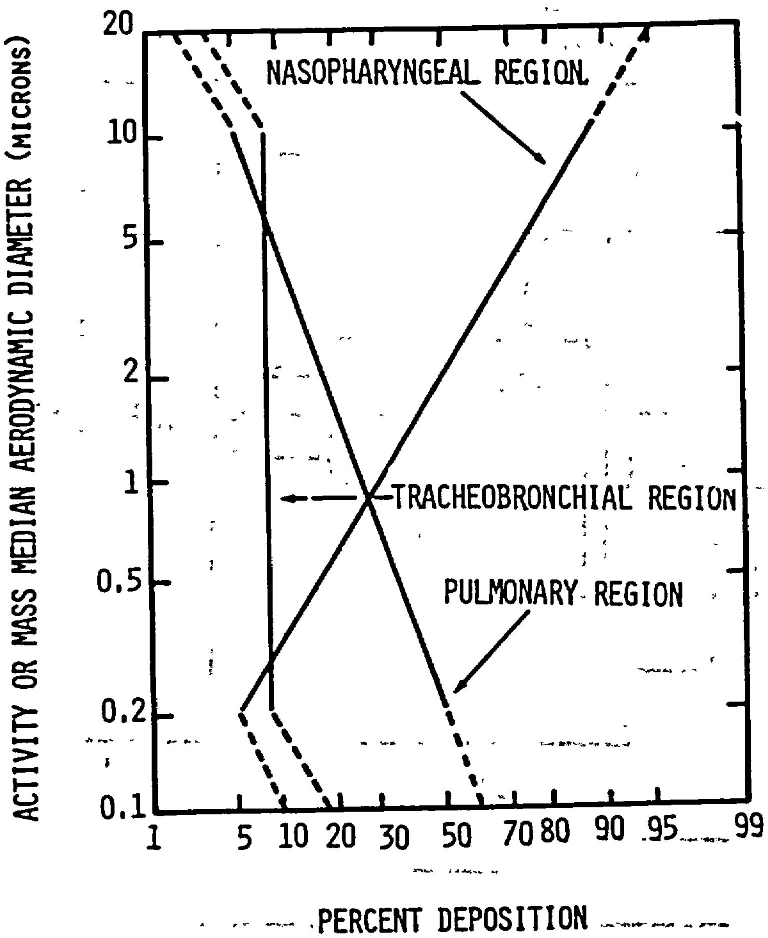

FIGURE C-2. DEPOSITION MODEL (Ref. C-7).

The radioactive or mass fraction of an aerosol that is deposited in the nasopharyngeal, tracheobronchial, and pulmonary regions is given in relation to the activity of mass median aerodynamic diameter (AMAD) or (MMAD) of the aerosol distribution. The model is intended for use with aerosol distributions that have an AMAD or MMAD between 0.2 and 10 microns with geometric standard deviations of less than 4.5. Provisional deposition estimates further extending the size range are given by the broken lines. For the unusual distribution having an AMAD or MMAD greater than 20 microns, complete nasopharyngeal deposition can be assumed. The model does not apply to aerosols with AMADs or MMADs below 0.1 micron.

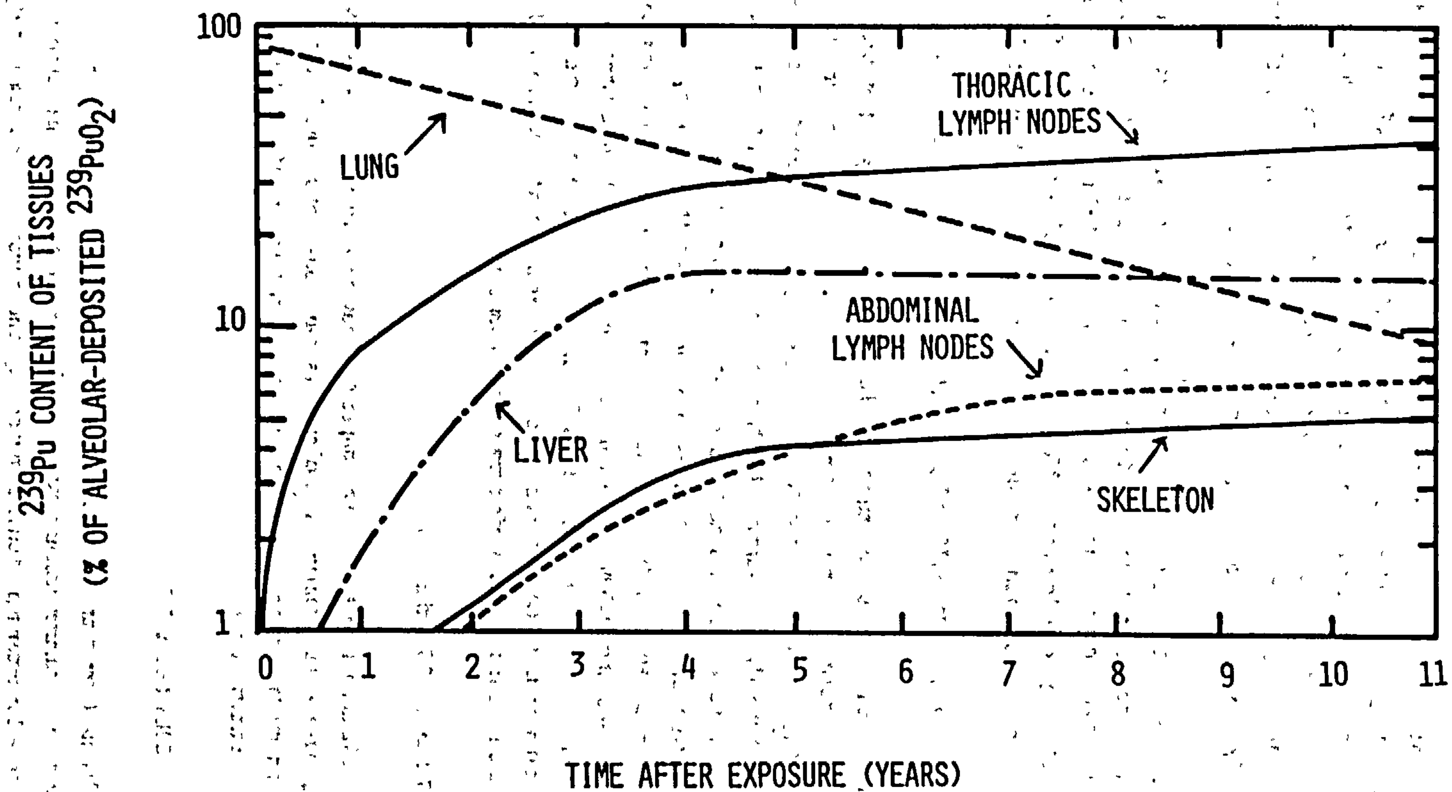

FIGURE C-3. TRANSLOCATION OF PULMONARY-DEPOSITED Pu-239 IN BEAGLE DOGS (Ref. C-16).

apparently due to particle disintegration or surface fragmentation caused by its higher specific activity.

C.5 BIOLOGICAL EFFECTS

The effects of plutonium on tissue are largely a function of the high-energy alpha and beta radiation emitted during radioactive decay. Because of the nature of alpha and beta particles, their energy deposition occurs in a relatively small amount of body tissue. When tissue of laboratory animals is exposed to a sufficient quantity of plutonium, the energy deposition results in early effects ranging over several degrees of illness including death. In smaller doses, the radiation appears to act as a carcinogenic agent.

It should be noted here that no evidence of cancer, other illness, or death that can be attributed unequivocably to accidental or intentional plutonium exposure in human beings has occurred (Refs. C-4, C-11, C-12, C-13, C-14, C-15, C-16, C-17, and C-18). This record does not exclude the possibility of long-term low-dose effects that may require more than 20-30 years to reveal themselves. Specific effects within organs of interest are discussed in detail below.

C.5.1 EFFECTS ON SKELETAL AND HEMATOPOIETIC SYSTEMS (Refs. C-3, C-4, C-16, C-19, and C-21)

If plutonium is translocated to skeletal sites, it is preferentially deposited on the bone surfaces. Depending on the rate of growth or remodeling of the bone (and hence on the age of the exposed individual) the deposit may remain on the surface or be buried. Very large bone accumulations of plutonium result in suppressed osteogenesis and eventual tissue necrosis. At lower doses, pathological bone fractures may occur. At low doses, the incidence of osteogenic sarcoma also shows a marked increase. All of these effects are on the skeletal tissue itself. The effect on hematopoietic tissue within the bone structure can result in depression of granular leukocytes at low doses and lymphophenia at higher doses. The evidence from either experimental or clinical studies that plutonium produces leukemia is, at present, scanty. However, theoretical consideration and clinical investigation of persons injected with Th-232 indicate that leukemia should not be excluded as a risk from plutonium exposure.

C.5.2 EFFECT ON LIVER (Refs. C-16 and C-17)

Very low doses of plutonium to the liver appear to have no effect in laboratory animals. As the dose increases, bile duct tumors and cirrhosis have been observed although bile duct tumors also occurred in control animals. The correlation of liver results from animals to man remains somewhat unclear at this time.

C.5.3 EFFECT ON LYMPH NODES (Ref. C-16)

It has been concluded from the rodent and dog experiments that the lymph nodes are not especially susceptible to the carcinogenic action of alpha radiation from plutonium. However, the question of possible long-term plutonium-induced lymphosarcoma is not completely addressed by these results. Information obtained from long-term studies on occupationally exposed plutonium workers should provide more definitive information on lymph-system effects.

C.5.4 EFFECTS ON LUNGS (Refs. C-16 and C-22)

The data on plutonium effects in the lungs are heavily based on beagle experiments. Large deposits (>0.5 μCi/g of lung) in the pulmonary tissue of these animals have caused severe inflammation, edema, hemorrhage, and death within a relatively short period of time (1 week). At somewhat lower doses (0.05 - 0.1 μCi/g of lung) pulmonary fibrosis occurs, resulting in respiratory insufficiency and eventual death. At lower deposition levels (0.6 to 14 μCi total lung burden), bronchiolo-alveolar carcinomas have developed. Although the pathogenesis is not well known, it appears that the bronchiolo-alveolar carcinogenesis may be related to the fibrotic repair of the localized radiation damage.

C.5.5 GENETIC EFFECTS (Ref. C-23)

It has been known for several years that doses of high linear energy transfer (LET) radiation are more effective at producing somatic damage than low-LET radiation. However, the correlation of LET to mutation induction has not been well established. Based on recent mouse data, it appears that the RBE for genetic effects from low doses and dose rates of high LET radiation may be higher than anticipated. However, the ICRP feels that the quality factors in use are adequate. In view of the very small gonadal uptake of plutonium, the genetic risk is clearly less than the risk to lung or skeletal tissue.

C.5.6 MITIGATION OF PLUTONIUM CONTAMINATION (Ref. C-16)

Several techniques have been developed to mitigate the effects of plutonium exposure. The most common method of dealing with exposure to soluble plutonium compounds involves intravenous injection of DTPA (diethylenetinaminepentacetic acid). This acid forms stable plutonium complexes and increases urinary excretion of the element, in some cases by orders of magnitude.

In cases involving insoluble pulmonary plutonium deposits, pulmonary lavage with physiological saline has been used with some success. This is a relatively high-risk medical procedure, however, so the actual hazard of the deposited material must be carefully evaluated.

C.6 PLUTONIUM TOXICITY

The toxicity of plutonium has been the subject of considerable discussion. It has been alleged that plutonium is one of the most potent respiratory carcinogens known (Refs. C-24 and C-25). These assertions are based on two principal premises:

1. The so-called "hot particle" theory, which states that the dose received by an organ should be computed using the very small mass of irradiated tissue surrounding the deposited particle rather than the entire organ mass (Ref. C-24) and

2. The ciliary impairment that is alleged to be present in smokers (Ref. C-26).

Neither of these theories has gained widespread acceptance in the medical or health physics communities, and both have been strongly refuted by experts in the specific areas (Refs. C-18, C-27, C-28, C-29, C-30, C-31, and C-32)

The more widely accepted feeling is that, although plutonium is certainly a potent carcinogen, it is not "the most toxic substance known to man." As an acute toxin, plutonium is much less potent than several of the substances considered as "super toxins" shown in Table C-3 (Ref. C-33). As a carcinogen, comparison with chemical substances is more tenuous due to a multitude of units and exposure periods, although attempts have been made (Refs. C-20 and C-34). Comparisons of long-term toxicity have been made, however, with other radioactive materials (Ref. C-33) based on maximum permissible concentrations, and these results show plutonium to be the isotope of highest risk to bone from inhalation but of comparable or less risk than that of other isotopes in terms of ingestion hazard and hazaru to other organs.

TABLE C-3

ACUTE TOXICITY OF SOME SUBSTANCES (REF. C-33)

Substances	Criterion**	Species	Route++	Quantity* (per kg body weight)
Botulinus toxin A	LD_{50}	Mouse	Ipr	3×10^{-6} µg/kg
Botulinus toxin A (crystalline)	LD_{50}	Mouse	Ipr	7×10^{-9} µg/kg
Tetanus toxin	LD_{50}	Mouse	Ipr	1×10^{-4} µg/kg
Diptheria toxin	LD_{50}	Mouse	Ipr	0.3 µg/kg
Nerve Gas				
GB	50% deaths in 1-2 hr.	Human	INH	16 µg/kg+
VX	"	Human	INH	8 µg/kg+
Bufotoxin	LD_{50}	Cat	IV	390 µg/kg
Curare	LD_{50}	Mouse	Ipr	500 µg/kg
Strychnine	LD_{50}	Mouse	Ipr	500 µg/kg
Pu-239	$LD_{50/30}$	Dog	INH	500-800 µg/kg
Pu-239	$LD_{50/30}$	Rat	INH	2000 µg/kg

*After Wacholz (1975) assuming a 75 kg man and 17 liter/min breathing rate.

**The items marked LD_{50} are actually the lowest figures found in the literature for classical LD_{50}. Except for the confusion of terminology engendered, they might be labelled "LD_{LO}."

+Estimate.

++Ipr - percentaneous injection; INH - inhalation; IV - intravenously.

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APPENDIX D

POPULATION DOSE FORMULAS FOR NORMAL TRANSPORT

The formulation for the assessment of population dose is based on an expression for dose rate as a function of distance from a point source of radiation. This point source approximation is acceptable for distances between the receptor and the source of more than two source characteristic lengths. At smaller distances, the point-source approximation overpredicts exposure and, therefore, will provide a conservative estimate of dose. The dose rate formulation is given by:

$$D(d) = \frac{Ke^{-\mu d}\ B(d)}{d^2} \qquad \text{(D-1)}$$

where $D(d)$ = dose rate at a distance d (mrem/hr)
d = distance from source (ft)
μ = absorption coefficient for air (.00118 ft^{-1})
$B(d)$ = Berger buildup factor in air, where in this case $B(d) = .0006d + 1$ (dimensionless) (Ref. D-1)
K = dose rate factor (mrem-ft^2/hr)

D.1 DOSE TO PERSONS SURROUNDING THE TRANSPORT LINK WHILE THE SHIPMENT IS MOVING

An expression for the total integrated dose absorbed by an individual at a distance x from the path of a radioactive shipment with dose rate factor K passing at velocity V has been derived (Ref. D-1) from Equation (D-1) and is given by

$$D(x) = 2\frac{K}{V}I(x) \qquad \text{(D-2)}$$

where V = shipment speed (ft/hr)
x = perpendicular distance of individual from shipment path (ft)

$$I(x) = \int_x^\infty \frac{e^{-\mu r}\ B(r)dr}{r(r^2-x^2)^{\frac{1}{2}}}$$

By appropriate transformations, this integral can be expressed in terms of modified Bessel functions of the second kind of order zero, which can be evaluated. For a K of 1 mrem-ft^2/hr and a V of 1 mile/hr, the absorbed dose as a functon of x is as shown in Figure D-1.

In order to obtain integrated population dose in sectors of length L and width d on both sides of the roadway (Figure D-2), Equation (D-2) is multiplied by the average population density and L and integrated over the width of the strip

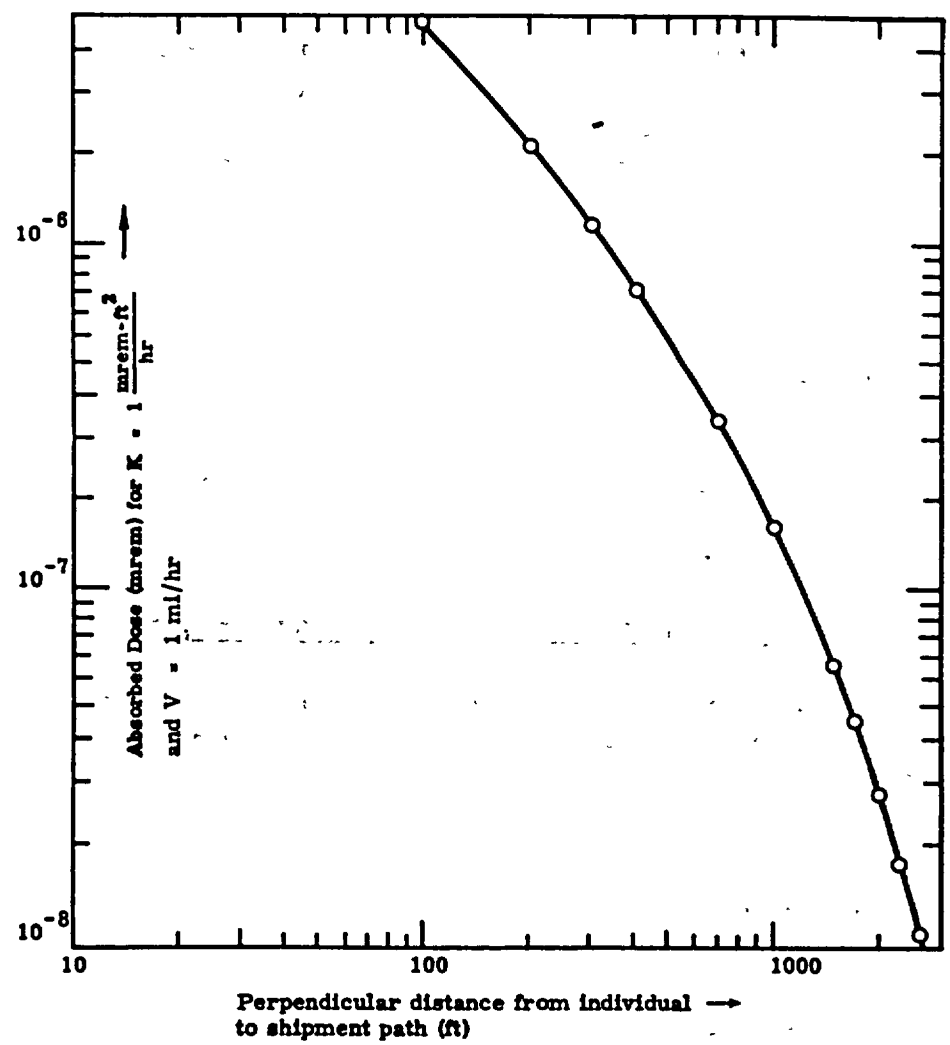
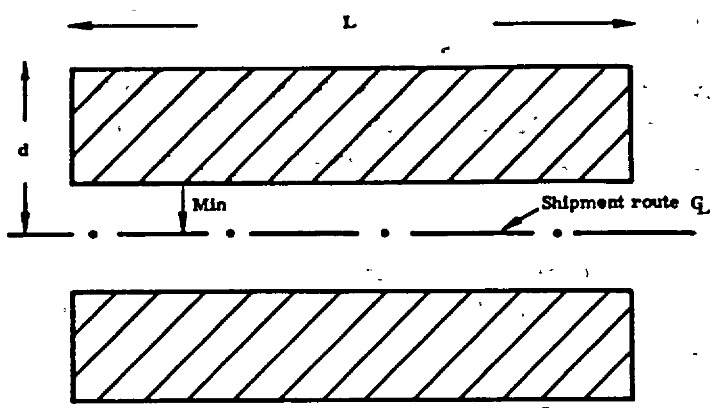


FIGURE D-1: DOSE RECEIVED BY AN INDIVIDUAL AS A SHIPMENT PASSES



- populated zone with uniform population density PD

L - length of populated strip

d - maximum distance over which exposure is evaluated

min - smallest distance between exposable population and shipment centerline.

FIGURE D-2. DOSE TO PERSON LIVING ALONG THE TRANSPORT LINK

$$\text{Dose} = 2(PD)(L)\int_{min}^{d} D(x)dx \qquad \text{(D-3)}$$

where Dose = integrated population dose in strip (person-mrem)

PD = average population density (person/ft^2)

L = length of strip (ft)

min = minimum distance from population to shipment centerline (ft)

d = maximum distance over which exposure is evaluated (ft)

D(x)dx = incremental dose function from Equation (D-2) (mrem-ft)

Equation D-3 predicts an infinite dose as min approaches 0; thus a limit on this value must be set. Values for min were selected based on actual roadway dimensions. A value of 2,600 feet was selected for d based on a previous assessment (Ref. D-1).

Consider a single trip made by a radioactive package with dose rate factor K. The trip is considered to involve three population density zones: rural, suburban, and urban. The total population dose resulting from the trip of length L (feet) is made up of the sum of the doses received in each of the three zones:

$$\text{Dose} = \text{Dose}_r + \text{Dose}_s + \text{Dose}_u$$

where the subscripts r, s, and u refer to rural, suburban, and urban, respectively. The use of the integrated dose expression of Equation D-3 results in the following expression:

$$\text{Dose} = 4K(L)\left[\frac{f_r PD_r}{V_r} I_r + \frac{f_s PD_s}{V_s} I_s + \frac{f_u PD_u}{V_u} I_u\right] \qquad \text{(D-4)}$$

where f_r = fraction of distance traveled in rural population density zone

f_s = fraction of distance traveled in suburban population density zone

f_u = fraction of distance traveled in urban population density zone

PD_r = population density (rural) (people/ft^2)

PD_s = population density (suburban) (people/ft^2)

PD_u = population density (urban) (people/ft^2)

$$I_r = \int_{min_r}^{d} I(x)dx$$

$$I_s = \int_{min_s}^{d} I(x)dx$$

$$I_u = \int_{min_u}^{d} I(x)dx$$

min_r = minimum distance from exposable population to shipment centerline (ft) (rural)

min_s = minimum distance from exposable population to shipment centerline (ft) (suburban)

min_u = minimum distance from exposable population to shipment centerline (ft) (urban)

V_r = average speed in rural area (ft/hr)

V_s = average speed in suburban area (ft/hr)

V_u = average speed in urban area (ft/hr)

Long-haul shipments use freeways or four-lane roads in most low and medium population density zones. However, in high density zones, use of city streets is often unavoidable. Since the minimum exposure distance (min) is smaller under these circumstances, the last term of Equation (D-4) is modified as follows:

$$Dose_u = \frac{4K(f_u)(PD_u)(L)}{V_u} I_u(f_o + K'f_1) \qquad \text{(D-5)}$$

where f_o = fraction of high density zone distance traveled on freeways or four-lane roads

f_1 = fraction of high density zone distance traveled on city streets

K' = constant that accounts for closer minimum distance on city streets. This constant K' is given by

$$K' = \frac{\int_{min_1}^{d} I(x)dx}{\int_{min_u}^{d} I(x)dx}$$

where min_1 = is the minimum distance of the exposable population from the shipment centerline for shipments on city streets.

The upper integration limit d was taken to be 2,600 ft, and the lower limits $min_r = min_s = min_u$ = 100 ft in all three population density zones. A value of 30 ft was selected for min_u on city streets, resulting in a value of 1.636 for K'. With these limits, the dimensionless integral $I_r = I_s = I_u$ was evaluated numerically and found to be equal to 2.42

When the expression for urban dose D_u of Equation (D-5) is substituted into Equation (D-4), the following expression results:

$$Dose = 4KL(2.42)\left[\frac{f_r PD_r}{V_r} + \frac{f_s PD_s}{V_s} + \frac{f_u PD_u}{V_u}(f_o + 1.636f_1)\right] \qquad \text{(D-6)}$$

If the population densities (PD) are expressed as persons/mi^2 and the velocities (V) are expressed in miles per hour (mph), the dose received per mile traveled is:

$$\text{Dose (person-rem/mile)} = 3.47 \times 10^{-10}(K)\left[\frac{f_r PD_r}{V_r} + \frac{f_s PD_s}{V_s} + \frac{f_u PD_u}{V_u}(f_o + 1.636 f_1)\right] \quad \text{(D-7)}$$

The annual normal population dose for this shipment scenario is obtained by multiplying the above equation by the total number of package-miles per year for this type of shipment, or PPS x SPY x FMPS,

where PPS = average number of packages per shipment
SPY = number of shipments per year
FMPS = average distance traveled (miles) per shipment

The dose rate factor K may be expressed as $K = K_o TI$, where K_o is a transport index to dose rate conversion factor:

$$K_o = (3 + d)^2$$

where 2d = typical package dimension in feet.

In this assessment:

K_o = 13.4 ft^2 for a typical Type A package
K_o = 16.0 ft^2 for a typical Type B package

An irradiated fuel cask, however, is treated simply as a source with a dose rate factor K = 1000 mrem-ft^2/hr; no TI is assigned.

The final expression for the annual population dose for a given shipment scenario, and the one used in this assessment to evaluate the normal population dose to surrounding population while the shipment is moving, is the following:

$$\left.\begin{array}{l}\text{(Dose)}_{mov} \\ \text{(person-rem/} \\ \text{year)}\end{array}\right\} = 3.47 \times 10^{-10}(K_o)(TI)(PPS)(SPY)(FMPS)\left[\frac{f_r PD_r}{V_r} + \frac{f_s PD_s}{V_s} + \frac{f_u PD_u}{V_u}(f_o + 1.636 f_1)\right] \quad \text{(D-8)}$$

where K_o = 13.4 ft^2 for a Type A package and 16.0 ft^2 for a Type B package
TI = average TI per package
PPS = average number of packages per shipment
SPY = number of shipments per year
FMPS = average distance (miles) per shipment
f_r, f_s, f_u = fraction of distance traveled in rural, suburban, and urban areas, respectively
PD_r, PD_s, PD_u = population density (person/mi^2) in rural, suburban, and urban areas, respectively
V_r, V_s, V_u = average speed (mph) in rural, suburban, and urban areas, respectively
f_o = fraction of urban travel on freeways or four-lane roads
f_1 = fraction of urban travel on city streets

D.2 DOSE TO POPULATION DURING SHIPMENT STOPS

If the shipment stops for crew change, meals, refueling, etc., people in an annular area around the stop point are exposed. The population dose is again obtained by integrating a form of Equation (D-1) that includes an annular differential element, $2\pi r dr$:

$$\text{Dose} = K_o(TI)(\Delta T)(PD)\int_x^d (2\pi r)\left(\frac{e^{-\mu r}B(r)}{r^2}\right)dr \qquad \text{(D-9)}$$

where Dose = integrated population dose per shipment (person-mrem)

ΔT = total stop time per shipment (hr)

Numerical evaluation of the integral for various values of x and d yields:

x(ft)	d(ft)	integral
5	400	26.104
5	1000	29.827
5	2600	31.613
10	2600	27.275

By accounting for the fraction of stops that occur in various population density zones and by making appropriate unit conversions, the integrated population dose in person-rem per year resulting from stops for a given shipment type is given by:

$$\text{Dose} = Q_1\, K_o(TI)(PPS)(SPY)\left[\Delta T_r(PD_r) + \Delta T_s(PD_s) + \Delta T_u PD_u\right] \qquad \text{(D-:0)}$$

where T_r = total stop time in rural population density zones (hours)

T = total stop time in suburban population density zones (hours)

T_u = total stop time in urban population density zones (hours)

Q_1 = 2.54×10^{-9}(rem-km^2/mrem-ft^2) (for x = 10 feet and d = 2600 feet)

D.3 DOSE TO WAREHOUSE PERSONNEL WHILE PACKAGE IS IN STORAGE

The dose to warehouse personnel is computed the same way as the dose received by persons while the shipment is stopped. The result is:

$$(\text{Dose})_{stor} = Q_2 K_o(TI)(PPS)(SPY)(\Delta T_{stor})(PD_{stor}) \qquad \text{(D-11)}$$

where Dose_{stor} = integrated population exposure (person-rem/year)

T_{stor} = total storage time per shipment (hours)

PD_{stor} = population density in warehouse area

Q_2 = 2.77×10^{-9}(rem-km^2/mrem-ft^2) (for x = 5 feet and d = 1,000 feet)

D.4 DOSE TO CREWMEN

The annual dose to crewman is obtained directly from Equation (D-1) by using an average source-to-crew characteristic distance (d) for each transport mode:

$$(\text{Dose})_{crew} = Q_3(K_o)(TI)(PPS)(SPY)(N_c)\,\frac{e^{-\mu d}\,B(d)}{d^2}\,\Delta T_{ship} \qquad \text{(D-12)}$$

where
N_c = number of crewman aboard
d = average distance to crew compartment (ft)
Q3 = 10^{-3} (rem/mrem)
ΔT_{ship} = average time required for a shipment $= \left[\frac{f_r}{V_r} + \frac{f_s}{V_s} + \frac{f_u}{V_u}\right]$ FMPS
FMPS = average distance (miles) per shipment

The values of $\frac{e^{-\mu d}\,B(d)}{d^2}$ for the assumed values of d for the various modes are shown below:

Mode	d(feet)	$\frac{e^{-\mu d}\,B(d)}{d^2}$
Van	7	2.03×10^{-2}
Truck	10	9.94×10^{-3}
Pass. Aircraft	50	3.88×10^{-4}
Cargo Aircraft	20	2.47×10^{-3}
Rail	500	2.88×10^{-6}
Ship	200	2.21×10^{-5}
Barge	150	4.06×10^{-5}

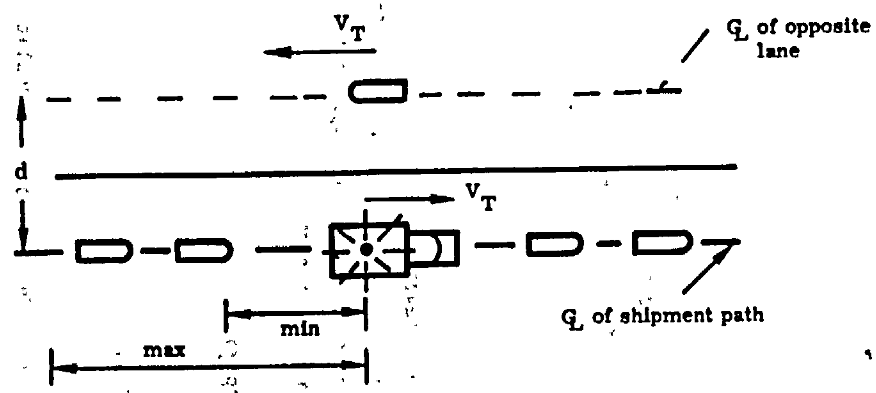
Because of regulatory limits for dose rate in the crew compartment, 2 mrem/hr is used as an upper limit for dose rate in this assessment. If the TI carried would cause this limit to be exceeded, it is assumed that shielding would be introduced to reduce the dose rate to this level.

D.5 DOSE TO PERSONS IN VEHICLES SHARING THE TRANSPORT LINK WITH THE SHIPMENT

Figure D-3 shows a truck carrying radioactive material. The truck is traveling at a speed V along with other vehicles in the same lane. Occasionally vehicles traveling in the opposite direction pass the truck in the other lane. There are two separate doses to be computed:

1. The dose to persons traveling in the opposite direction from the shipment and

2. The dose to persons traveling in the same direction as the shipment.



V = traffic velocity
d = lane separation distance
min = minimum following distance
max = maximum exposure distance

FIGURE D-3. DOSE TO PERSONS IN VEHICLES SHARING THE TRANSPORTATION LINK WITH THE SHIPMENT

D.5.1 DOSE TO PERSONS TRAVELING IN THE OPPOSITE DIRECTION

Assume that both the shipment and the oncoming traffic are moving at speed V(km/hr). The dose received by an individual in an oncoming vehicle may be computed by assuming that this vehicle is at rest and he is passed by the shipment at a speed of 2V. An expression for the integrated dose from a moving source was given in Equation (D-2).

Thus, the average integrated dose received by a person in an oncoming vehicle passing the truck at a distance x is:

$$D = \frac{2K}{(2V_T)} I(x) \qquad (D\text{-}13)$$

The average number N of oncoming vehicles per mile is

$$N_c = \frac{N'}{V_T} \qquad (D\text{-}14)$$

where N' is the traffic count (average number of cars per hour traveling in one direction). Let P be the average number of persons per vehicle. Thus the average number N of persons who travel in the opposite direction to the shipment and who are exposed per kilometer traveled by the truck is

$$N_{avg} = N_c P = \frac{N'F}{V_T} \qquad (D\text{-}15)$$

The average annual population dose to persons traveling in the opposite direction to the shipment is given by $D \times N_{avg} \times$ FMPS, where FMPS is the average distance per shipment. Multiplication of this number by SPY, the annual number of shipments of the type being considered, results in the annual population dose for the given shipment scenario:

$$\begin{aligned} \text{Dose} &= \frac{K}{V_T} I(x) \frac{N'}{V_T} P(\text{FMPS})(\text{SPY}) \\ &= KI(x) \frac{N'}{V_T^2} P(\text{FMPS})(\text{SPY}) \end{aligned} \qquad (D\text{-}16)$$

The traffic count N' and the average velocity V depend upon the population density zone and the time of day (i.e., rush hour or normal traffic). The value of the integral I(x) depends on the distance x of closest approach, which in turn depends on the type of road. The assumptions made for the various values for x and the corresponding values for I(x) are tabulated below:

Type of Road	x(ft)	$I(x)(ft^{-1})$
Freeway	50	2.9×10^{-2}
Four-Lane	30	4.8×10^{-2}
City Streets	10	1.5×10^{-1}

The following additional assumptions are made:

1. All rural and suburban truck travel is on freeways.

2. The traffic count doubles during the commuter rush periods (applicable in urban and suburban population zones).

3. The average speeds decrease by a factor of 2 during commuter rush periods (applicable in urban and suburban population zones).

4. Urban travel may be on freeways, four-lane roads, or city streets. Suburban and rural travel is all on freeways.

5. Urban travel on freeways and four-lane roads during rush hour is at half the average suburban velocity.

6. Urban travel on freeways during non-rush hours is at the average rural velocity. Urban travel on four-lane roads during non-rush hours is at the average suburban velocity.

Under these assumptions the following expression is obtained for the annual population dose in person-rem/year to persons traveling in a direction opposite to the shipment for a given shipment type:

$$(\text{Dose})_{opp} = Q(K_0)(TI)(PPS)(SPY)(FMPS)(P)(F) \qquad \text{(D-17)}$$

where

$$\begin{aligned} F = {} & f_r \frac{N'_r I_{fwy}}{V_{Tr}^2} + f_s\left(\frac{f_{rh} 2N'_s I_{fwy}}{(V_{Ts}/2)^2} + \frac{f_n N'_s I_{fwy}}{(V_{Ts})^2}\right) \\ & + f_u \left[f_{fwy}\left(\frac{f_{rh} 2N'_u I_{fwy}}{(V_{Ts}/2)^2} + \frac{f_n N'_u I_{fwy}}{(V_{Tr})^2}\right) \right. \\ & \quad + f_{4\ell}\left(\frac{f_{rh} 2N'_u I_{4\ell}}{(V_{Ts}/2)^2} + \frac{f_n N'_u I_{4\ell}}{(V_{Ts})^2}\right) \\ & \quad \left. + f_{cs}\left(\frac{f_{rh} 2N'_u I_{cs}}{(V_{Tu}/2)^2} + \frac{f_n N'_u I_{cs}}{(V_{Tu})^2}\right) \right] \end{aligned}$$

In deriving this expression, the substitution $K = K_0 \times TI \times PPS$ has been made, where TI = TI/package, and PPS = number of packages/shipment. Other symbols in this equation are as follows:

f_r, f_s, f_u = fractions of distance traveled in rural, suburban, and urban zones, respectively

f_{rh} = fraction of distance traveled in rush hour traffic

f_n = fraction of distance traveled in normal traffic

f_{fwy} = fraction of travel on freeways or interstates

$f_{4\ell}$ = fraction of travel on four-lane roads

f_{cs} = fraction of travel on city streets

V_{Tr} = average velocity on freeways (miles/hour)

V_{Ts} = average velocity on freeways in suburban population density zones and on all four-lane roads (miles/hour)

V_{Tu} = average velocity on city streets (miles/hour)

I_{fwy} = I (50 ft) = $2.9 \times 10^{-2} ft^{-1}$

$I_{4\ell}$ = I (30 ft) = $4.8 \times 10^{-2} ft^{-1}$

I_{cs} = I (10 ft) = $1.5 \times 10^{-1} ft^{-1}$

$$Q = \left(10^{-3}\ \frac{rem}{mrem}\right)\left(\frac{1\ mile}{5280\ ft}\right) = 1.89 \times 10^{-7}$$

The annual dose is computed for each shipment scenario using Equation (D-17), and the results are summed over all the standard shipments to obtain the total annual dose to persons traveling in a direction opposite to that of the shipment.

D.5.2 DOSE TO PERSONS TRAVELING IN THE SAME DIRECTION AS THE SHIPMENT

On the average, vehicles carrying radioactive material move at the same speed as the rest of the traffic. Thus, vehicles traveling in the same direction as the shipment can be modeled as a static set of vehicles at fixed distances from the shipment. The dose in millirem received by a person located at distance x from the radioactive material may be computed by multiplying the dose rate from Equation (D-2) by the duration ΔT of the exposure:

$$D = \frac{Ke^{-\mu x}B(x)}{x^2}\,\Delta T \qquad \text{(D-18)}$$

For a given scenario, the total annual exposure time is given by the quotient of total miles per year (miles per shipment x shipments per year) and average velocity:

$$\Delta T_{ann} = \frac{(FMPS)(SPY)}{V_T} \qquad \text{(D-19)}$$

It is assumed that people are distributed uniformly along the shipment path with a linear density given by

$$\text{Linear Density (persons/mile)} = \frac{N'P}{V_T} \qquad \text{(D-20)}$$

The annual dose to persons traveling in the same direction as the shipment for a given scenario is determined by multiplying the expression for the dose given in Equation (D-18) by the linear density given in Equation (D-20), using Equation (D-19) for ΔT_{ann}, and integrating over x from some minimum distance d out to a maximum distance "max":

$$(\text{Dose})_{\text{same dir.}} = 2\left(\frac{N'P}{V_T}\right)\left(\frac{(FMPS)(SPY)}{V_T}\right) K \int_d^{max} \frac{e^{-\mu x}B(x)}{x^2}\,dx \qquad \text{(D-21)}$$

The factor of 2 takes into account vehicles ahead of and behind the shipment.

As in the case of persons traveling in the opposite direction, N' and V_T depend on the population density zone and the time of day (rush hour or normal traffic). Also the distance d of closest approach depends on the type of road. The average values selected for d are 100 ft for freeways and interstates, 30 ft for four-lane roads, and 10 ft for city streets. Using the same traffic assumptions as made for the calculation of the dose to persons traveling in the direction opposite to that of the shipment, the following expression is obtained for the annual dose (for a given shipment scenario) received by persons traveling in the same directions as the shipment:

$$(\text{Dose})_{\text{same dir.}} = Q'(K_o)(TI)(PPS)(FMPS)(SPY)(P)F \qquad \text{(D-22)}$$

where the traffic factor F is the same as that given in Equation (D-17), except that:

$$I_{fwy} = I_1\ (100\ \text{ft}) = .008$$

$$I_4 = I_1\ (30\ \text{ft}) = .031$$

$$I_{cs} = I_1\ (10\ \text{ft}) = .097$$

$$\text{and } I_1\ (d) = \int_d^{2600\ \text{ft}} \frac{e^{-\mu x} B(x)}{x^2}$$

The constant Q' is:

$$Q' = 2 \times 10^{-3}\ \frac{\text{rem}}{\text{mrem}} \times \frac{1\ \text{mile}}{5280\ \text{ft}} = 3.79 \times 10^{-7}$$

The annual dose is computed for each shipment scenario using Equation (D-22), and the results are summed over all the standard shipments to obtain the total annual dose to persons traveling along the route in the same direction as the shipment.

REFERENCE

D.1. U. S. Atomic Energy Agency, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972.

APPENDIX E
DEMOGRAPHIC MODEL

E.1 INTRODUCTION

The analyses of both the normal and accident transport risks depend on the population density, i.e., the average number of people per unit area. Because population densities vary greatly, three different population density zones corresponding roughly to urban, suburban, and rural areas were considered. The average population densities assigned to each were determined from 1970 census data (Ref. E-1).

According to the 1970 census definition, urban population comprises all persons in places of 2,500 or more inhabitants, but not those living in rural portions of extended cities. Urban areas contain 73.5 percent of the total population.

E.2 URBANIZED AREAS

The Census Bureau has delineated so-called "urbanized areas" to provide a better separation of urban and rural population in the vicinities of the larger cities. An urbanized area consists of a central city with 50,000 or more inhabitants and surrounding closely-settled territory. Areas of large non-residential tracts devoted to such urban land uses as railroad yards, airports, factories, parks, golf courses, and cemeteries are excluded in computing the population density. The average population density in urbanized areas is 1,303/km^2 (3,375/mi^2); 31.5 percent of the total population live within the central cities of urbanized areas, and 26.8 percent live in the urban fringe, for a total of 58.3 percent living inside urbanized areas.

Urbanized areas such as Columbus, Ohio; Memphis, Tennessee; New Haven, Connecticut; San Antonio, Texas; and Wilmington, Delaware, have population densities higher than the average, while Atlanta, Georgia; Dallas, Texas; Des Moines, Iowa; and Bridgeport, Connecticut, have population densities lower than the average.

The average urban housing area consists of four to five housing units per acre or about 3,861 persons/km^2 (10,000 persons/mi^2). If this value for urban population density is assumed and 54 percent of the urbanized area population live in the central city, 18.2 percent of the urbanized area is occupied by the central city. This assumption forces an assumed density of 719 persons/km^2 for the so-called urban fringe. These two densities were selected to represent the urban and suburban population densities throughout the country.

E.3 OTHER URBAN AREAS

About 15.2 percent of the total population live in areas that are classified as urban, but that are outside the urbanized areas in and around the larger cities. The average population density in these areas is taken to be 719 persons/km^2, as in suburban population density zones.

E.4 RURAL AREAS

Rural areas, which contain 98.5 percent of the land area (approximately 3.5 million square miles) and 26.5 percent of the total population (approximately 50 million people), have an average population density of 6 persons/km^2. This figure was selected to represent rural areas.

E.5 EXTREME-DENSITY URBAN AREAS

Certain cities have population densities far in excess of the average value for urbanized areas. An analysis of population densities of cities, each having a total population of more than 100,000 persons, indicated that there were:

1. 98 cities with a population density less than 1,930/km^2 (5,000/mi^2);
2. 37 cities with a population density between 1,930 and 3,861/km^2 (5,000 - 10,000/mi^2);
3. 10 cities with a population density between 3,861 and 5,792/km^2 (10,000 - 15,000/mi^2);
4. 7 cities with a population density between 5,792 and 7,722/km^2 (15,000 - 20,000/mi^2);
5. 0 cities with a population density between 7,722 and 9,653/km^2 (20,000 - 25,000/mi^2); and
6. 1 city (New York City) with a population density greater than 9,653/km^2.

In each of these cases, the population density was determined by dividing the total population in the city by the land area enclosed by the city limits. Two additional points were noted:

1. New York City is clearly in a class by itself. The most densely populated borough is Manhattan, with a population density of 26,188 persons/km^2 (67,808/mi^2).

2. Cities with the larger population densities are not always the cities with the larger total populations. For example, Los Angeles, California, with a total population of 2,816,000, has a population density of 2,345/km^2, while Paterson, New Jersey, with a total population of 145,000, has a population density of 6,657/km^2, almost three times as great as that of Los Angeles.

The risks associated with the transportation of radioactive material through areas of very high population density are currently being evaluated in a follow-on study. In the current report, the consequences of a severe accident within such an area are evaluated for certain worst-case isotopes and are presented along with an estimate of the probability of occurrence. The annual risk estimates for all radioactive material transport, however, are made using the average values of 3,861, 719, and 6 persons/km^2.

E.6 SUMMARY AND CONCLUSIONS

For the purposes of this assessment, the 1970 census data were reduced to a nationwide model that specified three population zones - urban, suburban, and rural. The fraction of total land area, fraction of total population, and associated population densities for each of the population zones are shown in Table E-1. A population density of 15,444 persons/km^2 was used to represent an extremely dense urban area in the worst-case accident analysis in Chapter 5.

TABLE E-1

TABULAR SUMMARY OF DEMOGRAPHIC MODEL

Population Zone	Fraction of Land Area	Fraction of Population	Population Density (persons/km^2)
A. Urbanized Area	.0098	.583	1303
1. Central city	.0018	.315	3861
2. Urban fringe	.008	.268	719
B. Other Urban Areas	.0053	.152	719
C. Rural Areas	.985	.265	6
D. Demographic Model Used in This Assessment			
1. Urban (A.1)	.0018	.315	3861
2. Suburban (A.2+B)	.013	.42	719
3. Rural (C)	.985	.265	6
4. Extreme density urban	-	-	15444

REFERENCE

E-1. "Statistical Abstracts of the United States 1974" (95th Edition), U.S. Department of Commerce Social and Economic Statistics Division; U.S. Bureau of the Census.

APPENDIX F

INCIDENTS REPORTED TO DOT INVOLVING RADIOACTIVE MATERIAL FROM 1971 THROUGH 1974

This Appendix contains a list of the 98 incidents involving radioactive materials that were reported to the U.S. Department of Transportation (DOT) from 1971 through 1974. The data, tabulated in Table F-1, were obtained from the DOT Hazardous Materials Incident Reports. A sample of the DOT reoort form is presented as Figure F-1.

Columns 1 and 2 of Table F-1 describe the material involved for each incident (e.g., R.A.M.N.O.S. - Radioactive Material - Not Otherwise Specified) and give the 5-digit code for that material. Columns 3 and 4 describe the packaging in which the material was shipped, as obtained from Item G on Figure F-1. Columns 5 and 6 list the nature of the packaging failure from the 15 possibilities listed on Item F of Figure F-1. Columns 7 and 8 show the number of failed containers and the total number of containers in the shipment. Column 9 shows the special permit number obtained from Item G.30 on Figure F-1. Column 9 shows the special permit number obtained from Item G.30 on Figure F-1. Column 10 gives the incident report number: the first digit is the last digit of the year in which the incident occurred (e.g., 4... refers to 1974), and the second and third digits refer to the month of the incident. The remaining five digits codify the report within the month.

TABLE F-1

INCIDENTS REPORTED TO DOT INVOLVING RADIOACTIVE MATERIALS (SORTED BY REPORT NUMBERS)

COMMODITY	CODE	CONT 1	CONT 2	FAILURE 1	FAILURE 2	# FAIL	# SHIP	SP NO.	REPORT NO.
RADIOACTIVE MATERIA	08930	DRUM MTL		EXT PUNCT	OTHER	0	2	SP6000	1020027A
ZIRCONIUM SCRAP(BOR	11050			BODY-SIDE	OTHER	1	1		1030104A
UNKN	00000	TANK CAR		##########	##########	1	1		1050096A
QUES	00000			##########	##########	0	1		1080013A
UNKN	00000	DRUM MTL		OTHER	##########	1	44		1090113A
RADIOACTIVE DEVICES	08910			LOOSE FVC	##########	1	1		1100076A
RADIOACTIVE DEVICES	08910	BOX WOOD		EXT PUNCT	OTHER	1	4	SP5248	1110102A
RADIOACTIVE MATERIA	08930	CONT LD		##########	##########	0	1		1120173A
RADIOACTIVE MATERIA	08930			OTHER	##########	0	2		2010124A
RADIOACTIVE MATERIA	08930	CYL MTL	BOX WOOD	LOOSE FVC	##########	1	1		2010137A
RADIOACTIVE MTATERI	08920	CONT PLS	6D	##########	##########	1	29		2010193A
RADIOACTIVE MATERIA	08930	CONT LD	BOX FBR	DROPPED	##########	1	1		2020138A
RADIOACTIVE MATERIA	08940			##########	##########	0	0		2030227A
FISSILE RADIOACTIVE	05110	DRUM MTL		EXT PUNCT	##########	1	6		2040118A
RADIOACTIVE MATERIA	08930	BOX WOOD		OTHER	##########	1	1		2040229A
RADIOACTIVE MATERIA	08930	TUBE GLS	TUBE FBR	DROPPED	##########	2	2		2050044A
RADIOACTIVE MTATERI	08920	TANK TRK		EXT PUNCT	FREEZING	1	1		2070120A
RADIOACTIVE MATERIA	08930	LINR PLS	DRUM MTL	INT PRESS	CORR-RUST	1	4		2070331A
RADIOACTIVE MATERIA	08930	CYL MTL	7A	OTHER	##########	1	5		2070390A
RADIOACTIVE MATERIA	08930		BOX WOOD	OTHER FRT	##########	1	1		2080001A
RADIOACTIVE MATERIA	08930	17E		INNER REC	BOTTOM	1	9		2090377A
RADIOACTIVE MATERIA	08930	CYL MTL		LOOSE FVC	##########	1	1		2100389A
RADIOACTIVE MTATERI	08920	BOX MTL	BOX WOOD	EXT HEAT	##########	4	74		2100393A
RADIOACTIVE MTATERI	08920	17E		WELD	##########	1	57		2120196A
RADIOACTIVE MATERIA	08930	DRUM MTL		OTHER FRT	LOOSE FVC	0	10		2120264A
RADIOACTIVE MATERIA	08930	DRUM MTL		OTHER FRT	LOOSE FVC	4	10		3010116A
RADIOACTIVE MATERIA	08930	PAIL MTL		DEF FVC	LOOSE FVC	2	22		3010262A
RADIOACTIVE MTATERI	08920	BAG PPR		EXT PUNCT	##########	1	1K		3030098A
R.A.M. N.O.S.	08930	CAN MTL	BOX FBR	DROPPED		1	1		3070241A
R.A.M. N.O.S.	08930	21C		EXT PUNCT	BOTTOM	1	1		3070270A
R.A.M. SMALL QUANTY	08940	BOTL GLS	21C	OTHER FRT		1	4		3080530A
R.A.M. LOW SPEC ACT	08920	DRUM MTL		CORR-RUST		1	21		3100029A
R.A.M. N.O.S.	08930	CYL MTL	12B	DROPPED	BOTTOM	1	1		3100274A
R.A.M. LOW SPEC ACT	08920	17H		DROPPED		1	53		3110050A
RADIOACTIVE DEVICES	08910	BOX FBR		OTHER LIQ		1	1		3110179A
R.A.M. LOW SPEC ACT	08920	17H		EXT PUNCT		2	79		3120045A
R.A.M. LOW SPEC ACT	08920	DRUM MTL		CORR-RUST	BODY-SIDE	1	62		4020081A
RADIOACTIVE DEVICES	08910	BOX WOOD		OTHER FRT	OTHER	1	1		4020263A
R.A.M. N.O.S.	08930	CAN MTL	21C	OTHER		1	1		4020394A
R.A.M. N.O.S.	08930	BLANK		BOTTOM	BODY-SIDE	1	1		4030098A
R.A.M. N.O.S.	08930	7A		DROPPED	OTHER	1	1		4030170A
R.A.M. N.O.S.	08930	BOX FBR		WATER		0	6		4030232A
R.A.M. N.O.S.	08930	BLANK		OTHER		0	1		4030399A
R.A.M. N.O.S.	08930	DRUM MTL		EXT PUNCT	OTHER	2	0		4030476A
R.A.M. LOW SPEC ACT	08920	TANK PRT		OTHER		0	13		4040129A
R.A.M. N.O.S.	08930	CAN MTL		OTHER		1	1		4040132A
R.A.M. N.O.S.	08930	CAN MTL		OTHER		1	1		4040132B
R.A.M. N.O.S.	08930	55		OTHER		1	1		4040403A
R.A.M. N.O.S.	08930	12B		DROPPED	EXT PUNCT	0	12		4040404A
R.A.M. N.O.S.	08930	7A		DROPPED		1	2		4050132A

TABLE F-1 (continued)

COMMODITY	CODE	CONT 1	CONT 2	FAILURE 1	FAILURE 2	# FAIL	# SHIP	SP NO.	REPORT NO.
R.A.M. N.O.S.	08930	BLANK		OTHER		1	1	SP5874	4050139A
R.A.M. N.O.S.	08930	BLANK		OTHER		1	1	SP5874	4050140A
R.A.M. N.O.S.	08930	BLANK		OTHER		1	1	SP5874	4050141A
R.A.M. N.O.S.	08930	7A		DROPPED	OTHER FRT	0	1		4050229A
R.A.M. N.O.S.	08930	CONT STY	12B	OTHER		1	1		4050255A
R.A.M. N.O.S.	08930	BOTL GLS	TUBE FBR	DROPPED	EXT PUNCT	1	2		4050486A
R.A.M. SPEC. FORM	08950	DRUM MTL		BOTTOM		0	1		4060104A
R.A.M. N.O.S.	08930	7A		OTHER		1	1		4060105A
R.A.M. N.O.S.	08930	BOX FBR		EXT PUNCT		0	1		4060234A
R.A.M. N.O.S.	08930	17E		CHIME		1	11		4060680A
R.A.M. N.O.S.	08930			WATER		0	2		4060688A
R.A.M. N.O.S.	08930	12B		DROPPED		0	1		4070256A
R.A.M. N.O.S.	08930	CONT PLS	BOX FBR	DROPPED		1	19		4070349A
R.A.M. N.O.S.	08930	TANK PRT		OTHER		1	1	SP5660	4070362A
FISSILE R.A.M.	05110	DRUM MTL		EXT PUNCT	OTHER	0	70		4070629A
R.A.M. N.O.S.	08930	BLANK		OTHER		0	2		4070739A
R.A.M. N.O.S.	08930	CAN MTL	BOX FBR	DROPPED		0	1		4070805A
R.A.M. SMALL QUANTY	08940	BOX FBR		BODY-SIDE		3	3		4070846A
R.A.M. N.O.S.	08930	BLANK	12B	OTHER		1	2		4080265A
R.A.M. N.O.S.	08930	BOX MTL	BOX WOOD	OTHER FRT		0	6		4080493A
R.A.M. N.O.S.	08930	BOX MTL	BOX FBR	WATER	BODY-SIDE	1	4		4080497A
R.A.M. N.O.S.	08930	BOX MTL	BOX FBR	OTHER FRT		1	1		4080630A
R.A.M. LOW SPEC ACT	03920	TYPE B		DROPPED		0	1		4080679A
R.A.M. N.O.S.	08930	LINR PLS	BOX FBR	OTHER		0	3		4080698A
R.A.M. N.O.S.	08930	BLANK	BOX FBR	DROPPED		1	1		4080789A
R.A.M. LOW SPEC ACT	03920	TANK PRT		OTHER		0	1		4080947A
R.A.M. N.O.S.	08930	BOTL GLS	BOX FBR	EXT PUNCT		1	1		4090093A
R.A.M. N.O.S.	08930	DRUM MTL		EXT PUNCT		0	1		4090112A
R.A.M. N.O.S.	08930	BOTL PLS	7A	OTHER		1	1		4090307A
THORIUM NITRATE SOL	10270	21C		DROPPED		1	24		4090323A
R.A.M. SPEC. FORM	08950	55		OTHER		1	1		4090359A
R.A.M. N.O.S.	08930	CAN MTL	DRUM MTL	LOOSE FVC		1	1		4090529A
R.A.M. N.O.S.	08930	PAIL MTL		LOOSE FVC		1	2		4090721A
R.A.M. N.O.S.	08930	BLANK	12B	OTHER FRT		0	1		4090845A
R.A.M. SPEC. FORM	08950	BLANK	CAN MTL	CORR-RUST	BOTTOM	1	1		4100206A
R.A.M. SPEC. FORM	08950	55	BOX WOOD	OTHER FRT		1	1		4100433A
R.A.M. N.O.S.	08930	CAN MTL		EXT PUNCT	BODY-SIDE	1	3		4100585A
R.A.M. N.O.S.	08930	BLANK		DROPPED		0	0		4100655A
R.A.M. N.O.S.	08930	BOX MTL	BOX FBR	WATER		0	1		4110247A
R.A.M. N.O.S.	08930	15A	7A	LOOSE FVC	BOTTOM	1	2		4120197A
R.A.M. N.O.S.	08930	15A	7A	LOOSE FVC	BOTTOM	1	21		4120197B
R.A.M. N.O.S.	08930	BOTL	7A	EXT PUNCT	OTHER FRT	0	3		4120235A
R.A.M. N.O.S.	08930	BOTL	7A	EXT PUNCT	OTHER FRT	0	2		4120235B
R.A.M. N.O.S.	08930	TYPE B				0	1	SP5874	4120390A
R.A.M. N.O.S.	08930	7A		OTHER		1	1		4120628A
R.A.M. SPEC. FORM	08950	CAN MTL	BOX FBR	DEF FVC		0	2		4120638A
R.A.M. N.O.S.	08930	BLANK		OTHER		0	1		4120646A

DEPARTMENT OF TRANSPORTATION

Form Approved OMB No. 04-5613

HAZARDOUS MATERIALS INCIDENT REPORT

INSTRUCTIONS: Submit this report in duplicate to the Secretary, Hazardous Materials Regulations Board, Department of Transportation, Washington, D.C. 20590, (ATTN: Op. Div.). If space provided for any item is inadequate, complete that item under Section H, "Remarks", keying to the entry number being completed. Copies of this form, in limited quantities, may be obtained from the Secretary, Hazardous Materials Regulations Board. Additional copies in this prescribed format may be reproduced and used, if on the same size and kind of paper.

A INCIDENT

1. TYPE OF OPERATION
1 ☐ AIR 2 ☐ HIGHWAY 3 ☐ RAIL 4 ☐ WATER 5 ☐ FREIGHT FORWARDER 6 ☐ OTHER *(Identify)* ______

2. DATE AND TIME OF INCIDENT *(Month - Day - Year)* ______ a.m. ______ p.m.

3. LOCATION OF INCIDENT

B REPORTING CARRIER, COMPANY OR INDIVIDUAL

4. FULL NAME

5. ADDRESS *(Number, Street, City, State and Zip Code)*

6. TYPE OF VEHICLE OR FACILITY

C SHIPMENT INFORMATION

7. NAME AND ADDRESS OF SHIPPER *(Origin address)*

8. NAME AND ADDRESS OF CONSIGNEE *(Destination address)*

9. SHIPPING PAPER IDENTIFICATION NO.

10. SHIPPING PAPERS ISSUED BY
☐ CARRIER ☐ SHIPPER
☐ OTHER *(Identify)* ______

D DEATHS, INJURIES, LOSS AND DAMAGE

DUE TO HAZARDOUS MATERIALS INVOLVED

11. NUMBER PERSONS INJURED

12. NUMBER PERSONS KILLED

13. ESTIMATED AMOUNT OF LOSS AND/OR PROPERTY DAMAGE INCLUDING COST OF DECONTAMINATION *(Round off in dollars)* $

14. ESTIMATED TOTAL QUANTITY OF HAZARDOUS MATERIALS RELEASED

E HAZARDOUS MATERIALS INVOLVED

15. CLASSIFICATION (Sec. 172.4)	16. SHIPPING NAME (Sec. 172.5)	17. TRADE NAME

F NATURE OF PACKAGING FAILURE

18. *(Check all applicable boxes)*

☐ (1) DROPPED IN HANDLING	☐ (2) EXTERNAL PUNCTURE	☐ (3) DAMAGE BY OTHER FREIGHT
☐ (4) WATER DAMAGE	☐ (5) DAMAGE FROM OTHER LIQUID	☐ (6) FREEZING
☐ (7) EXTERNAL HEAT	☐ (8) INTERNAL PRESSURE	☐ (9) CORROSION OR RUST
☐ (10) DEFECTIVE FITTINGS, VALVES, OR CLOSURES	☐ (11) LOOSE FITTINGS, VALVES OR CLOSURES	☐ (12) FAILURE OF INNER RECEPTACLES
☐ (13) BOTTOM FAILURE	☐ (14) BODY OR SIDE FAILURE	☐ (15) WELD FAILURE
☐ (16) CHIME FAILURE	☐ (17) OTHER CONDITIONS *(Identify)*	19. *SPACE FOR DOT USE ONLY*

Form DOT F 5800.1 (10-70)

FIGURE F-1. HAZARDOUS MATERIALS INCIDENT REPORT

G	PACKAGING INFORMATION - *If more than one size or type packaging is involved in loss of material show packaging information separately for each. If more space is needed, use Section H "Remarks" below keying to the item number.*			
	ITEM	#1	#2	#3
20	TYPE OF PACKAGING INCLUDING INNER RECEPTACLES *(Steel drums, wooden box, cylinder, etc.)*			
21	CAPACITY OR WEIGHT PER UNIT *(55 gallons, 65 lbs., etc.)*			
22	NUMBER OF PACKAGES FROM WHICH MATERIAL ESCAPED			
23	NUMBER OF PACKAGES OF SAME TYPE IN SHIPMENT			
24	DOT SPECIFICATION NUMBER(S) ON PACKAGES *(21P, 17E, 3AA, etc., or none)*			
25	SHOW ALL OTHER DOT PACKAGING MARKINGS *(Part 178)*			
26	NAME, SYMBOL, OR REGISTRATION NUMBER OF PACKAGING MANUFACTURER			
27	SHOW SERIAL NUMBER OF CYLINDERS, CARGO TANKS, TANK CARS, PORTABLE TANKS			
28	TYPE DOT LABEL(S) APPLIED			
29	IF RECONDITIONED OR REQUALIFIED, SHOW: A. REGISTRATION NO. OR SYMBOL			
	B. DATE OF LAST TEST OF INSPECTION			
30	IF SHIPMENT IS UNDER DOT OR USCG SPECIAL PERMIT, ENTER PERMIT NO.			

H REMARKS - Describe essential facts of incident including but not limited to defects, damage, probable cause, stowage, action taken at the time discovered, and action taken to prevent future incidents. Include any recommendations to improve packaging, handling, or transportation of hazardous materials. Photographs and diagrams should be submitted when necessary for clarification.

31. NAME OF PERSON PREPARING REPORT *(Type or print)*	32. SIGNATURE
33. TELEPHONE NO. *(Include Area Code)*	34. DATE REPORT PREPARED

Reverse of Form DOT F 5800.1 (10-70)

GPO 1970 O - 408 376

FIGURE F-1 (continued)

APPENDIX G

CALCULATION METHODOLOGY FOR ACCIDENT ANALYSIS

The methodology used to compute annual early fatalities and latent cancer fatalities resulting from accidents involving shipments of radioactive material is presented in detail in Reference G-1. The procedures are outlined in this Appendix.

G.1. COMPUTATION OF ANNUAL EARLY FATALITY PROBABILITY

The technique for computing annual early fatality probability is illustrated in Figure G-1. Initially, the average dose received by individuals within a given isodose area is computed for each radionuclide in each accident severity category:

$$\phi_{i,j,k} = (n_i)(RF_{j,k})(AER_i)(RESP_i)(E_i)(RPC_i)(DF) \qquad \text{(G-1)}$$

where

- ϕ = average dose received in the area (rem)
- i = index over radionuclides
- j = index over the accident severity categories
- k = index over the package types
- n = curies per shipment (Ci)
- RF = release fraction
- AER = aerosolized fraction
- RESP = fraction of aerosolized material of respirable dimension in reference mixture
- E = particle size distribution factor*
- RPC = dose per curie inhaled (rem/Ci)
- DF = dilution factor (This value includes the effects of a 0.01 m/sec deposition velocity.)

The appropriate dose-response relationship (see Chapter 3) is then used to determine the probability of early fatality for each exposed individual. This is shown as block 6 on Figure G-1. Once the individual probability per exposure has been computed, a combination of binomial and Poisson statistics is used to compute the probability of a given number of early fatalities within a given isodose area:

$$P(k) = \sum_{i=k}^{\infty} \binom{i}{k} P_I^{\,k} (1 - P_I)^{i-k} \left(\frac{\lambda^i e^{-\lambda}}{i!} \right) \qquad \text{(G-2)}$$

---

*This factor accounts for potential variation in particle size between the aerosol used for reference for the rem-per-curie value and the actual aerosol being shipped. In the analysis in Chapter 5, a respirability of 0.24 is used for rem-per-curie reference and a value of 0.11 was obtained from an industry survey. Hence, E = 0.46.

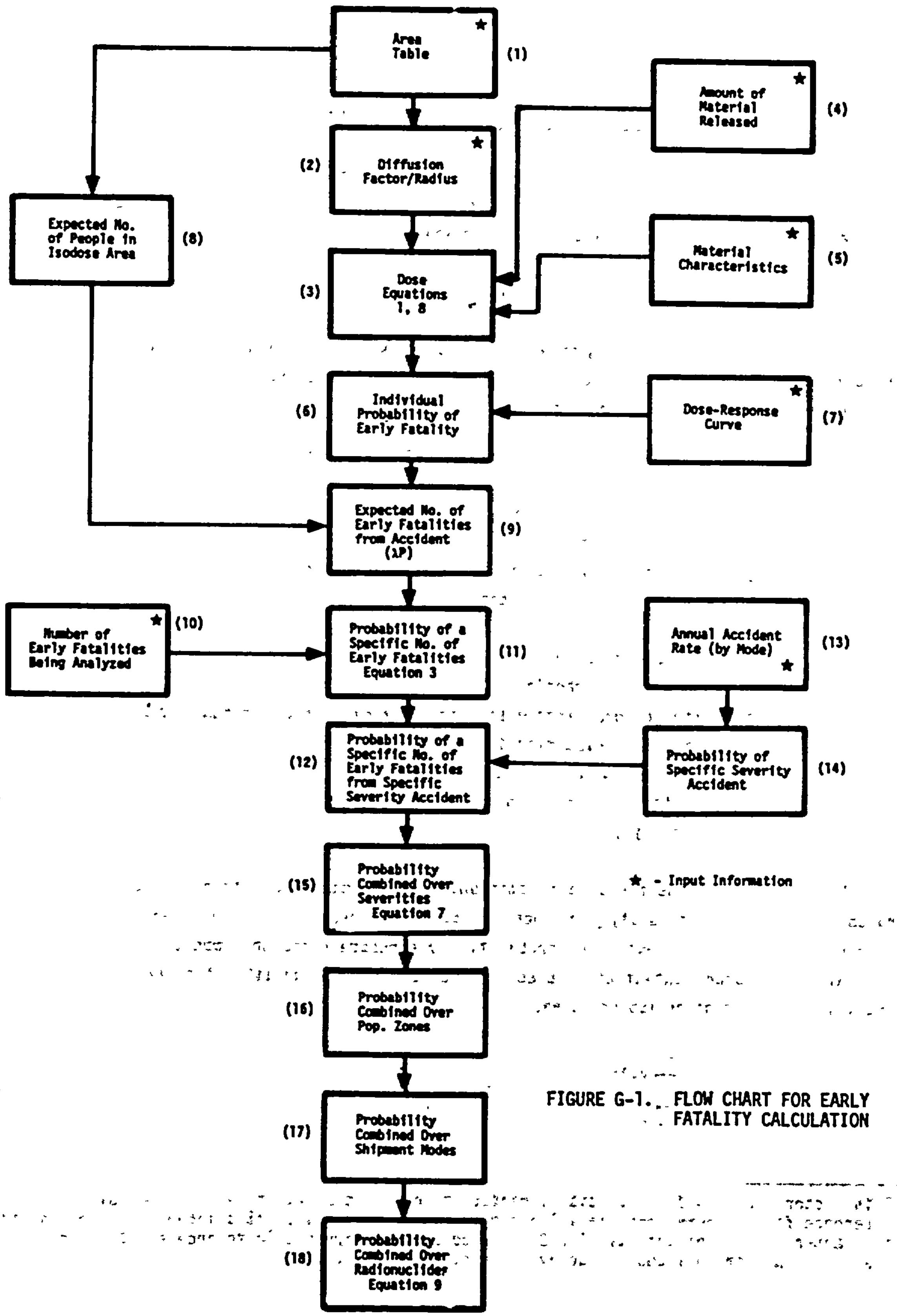


FIGURE G-1. FLOW CHART FOR EARLY FATALITY CALCULATION

$P(k)$ = probability of k early fatalities

i = predicted number of people in specific isodose area

P_1 = individual probability of early fatality when exposed to a given dose

λ = expected number of people in isodose area (product of area and average population density)

Using a Taylor expansion, Equation (G-2) can be reduced to

$$P(k) = \frac{(\lambda P_1)^k (e^{-\lambda P_1})}{k!} \quad \text{(G-3)}$$

which is in the form of a Poisson distribution with parameter $\lambda P1$* where P(k) is the probability of k early fatalities assuming that an accident does occur. This value must now be combined with the annual probability of an accident of specific severity in the specific population density zone involving a specific mode of transport:

$$P(k)_{i,j,k,l} = \left(P(k)_{i,k}\right)\left(P(acc)_{i,j,l}\right) \quad \text{(G-4)}$$

where

$P(acc)_{i,j,k,l}$ = annual probability of ith severity accident in jth population density zone involving kth radionuclide being shipped by the lth mode combination

$P(k)_{i,k}$ = P(k) from Equation (G-3)

The annual accident rate for accidents of a given severity is computed as follows:

$$\gamma_{i;j;k,l} = \left[\left(APM_{l,p}\right)\left(\eta_{i,l,p}\right)\left(\delta_{i,j,l,p}\right)\left(SPY_{k,l}\right)\left(FMPS_{k,l,p}\right)\right] + \left[\left(APM_{l,s}\right)\left(\eta_{i,l,s}\right)\left(\delta_{i,j,l,s}\right)\left(SPY_{k,l}\right)\left(FMPS_{k,l,s}\right)\right] \quad \text{(G-5)}$$

where

$\gamma_{i,j,k,l}$ = accidents per year of ith severity in jth population density zone for kth radionuclide transported by lth mode combination

p = contribution from primary mode

s = contribution from secondary mode

$APM_{l,p}$ = overall accident rate for lth mode primary vehicle

$\eta_{i,l}$ = fraction of lth mode combination accidents that are of severity i

$\delta_{i,j,l}$ = fraction of ith severity accidents with lth mode combination in jth population density zone

$SPY_{k,l}$ = shipments per year of kth radionuclide by lth mode combination

$FMPS_{k,l}$ = distance per shipment for kth radionuclide by lth mode combination

P(acc) is obtained by using the Poisson distribution on $\gamma_{i,j,k,l}$ from Equation (G-5).

The assumption is now made that fatality-producing transportation accidents involving radioactive material shipments are statistically independent on an annual basis. This allows the use of the Boolean identity

*It should be noted that the Poisson approximation for the probability of a given number of people in an isodose area combined with the binomial dose-effect relationship over predicts fatality probability for small values of λ.

$$P(A \cup B \cup C) = 1 - P(\bar{A})P(\bar{B})P(\bar{C}) \quad \text{(G-6)}$$

where $P(\bar{A})$ = the Boolean complement of P(A),

to combine fatality probabilities over all severity categories, population density zones, mode combinations, and materials.

Thus, the annual probability of a specific number of early fatalities from a given radionuclide, shipped by a given mode combination in a given population density zone, over all accident severity categories is given by:

$$P_{j,k,l} = 1.0 - \prod_{i=1}^{8} (1 - P_i) \quad \text{(G-7)}$$

where i = index over accident severity categories
$P_i = P(k)_{i,j,k,l}$ computed in Equation (G-4)
j = index over the population density zones
k = index over the radionuclides
l = index over the mode combinations for specific radionuclide

This technique is used to combine results for the population density zones and mode combinations for each atmospherically dispersed radionuclide that can produce a sufficient dose to cause an early fatality.

Some sources of whole-body external penetrating radiation also have the potential for providing sufficient dose to cause early fatalities. The number of these fatalities can be computed using the following formula for the dose rate at a distance r from this type of source:

$$DR(r) = \frac{(5597.2)(n)(E)(e^{-\mu r})(B(r))}{r^2} \quad \text{(G-8)}$$

where DR(r) = dose rate at r (rem/hr)
n = curies of material (Ci)
E = energy of photons (MeV)
μ = energy attenuation coefficient (0.00393 m^{-1} (0.00118 ft^{-1}))
r = distance to source (m)
B(r) = Berger buildup factor (0.00018r + 1) (dimensionless, r in meters)

This result is most accurate for photon energies between approximately 0.25 MeV and 4.5 MeV. Outside those ranges, the values for μ, B(r) and the numerical constant would need to be adjusted (Refs. G-2 and G-3). The method of computing results for this type of source is very similar to that used for atmospherically dispersed sources and is illustrated in Figure G-2.

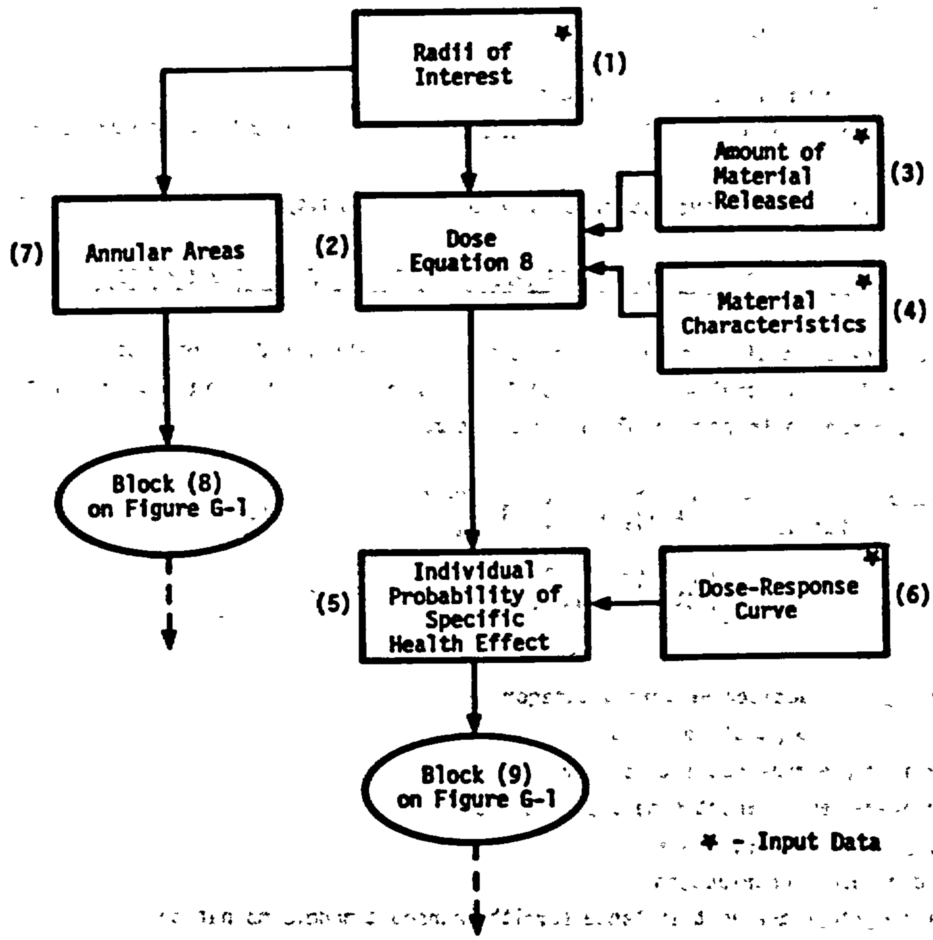


FIGURE G-2. EARLY FATALITY COMPUTATION FLOW DIAGRAM FOR EXTERNAL PENETRATING RADIATION SOURCES

The results of computation for all potentially fatal exposure sources and for all potentially fatal atmospherically dispersed sources can now be combined to give the annual probability of a specific number of early fatalities from transportation accidents involving all radionuclides shipped. This is given by:

$$P = 1.0 - \prod_{l=1}^{n} (1 - P_l) \qquad \text{(G-9)}$$

where l = index over the radionuclides shipped

n = number of radionuclides shipped that can produce a sufficient dose to cause early fatalities

P_l = probability combined over severities, population density zones, and mode combinations

G.2 COMPUTATION OF LATENT CANCER FATALITIES DUE TO AIRBORNE RELEASES FROM ACCIDENTS

The method for computing annual latent cancer fatalities (LCF) from accidents is illustrated in Figure G-3. Initially, the accident rate for each of the eight severity categories for each mode combination in each population zone is computed:

$$\frac{\text{class h accidents}}{\text{year}}_{i,j,k,l} = \left[\left(\lambda_{l,p}\right)\left(\delta_{j,l,p}\right)\left(\gamma_{l,p}\right)\left(SPY_{k,l,p}\right)\left(FMPS_{k,l,p}\right)\right] + \left[\left(\lambda_{l,s}\right)\left(\delta_{j,l,s}\right)\left(\gamma_{l,s}\right)\left(SPY_{k,l,s}\right)\left(FMPS_{k,l,s}\right)\right] \qquad \text{(G-10)}$$

where i = index over the accident severity categories

j = index over the population zones

k = index over the radionuclides shipped

l = index over the transport mode combinations

p = primary mode contribution

s = secondary mode contribution

λ_l = total accidents per unit distance for lth transport mode combination

$\delta_{j,l}$ = fraction of class i accidents in jth population density zone for lth mode

λ_l = class h accident fraction for lth transport mode

$SPY_{k,l}$ = shipments per year for kth radionuclide by lth mode

$FMPS_{k,l}$ = distance per shipment for kth radionuclide by lth mode

The number determined using Equation (G-10) is the annual accident rate for a specific severity accident, occurring in a specific population density zone, involving a specific radionuclide, shipped by a specific mode combination.

This must now be combined with the integrated organ dose resulting from a given atmospheric release of material. This dose is computed for a single exposure to the nth organ from the kth radionuclide involved in a category h accident in the jth population density zone.

$$\phi_{j,k,n} = \left(ci_k\right)\left(PPS_k\right)\left(RF_k\right)\left(AER_k\right)\left(RESP_k\right)\left(RPC_{n,k}\right)\left(IF\right)\left(DF\right)\left(PD_j\right)\left(RDF_i\right) \qquad \text{(G-11)}$$

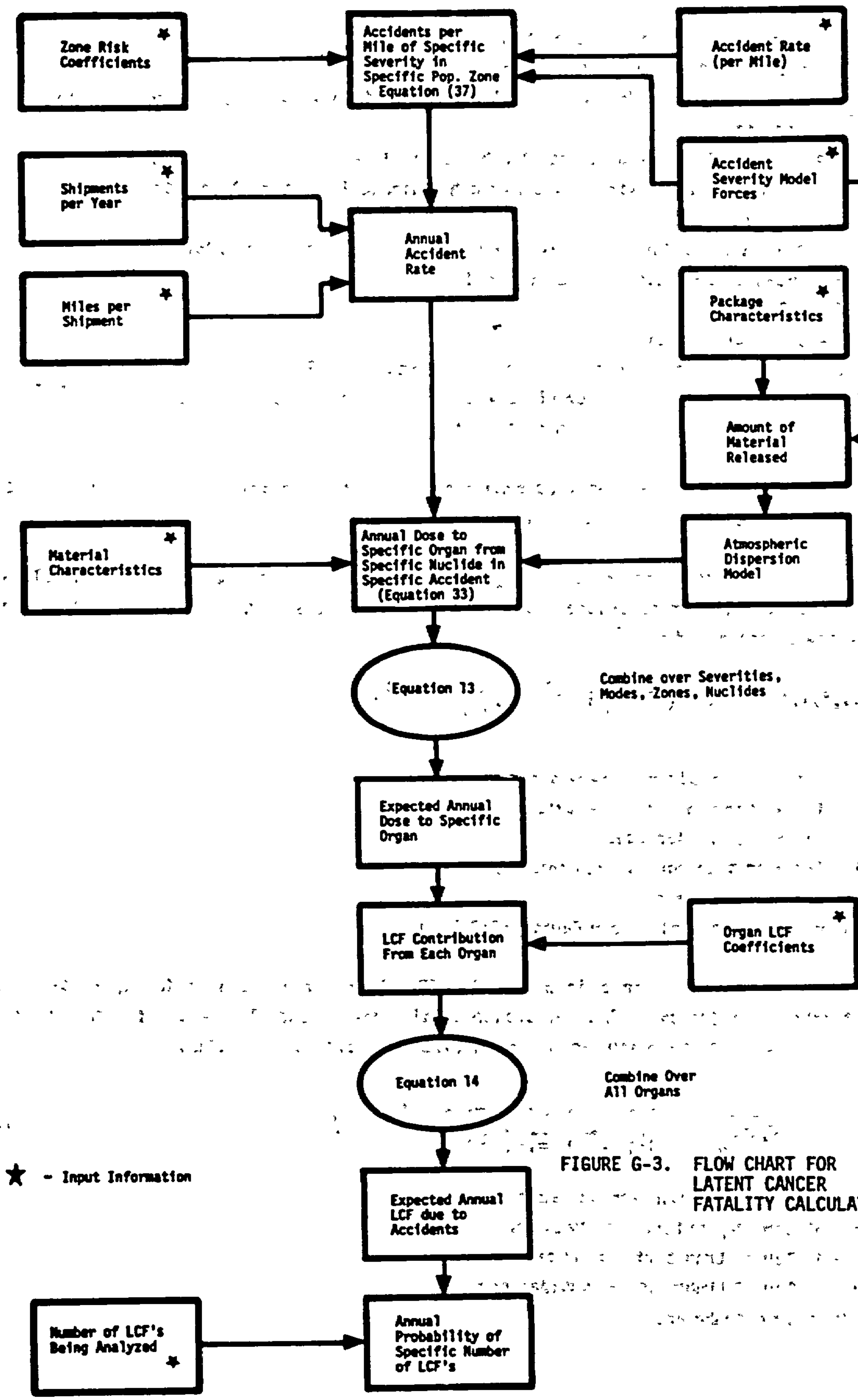


FIGURE G-3. FLOW CHART FOR LATENT CANCER FATALITY CALCULATION where Ci_k = curies per package for the kth radionuclide

PPS_k = packages of the kth radionuclide per shipment

$RF_{k,h}$ = release fraction for an h severity accident involving a package used to ship the kth radionuclide

AER_k = percent of released amount of kth radionuclide that is aerosolized

$RESP_k$ = percent of aerosolized amount of kth radionuclide material that is of a respirable size

$RPC_{k,n}$ = rem per curie (inhaled) delivered to nth organ by kth radionuclide

IF = integration factor over designated area

DF = dilution factor

PD = population density

E = particle size distribution factor (see Equation (G-1))

RDF_i = resuspension dose factor (This value includes a resuspension factor of 10^{-5} m^{-1} and is evaluated for each isotope.)

The IF and DF values are obtained from appropriate meteorological data, and the E and RPC values are obtained from appropriate dosimetric data.

The total integrated organ dose per year to the nth organ from the ith severity class of accidents for the lth transport mode with the kth radionuclide in the jth population density zone can now be specified by:

$$\text{Dose/yr}_{i,j,k,l,n} = \left(\lambda_l\right)\left(\gamma_{i,l}\right)\left(\delta_{i,j}\right)\left(SPY_{k,l}\right)\left(FMPS_{k,l}\right)\left(\phi_{j,l,n}\right) \quad \text{(G-12)}$$

where i = index over accident severity categories

j = index over population density zones

k = index over radionuclides

l = index over transport mode combinations

n = index over organs

(λ, γ, δ, are variables from Equation (G-10))

By summing the values determined in Equation (G-12) over all modes of transportation, all accident severity categories, all population density zones, and all transported radionuclides, the total annual dose to the nth organ for all classes of accident is obtained.

$$\frac{\text{Dose}}{\text{Year}_n} = \sum_{i=1}^{r} \sum_{j=1}^{s} \sum_{k=1}^{t} \sum_{l=1}^{u} \left(\text{Dose/yr}_{i,j,k,l,n}\right) \quad \text{(G-13)}$$

where r = number of accident severity categories

s = number of population density zones

t = number of transported radionuclides

u = number of transport mode combinations

n = index over organs

Once the total annual organ doses are computed, they are converted to expected latent cancer fatalities using the LCF coefficients discussed in Chapter 3.

$$LCF = \sum_{n=1}^{v} K_n \text{ (Dose/year)}_n \qquad \text{(G-14)}$$

where LCF = expected latent cancer fatalities

K_n = latent cancer fatality coefficient for nth organ

n = index over organs

v = number of organs

G.3 COMPUTATION OF LATENT CANCER FATALITIES FROM EXTERNAL EXPOSURE SOURCE

Certain transported radioactive materials are not readily dispersible by virtue of their packagings (e.g., special form packages) or their chemical or physical form (e.g., nonvolatile components of spent reactor fuel or radiography source capsules). These materials may, however, provide a significant point source of external penetrating radiation. The integrated dose from shipments of this type (based on a 1-hour exposure) is given by:

$$ID = C\ K\ n\ E\ T\ PD\left(\int_x^d \frac{(2\pi r)}{r^2}\, e^{-\mu r}\, B(r)dr\right) \qquad \text{(G-15)}$$

where ID = integrated population exposure (person-rem)

C = units conversion constant (rem/mrem x $km^2/ft^2 = 9.3 \times 10^{-11}$)

K = 5597.2 (see Equation G-8)

n = curies per package (Ci)

E = photon energy (MeV)

T = exposure time (assumed to be 1 hour)

PD = population density (persons/km^2)

x = minimum distance from source to populated zone (assumed to be 3 meters)

d = maximum distance over which exposure is assumed to occur (assumed to be 780 meters)

The similarity between this and the "Dose while stopped" in Appendix D is intentional. When the integral is evaluated for the given limits and the expression is simplified, the result is:

$$ID = 1.4183 \times 10^{-5}\ (n)(E)(PD) \qquad \text{(G-16)}$$

Once the integrated dose is determined, the LCF coefficient of 121.6 per 10^6 person-rem is applied to predict the latent cancer fatalities. This value is then combined with the LCF for dispersion calculations to give a total expected annual LCF.

REFERENCES

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G-2. S. Glasstone and A. Sesonske, Nuclear Reactor Engineering, Van Nostrand Reinhold Company, New York, 1967.

G-3. U.S. Atomic Energy Commission, "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972.

APPENDIX H

METHOD FOR DERATING ACCIDENT SEVERITY CATEGORIES

The accident severity categories for aircraft presented in Chapter 5 are based on an equivalent drop height impact onto an unyielding surface as a measure of energy available for container deformation. This can be expressed in terms of impact velocity as shown on Figure 5-2. The actual damage mechanism, however, is the abrupt deceleration that results in package deformation.

One "unyielding" surface that has been used in shipping container tests at Sandia Laboratories (Ref. H-1) is a 10-centimeter-thick sheet of steel over a 4.5-meter-thick slab of reinforced concrete. However, a very small fraction of the earth's surface approaches this criterion for being unyielding.

To evaluate and quantify the extent to which surfaces are unyielding, an analysis was performed to relate the impact velocities on real elastic surfaces to those experienced onto an unyielding surface in terms of Poisson's ratio and Young's modulus of elasticity.

Consider an infinitely rigid sphere ($E = \infty$) being dropped onto an elastic half plane ($E < \infty$). The maximum displacement of the half plane is given in Reference H-2 as:

$$\alpha = \left[\frac{15\pi\left(\frac{1 - \nu}{\pi E}\right)(mv^2)}{16\sqrt{R}}\right]^{2/5} \qquad \text{(H-1)}$$

where
- α = displacement of half plane
- m = mass of sphere
- R = radius of sphere
- E = Young's modulus of half plane
- ν = Poisson ratio for half plane
- v = impact velocity of sphere

If sinusodial behavior of the half plane is assumed, the maximum value of deceleration can be derived:

$$A_{max} = 0.1157\pi^2 \, v^{6/5} \left[\frac{16\sqrt{R}}{15\pi\frac{1 - \nu}{\pi E}\, m}\right]^{2/5} \qquad \text{(H-2)}$$

If steel is used as an "unyielding" target, the equivalent velocity for a given value of deceleration can be found by solving Equation (H-2) for velocity for both the unyielding target and the real target at the same value of deceleration. If this is done, the following relationship is obtained:

$$\frac{V_{yielding}}{V_{steel}} = \left[\frac{1 - \nu_y^2}{1 - \nu_s^2}\right]\left[\frac{E_s}{E_y}\right]^{1/3} \qquad \text{(H-3)}$$

Table H-1 shows a breakdown of actual surface occurrence probabilities in the United States (based on air carrier routes) together with surface properties. Values computed for V/V_s are shown for each surface type.

The ratio of velocities shown in Table H-1 was used to evaluate the joint probability of experiencing an accident of a given severity and having it occur on a surface of given hardness. The result is a "derating system" that shifts accidents that have velocities typical of a Class VIII accident, for example, to a lower severity class typical of an impact velocity given by

$$V = V_{observed}/(V/V_s) \qquad \text{(H-4)}$$

For example, a hard rock impact (V/Vs = 2.21) has a probability of 0.05. Applying the 2.21 factor to a velocity typical of a Class VIII accident gives an effective velocity of 507 km/hr (1127/2.21), which is in the Class VII accident severity category. As a result, 5% of the Class VIII accidents are reassigned to Class VII due to impacts on hard rocks. A similar procedure is used for all other surfaces. The procedure is shown explicitly in Table H-2.

TABLE H-1

CALCULATED PROBABILITIES AND CHARACTERISTICS OF SURFACES UNDER FLIGHT PATHS BETWEEN MAJOR U.S. AIR HUBS (Ref. H-3)

Surface Type	Example	Probability	Young's Modulus-E (pascal)	Poisson's Ratio	V/Vs
Water	Water, marsh	0.18	1.5×10^{9}	0.5	4.48
Soft Soil	Sand, cultivated soil	0.28	6.9×10^{8}	0.2	7.05
Hard Soil	Partially consolidated clay	0.39	5.52×10^{9}	0.3	3.37
Soft Rock	Tuff, alluvium sandstone	0.09	1.38×10^{10}	0.2	2.53
Hard Rock	Granite, gneiss	0.05	2.07×10^{10}	0.2	2.21
Unyielding*	Abutments, steel	0.01	2.07×10^{11}	0.33	1.0

*A 1-percent unyielding surface has been added to the information in Reference 3 to add conservatism.

TABLE H-2

DETAILED DERATING SCHEME

I Accident Severity Category	II Fraction of accidents with damage in given severity category (based upon drop height onto an unyielding surface)	III Equivalent impact velocity onto an unyielding surface (for fire < 0.5 hr) kilometer/hr	IV Fraction deleted from category as a result of derating	V Fraction of category due to unyielding surface	Fraction added to category as a result of derating (shown by source category	Impact Surface Contribution to Fraction Added hard rock	soft rock	hard soil	soft soil	water	Fraction of accidents with damage in given severity category (based upon real surfaces)
VIII	0.03	604-1127	0.0297	0.0003	0	0	0	0	0	0	0.0003
VII	0.04	306-604	0.0396	0.0004	VIII - .0042	0.0015	.0027	0	0	0	0.0046
VI	0.03	225-306	0.0297	0.0003	VIII - 0.0171	0	0	0.0117	0	0.0054	0.0194
					VII - 0.002	0.002	0	0	0	0	
V	0.03	129-225	0.0297	0.0003	VIII - 0.0084	0	0	0	0.0084	0	0.0279
					VII - 0.0192	0	0.0036	0.0156	0	0	
					VI - 0.0	0	0	0	0	0	
IV	0.05	89-129	0.0495	0.0005	VIII - 0.0	0	0	0	0	0	0.0107
					VII - 0.0072	0	0	0	0	0.0072	
					VI - 0.0015	0.0015	0	0	0	0	
					V - 0.0015	0.0015	0	0	0	0	
III	0.09	48-89	0.0891	0.0009	VIII - 0.0	0	0	0	0	0	0.0434
					VII - 0.0112	0	0	0	0.0112	0	
					VI - 0.0144	0	0.0027	0.0117	0	0	
					V - 0.0144	0	0.0027	0.0117	0	0	
					IV - 0.0025	.0025	0	0	0	0	
I, II	0.73	0-48	0	NA - categories I, II not derated	VIII - 0.0	0	0	0	0	0	0.8937
					VII - 0.0	0	0	0	0	0	
					VI - 0.0138	0	0	0	0.0084	0.0054	
					V - 0.0138	0	0	0	0.0084	0.0054	
					IV - 0.0470	0	0.0045	0.0195	0.014	0.009	
					III - 0.0891	0.0045	0.0081	0.0351	0.0252	0.0162	

REFERENCES

H-1. L. L. Bonzon, M. McWhirter, "Special Tests of Plutonium Shipping Containers," IAEA-SR-10/21, International Atomic Energy Seminar on Radioactive Material Packaging and Transportation, Vienna, Austria, August 1976.

H-2. S. P. Timoshenko, J. N. Goodien; Elasticity Theory, McGraw-Hill, 1970.

H-3. D. W. Larson, R. K. Clarke, J. T. Foley, and W. F. Hartman, "Severities of Transportation Accidents - Volume II - Aircraft (SLA74-0001)," Sandia Laboratories, Albuquerque, NM, September 1975.

APPENDIX I
SENSITIVITY ANALYSIS

I.1 INTRODUCTION

This appendix contains an analysis of the sensitivity of the risk assessment presented in this document to some of the parameters used in the calculation. It should be noted from the outset that this is neither an error analysis nor a full parametric study. The purpose of this analysis is simply to determine how sensitive the calculation is to some of the more important parameters. Since values chosen for many of these parameters were based on certain assumptions, the results of this parameter study should help to indicate the sensitivity of this assessment to those assumptions. The parameters considered are divided into three categories: fundamental parameters, general parameters, and shipment parameters. The fundamental parameters are those included in both the normal and accident calculations or used throughout one of these two calculations. The fundamental parameters include the population densities and the meteorological parameters. General parameters are those parameters included in part of either of the two calculations. Examples are release fractions for a specific package type and average velocities. Shipment parameters are those determined from the 1975 survey data. They include the average curies per package, distance per shipment, and TI per package. In the following sections, the sensitivity of the calculation to each of these three parameter types is discussed.

I.2 SENSITIVITY OF ANALYSIS TO FUNDAMENTAL PARAMETERS

The sensitivity of the assessment to fundamental parameters is measured by the change in the annual risk (either the normal or accident components) when the value of the parameter is changed by a fixed amount. In the two following sections, the changes in annual risks (expressed as a percent) are presented for a fixed (10 percent) change in one parameter with all other parameters held constant.

I.2.1 CHANGES IN POPULATION DENSITY

Using the parameters in the 1975 Baseline model, an incremental increase of 10 percent was made (independently) in each of the three population densities. The results are shown in Table I-1.

TABLE I-1

PERCENT CHANGES IN NORMAL AND ACCIDENT RISKS FOR A 10 PERCENT INCREASE IN POPULATION DENSITY

Parameter	Change in Annual Risk: Normal	Change in Annual Risk: Accident
Urban Population Density	0.7%	8.5%
Suburban Population Density	0.4%	2.1%
Rural Population Density	0	0

It is evident from the table that the accident risk component is much more sensitive to the value chosen for the urban population density than is normal risk. Normal risk is relatively insensitive to population density changes. Changes in rural density are unimportant in all cases.

I.2.2 CHANGES IN THE METEOROLOGICAL PARAMETERS

The atmospheric dispersion model used in the accident risk analysis is a Gaussian plume model using turbulent diffusion coefficients. An initial release height of 10 meters is assumed, and cloud depletion by dry deposition is allowed. Rather than investigate the sensitivity of the atmospheric dispersion model to these parameters, a 10 percent increase in the diffusion factors was assumed (see Figure 5-7). The result was a 9 percent change in the annual accident radiological risk. The annual normal risk value is, of course, unaffected by this change.

I.3 SENSITIVITY OF THE ACCIDENT ANALYSIS TO GENERAL PARAMETERS

In this section, the sensitivity of the calculation of the annual radiological risk resulting from potential transportation accidents is examined. Because of the different nature of the normal transport risk calculation, its sensitivity to both general and shipment parameters is discussed in Section I.5.

The accident risk depends on, among other things, the product of the annual accident rate, the package release fraction, the fraction of all accidents estimated to occur in a given population zone, and the population density of that zone. Each component of this product (and thus the product itself) is a function of both the transport mode and the accident severity category. Table I-2 is a tabulation of these products by severity category for each population zone for type A packages (or drums) transported by the truck mode. The last column in Table I-2 shows the percent contribution of each product to the total (sum of all the products). The table shows that for transport of any given type A package by truck under all the assumptions inherent in the calculation, 84 percent of the accident risk is from accidents that occur in urban zones, and most of this results from class II, III, and IV accidents. Thus, an error in estimating the urban population density or the fraction of distance traveled in urban areas has a much greater effect on the risk estimate (for type A packages by truck) than corresponding errors for suburban and rural zones. Abbreviated tabulations were made for each transport mode, package type, and population zone calculation and are presented in Tables I-3 to I-7.

The values shown in these tables are independent of the standard shipment model; they apply individually to each package transported. By the same token, a comparison of the relative risks of two transported packages can be made directly from these tables only if they contain the same quantities of the same material and are transported the same distance. Different materials may still be compared by recalling that the risk is proportional to the quantity of material transported, to the distance traveled, and to material characteristics such as fraction aerosolized, fraction respirable, and the rem-per-curie value.

TABLE I-2

PRODUCT OF ACCIDENT RATE, RELEASE-FRACTION, FRACTION OF ACCIDENTS IN GIVEN POPULATION ZONE, AND POPULATION DENSITY FOR TYPE A PACKAGES BY TRUCK

Severity Category	Population Zone	Product	Fraction Of Total	
I	R	0	0	
II	R	.23	4.5×10^{-5}	
III	R	1.3	2.6×10^{-4}	
IV	R	3.1	6.0×10^{-4}	Total Rural 0.1%
V	R	.89	1.7×10^{-4}	
VI	R	.49	9.6×10^{-5}	
VII	R	.043	8.5×10^{-6}	
VIII	R	.0086	1.7×10^{-6}	
I	S	0	0	
II	S	28	5.4×10^{-3}	
III	S	214	4.2×10^{-2}	
IV	S	489	9.6×10^{-2}	Total Suburban 16%
V	S	64	1.3×10^{-2}	
VI	S	17	3.3×10^{-3}	
VII	S	.65	1.3×10^{-4}	
VIII	S	.057	1.1×10^{-5}	
I	U	0	0	
II	U	1180	2.3×10^{-1}	
III	U	861	1.7×10^{-1}	
IV	U	1970	3.9×10^{-1}	Total Urban 84%
V	U	230	4.5×10^{-2}	
VI	U	45	8.8×10^{-3}	
VII	U	3.5	6.8×10^{-4}	
VIII	U	.31	6.0×10^{-5}	

TABLE I-3

PRINCIPAL CONTRIBUTORS TO ACCIDENT RISK FOR TRUCKS

Package Type	Accident Severity	Population Zone		Percent of Risk
A, Drum	IV	Urban		38.5
	II	Urban		23.1
	III	Urban		16.9
	IV	Suburban		9.6
	V	Urban		4.5
	III	Suburban		4.2
	V	Suburban		1.3
			TOTAL	98.1
B, Cask-2	V	Urban		32.1
	IV	Urban		27.5
	III	Urban		12.0
	V	Suburban		9.0
	IV	Suburban		6.8
	VI	Urban		6.3
	III	Suburban		3.0
	VI	Suburban		2.3
			TOTAL	99.0
B-Pu	VI	Urban		51.8
	VII	Urban		20.0
	VI	Suburban		19.3
	VII	Suburban		3.7
	VIII	Urban		3.5
			TOTAL	98.3
Cask-1 (exposure)	VIII	Urban		72.8
	VIII	Suburban		15.5
	VII	Urban		8.4
	VII	Suburban		1.6
	VI	Urban		1.1
			TOTAL	99.4

TABLE I-4

PRINCIPAL CONTRIBUTORS TO ACCIDENT RISK FOR AIRCRAFT

Package Type	Accident Severity	Population Zone		Percent of Risk
A, Drum	V	Suburban		21.0
	V	Urban		18.8
	VI	Suburban		14.6
	VI	Urban		13.1
	IV	Suburban		10.8
	IV	Urban		7.2
	II	Suburban		5.1
	III	Suburban		4.4
	III	Urban		2.9
	II	Urban		1.5
			TOTAL	99.4
B, Cask-2	V	Suburban		29.8
	V	Urban		26.6
	VI	Suburban		20.7
	VI	Urban		18.5
	IV	Suburban		1.5
	IV	Urban		1.0
			TOTAL	98.1
B-Pu	VI	Suburban		48.6
	VI	Urban		43.5
	VII	Urban		5.2
			TOTAL	97.3
Cask-1 (exposure)	VIII	Urban		59.3
	VIII	Suburban		11.0
	VII	Urban		9.3
	VIII	Rural		9.0
	VI	Suburban		4.4
	VI	Urban		3.9
	VII	Suburban		1.7
	VII	Rural		1.4
			TOTAL	100.0

TABLE I-5

PRINCIPAL CONTRIBUTORS TO ACCIDENT RISK FOR RAIL

Package Type	Accident Severity	Population Zone		Percent of Risk
A, Drum	III, IV	Urban		32.8
	II	Urban		14.6
	III, IV	Suburban		8.2
	V	Urban		2.2
			TOTAL	98.8
B, Cask-2	III, IV	Urban		29.4
	V	Urban		19.6
	III, IV	Suburban		7.3
	V	Suburban		5.5
			TOTAL	98.5
B-Pu	VII	Urban		50.0
	VI	Urban		21.7
	VII	Suburban		9.3
	VIII	Urban		8.3
	VI	Suburban		8.1
	VIII	Suburban		1.6
			TOTAL	99.0
Cask-1	VIII	Urban		73.3
	VIII	Suburban		13.7
	VII	Urban		9.0
	VIII	Rural		2.1
	VII	Suburban		1.7
			TOTAL	99.8

TABLE I-6

PRINCIPAL CONTRIBUTORS TO ACCIDENT RISK
FOR WATERBORNE MODES AND VARIOUS PACKAGE TYPES

Package Type	Accident Severity	Population Zone		Percent of Risk
A	IV	Suburban		56.4
	IV	Urban		33.6
	II	Urban		7.2
	II	Suburban		1.3
			TOTAL	98.5
B, Cask-2	IV	Suburban		57.0
	IV	Urban		34.0
	VII	Suburban		5.7
	VI	Suburban		2.2
			TOTAL	98.9
BPu	VII	Suburban		81.7
	VIII	Suburban		11.8
	VI	Suburban		6.4
			TOTAL	99.9
Cask-1 (exposure)	VIII	Suburban		87.5
	VII	Suburban		12.4
			TOTAL	99.9

TABLE I-7

PRINCIPAL CONTRIBUTORS TO ACCIDENT RISK FOR SECONDARY MODES AND VARIOUS PACKAGE TYPES

Package Type	Accident Severity	Population Zone		Percent of Risk
A, Drum	IV	Urban		41.7
	III	Urban		22.4
	II	Urban		11.5
	IV	Suburban		7.9
	V	Urban		7.3
	VI	Urban		2.9
	III	Suburban		2.7
	II	Suburban		1.4
			TOTAL	97.8
B, Cask-2	V	Urban		36.8
	IV	Urban		21.0
	VI	Urban		14.5
	III	Urban		11.3
	V	Suburban		7.0
	IV	Suburban		4.0
	VI	Suburban		2.7
			TOTAL	97.3
B-Pu	VI	Urban		58.0
	VII	Urban		17.8
	VI	Suburan		11.0
	VIII	Urban		6.3
	VII	Suburban		5.1
	VIII	Suburban		1.8
			TOTAL	100.0
Cask-1 (exposure)	VIII	Urban		72.9
	VIII	Suburban		20.9
	VII	Urban		4.2
	VII	Suburban		1.2
			TOTAL	99.2

I.4 SENSITIVITY OF THE ACCIDENT ANALYSIS TO THE SHIPMENT PARAMETERS

In this section the sensitivity of the accident risk analysis to the particular set of standard shipments is considered in a general way. Then the various combinations of mode, package type, accident severity, and population zone that make major contributions to the annual risk are tabulated using the 1975 standard shipments model.

In addition to the four-factor product discussed in Section I-3, the accident risk calculation also depends on the product of a number of factors that are characteristic of the material shipped and other shipment parameters. For purposes of comparing the relative hazards of different shipments, it is useful to define a new parameter called the "hazard factor."

Hazard Factor = (curies per package) x (packages per shipment) x (rem per curie inhaled) x (average distance per shipment) x (LCF coefficient for organ associated with rem per curie value) x (fraction aerosolized) x (fraction respirable) x (resuspension dose factor).

When comparing nondispersible materials, the gamma ray energy E is substituted for the rem per curie inhaled.

Table I-8 lists hazard factor sums for the various transport mode and package type combinations. Each entry represents the sum of all hazard factors for that package type and transport mode using the 1975 standard shipments model. These sums, which contain the standard shipments information, are then combined with the information contained in Tables I-3 through I-7 to obtain a ranking of the relative risk contributions by package type, transport mode, population zone, and accident severity category for the 1975 standard shipments. The results are shown in Table I-9. The first part of the table lists, in order of decreasing importance, the combinations that are the major contributors to the annual risk. Note the number of truck mode shipments that are major contributors. This does not necessarily mean that truck shipments are more hazardous. It simply reflects the predominance of truck shipments of the standard shipments model. The second table lists the percent contributions to the annual accident risk for each transport mode, summed over package types. The remaining three tables show the relative contributions of each package type, each of the eight accident severity categories, and each population zone to the accident risk. The major contribution made by type A packages is in part due to the relatively large number of packages of this type.

It is interesting to note that the most severe accidents do not contribute the greatest amounts to the annual accident risk under the assumptions used in this assessment. Over 80 percent of the risk comes from accidents of severities III, IV, and V. This results in part from the very low probability of category VII and VIII accidents and in part from the conservative set of release fractions for type A and B packages.

TABLE I-8

HAZARD FACTOR SUMS

Package Type/Mode	Truck	Van(Pa)*	Pass. Air	Cargo Air	Rail
A	1.1×10^{9}	6.8×10^{5}	1.2×10^{8}	4.4×10^{6}	1.3×10^{8}
B	4.9×10^{9}	2.0×10^{8}	5.7×10^{9}	5.1×10^{8}	5.0×10^{8}
BPu	4.3×10^{12}	1.9×10^{10}	6.5×10^{11}	9.8×10^{10}	0
Cask-1	1.6×10^{7}	0	0	0	3.2×10^{6}
Cask-2	1.1×10^{8}	0	0	0	2.4×10^{7}
Drum	1.2×10^{8}	7.2×10^{5}	8.6×10^{6}	5.2×10^{5}	0

Package Type/Mode	Ship	Barge	Van (T)*	Van (R)*	Van (Ca)*
A	1.0×10^{7}	0	1.9×10^{7}	1.1×10^{7}	5.1×10^{5}
B	1.0×10^{7}	0	1.4×10^{8}	1.7×10^{7}	3.5×10^{7}
BPu	0	0	1.4×10^{11}	0	6.1×10^{9}
Cask-1	0	0	0	2.1×10^{5}	0
Cask-2	0	0	0	1.6×10^{6}	0
Drum	0	0	8.1×10^{6}	0	8.8×10^{4}

*Pa - passenger air; T - truck; R - rail; Ca - cargo air.

TABLE I-9

OVERALL RISK CONTRIBUTION FROM ACCIDENTS FOR 1975 STANDARD SHIPMENTS

Mode	Package Type	Accident Severity	Population Zone	Percentage of Total Accident Risk
Truck	A, Drum	IV	Urban	14.5
Truck	BPu	VI	Urban	11.2
Truck	A, Drum	II	Urban	8.7
Truck	B, Cask-2	V	Urban	6.7
Truck	A, Drum	III	Urban	6.4
Truck	B, Cask-2	IV	Urban	5.7
Truck	BPu	VII	Urban	4.3
Truck	BPu	VI	Suburban	4.2
Truck	A, Drum	IV	Suburban	3.6
Truck	B, Cask-2	III	Urban	2.5
Sec. Modes	BPu	VI	Urban	2.1
Truck	B, Cask-2	V	Suburban	1.9
Truck	A, Drum	V	Urban	1.7
Truck	A, Drum	III	Suburban	1.6
Rail	A, Drum	IV	Urban	1.5
Rail	A, Drum	III	Urban	1.5
Truck	B, Cask-2	IV	Suburban	1.4
Truck	B, Cask-2	VI	Urban	1.3
Sec. Modes	B, Cask-2	V	Urban	1.3
			TOTAL	82.1%

TOTALS

Mode	Percentage of Accident Risk
Truck	79.3
Pass. Air	2.7
Cargo Air	0.2
Rail	8.8
Ship	1.1
Sec. Modes	7.9

Package Type	Percentage of Accident Risk
A, Drum	45.0
B, Cask-2	28.0
BPu	26.0

Accident Severity	Percentage of Accident Risk
1	0
2	10.0
3	15.0
4	31.0
5	14.0
6	23.0
7	6.0
8	1.0

Population Zone	Percentage of Accident Risk
Urban	80.2
Suburban	18.3
Rural	1.5

Although for most shipment scenarios the largest fractions of accidents were expected to occur in rural and suburban population zones, the urban zone contributes over 80 percent of the annual accident risk. The large population density of urban areas outweighs the relatively low fraction of accidents expected to occur in these areas.

I.5 SENSITIVITY OF THE NORMAL DOSE CALCULATION TO VARIOUS PARAMETERS

The annual normal population dose resulting from any one of the standard shipments is proportional to the total TI transported per year and the total distance. A 10 percent error, for example, in the average TI per package, the total packages per year, or the average distance per shipment would result in a 10 percent error in the annual normal dose.

Table I-10 contains tabulations of the percent of contributions to the annual normal risk by certain package types, population subgroups, transport modes, package type-population subgroup combinations, and transport mode-population subgroup combinations. The data for the table were obtained from the normal dose analysis using the 1975 standard shipment data. The dominant contribution of type A packages to the normal dose, as in the accident case, results from the comparatively large number of such packages in the standard shipments model. Type A packages make a larger contribution in the normal case because of the large fraction of the total TI that they represent. The truck mode is also the greatest contributor to the normal risk, again due in part to the comparatively large number of truck shipments. It is interesting to note that 65 percent of the normal risk results from doses to passengers, crew, attendants, handlers, and warehouse personnel. These dose calculations are independent of the population densities estimated for each of the three population zones.

TABLE I-10

PRINCIPAL CONTRIBUTORS TO THE NORMAL RISK

Package Type

Package	Percent of Normal Risk
A, Drum	88.0
B, B-Pu,	11.0
Cask	1.0

Population Subgroup

Subgroup	Percent of Normal Risk
Passengers	24
Crew	32
Attendants	1
Handlers	18
Off-Link	4
On-Link	4
Stops	11
Storage	6

Mode

Mode	Percent of Normal Risk
Truck	45.0
Pass. Air	29.7
Cargo Air	0.2
Rail	1.0
Ship	0.1
Sec. Modes	24.0

Package Type/Subgroup

Package Type	Subgroup	Percentage
A, Drum	Crew	27
A, Drum	Passengers	21
A, Drum	Handlers	16
A, Drum	Stops	11
A, Drum	Storage	6
B, B-Pu	Crew	5
A, Drum	Off-Link	4
A, Drum	On-Link	4
B, B-Pu	Passengers	3
B, B-Pu	Handlers	1

Model/Subgroup

Mode	Subgroup	Percentage
Truck	Crew	26
Pass. Air	Passengers	24
Sec. Modes	Handlers	12
Truck	Stops	10
Sec. Modes	Crew	5
Truck	On-Link	2
Pass. Air	Attendants	1
Pass. Air	Handlers	4
Truck	Off-Link	4
Truck	Storage	3
Sec. Modes	On-Link	2

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NUREG-0170
VOL. 2

FINAL ENVIRONMENTAL STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY AIR AND OTHER MODES

Docket No. PR-71, 73 (40 FR 23768)

December 1977

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U. S. Nuclear Regulatory Commission

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Date Published: December 1977

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CHAPTER 8
COMMENTS ON NUREG-0034 AND MAJOR CHANGES THAT HAVE OCCURRED SINCE NUREG-0034 WAS ISSUED

8.1 INTRODUCTION

The purpose of this chapter is twofold: (1) to provide a brief outline of the major changes made since the issuance of the draft version of this report (NUREG-0034), most of which were in response to comments received during the public review period and (2) to give detailed responses to each of these comments. A list of all comments received is given in Appendix J.

8.2 MAJOR CHANGES SINCE NUREG-0034 WAS ISSUED

Major changes in the Draft Environmental Statement were made both in response to certain public comments and as a result of new information. The purpose of this section is to outline these changes, both editorial and technical, and to discuss briefly the impact of these changes on the overall results. The changes are listed chapter by chapter. Items that affect the results are marked with an asterisk and are discussed in more detail in Section 8.3.

8.2.1 CHANGES IN CHAPTER I (INTRODUCTION)

*1. Data from the recently issued 1975 Radioactive Material Shippers Survey are now included and form the basis of the standard shipments model.

2. A section on experience with radioactive material transportation has been added.

3. The discussion from Chapter III of NUREG-0034 on radioisotope uses has been rated into Chapter 1.

4. Figure I-2 (HTGR fuel cycle diagram) has been deleted.

5. Table I-1 (Radioisotope Shipment Summary - July 1, 1975) and Table I-2 (Standard Shipments for the Nuclear Industry) of NUREG-0034 have been replaced by a summary of the standard shipment model information from Appendix A.

6. Table I-3 (Radioactive Material Shipments) of NUREG-0034 has been expanded to include packages per year, TI per year, curies per year, miles per year, and the expected number of latent cancers per year computed in this assessment and incorporated into Table 1-2.

7. The discussion in NUREG-0034 of the fault-tree/logic-model approach has been eliminated.

8.2.2 CHANGES IN CHAPTER II (THE REGULATIONS GOVERNING RADIOACTIVE MATERIALS TRANSPORT)

1. The consolidation of the DOT regulations into Title 49 of the Code of Federal Regulations has been incorporated.

2. "Exempt" quantities are now referred to as "limited" quantities.

3. Miscellaneous errors in Table II-5 of NUREG-0034 have been corrected.

8.2.3 CHANGES IN CHAPTER III (RADIOLOGICAL EFFECTS)

1. The concept of RBE is explained more fully.

2. Table III-1 of NUREG-0034 has been expanded.

3. The discussion in NUREG-0034 of background radiation has been significantly expanded.

*4. The discussion in NUREG-0034 of hazards of radiation has been subdivided into three separate sections: acute effects, carcinogenesis, and genetic effects. Genetic effects are now quantitatively discussed.

5. A discussion of sensitivities of other life forms to radiation has been added.

6. The section in NUREG-0034 on radiological properties of transported radionuclides has been eliminated. Certain selected sections of that discussion have been incorporated into Chapter 1.

7. Table III-8 of NUREG-0034 has been deleted. Selected values have been incorporated into Appendix A.

8. Figure III-3 of NUREG-0034 has been revised to incorporate new data concerning early effects of inhaled, long-lived, alpha-emitting isotopes.

8.2.4 CHANGES IN CHAPTER IV (TRANSPORT IMPACT UNDER NORMAL CONDITIONS)

1. References and figures in NUREG-0034 concerning the original fault-tree/logic-model methodology have been deleted.

2. Figure IV-1 has been redrawn.

*3. The normal dose calculations are based on the new standard shipments model.

*4. Some aspects of the computational scheme used to determine normal dose have been changed. The entire scheme is discussed in Appendix D (replacing Appendix E of NUREG-0034).

*5. Discussions of maximum individual dose have been added for each population subgroup.

*6. A revised demographic model has been incorporated and is explained in Appendix E.

7. The section on nonradiological impacts has been rewritten.

8. The section on abnormal occurrences has been expanded.

*9. A section on import and export shipments has been added.

*10. Results of the genetic effects analysis have been added.

8.2.5 CHANGES IN CHAPTER V (EFFECTS OF TRANSPORT UNDER ACCIDENT CONDITIONS)

1. The title of the chapter has been changed to "Impacts of Transportation Accidents."

2. The chapter has been reorganized into what is felt to be a more logical sequence.

3. The explanation of the concept of "risk" has been expanded.

4. All equations in NUREG-0034 have been deleted from the text and placed in Appendix G, where they are explained.

5. Figure V-1 has been revised and expanded.

6. The logic model figures in NUREG-0034 have been deleted.

*7. The computations are based on the new standard shipments model.

*8. The new demographic model has been incorporated into the calculations.

*9. The severity derating scheme for aircraft accidents on real surfaces has been revised, and a description of the derating is given in Appendix H.

*10. The overall accident rate for aircraft has been revised to incorporate a newer and more substantial data base.

11. The Integrated Container Vehicle has been added as the primary mode for transport of recycle plutonium in 1985.

*12. The values for fractions of accidents occurring in various population zones for trains have been modified.

13. A section on waterborne transport (barge and ship) has been added.

*14. The release fraction model has been modified based on recent test data. Three additional sets of release fractions are used; for Type B plutonium containers, one release fraction set for 1975 Pu containers has been introduced and one for 1985 Pu containers. A second release fraction model has been introduced for casks.

*15. The atmospheric dispersion model has been modified to include dry deposition and resuspension. In connection with this, a section on surface contamination has been added.

*16. The "worst case" analysis has been expanded to include other materials. Both consequences and probabilities are presented for category VIII accidents involving these materials in an urban area with a population density of 15,400/km^2.

17. Figures V-10, -11, -12, and -13 and Tables V-8, -9, -10, and -11 of NUREG-0034 have been deleted.

*18. The dose calculations (both early and long-term) are no longer based on Pu-239 dosimetry. The new dose calculation methodology is discussed in Appendix G, and the parameters used are given in Appendix A.

*19. The method used to compute early fatality probability has been revised and is explained in Appendix G.

*20. Results of the genetic effects analysis have been added.

8.2.6 CHANGES IN CHAPTER VI (ALTERNATIVES)

*1. The following alternatives are no longer considered: all cargo-only air shipments shifted to passenger aircraft, VFR-only flights, daytime-only flights, specific aircraft model requirements.

*2. The following alternatives have been added: a 0.5-mrem/hr maximum dose at seat level in passenger aircraft, all feasible irradiated fuel shipments by barge, and aircraft package monitoring. The discussion of the alternative to restrict irradiated fuel shipments to special trains has been revised and expanded.

*3. The alternatives evaluated for plutonium only in NUREG-0034 are now evaluated for all "high-hazard dispersible" materials. (These are defined in Section 6.2.4.)

4. Only the alternatives that were found to be cost effective are now included in the summary at the end of the chapter.

8.2.7 CHANGES IN CHAPTER VII (SECURITY AND SAFEGUARDS)

1. A section discussing the potentials for misuse of SNM and radioactive isotopes and waste has been added.

2. The section on "Transportation Security Systems" has been revised to contain an assessment of current physical protection measures. It has been renamed "Physical Protection of Highly Enriched Uranium and Plutonium During Transit."

3. An Alternatives section has been added. This section consists of a discussion of the Federal Guard Force, the ERDA Transport System, the Department of Defense, protection against a higher level threat, and restricting transport (of SNM) to a particular mode.

8.2.8 CHANGES IN APPENDIX A (ENVIRONMENTAL IMPACT LOGIC MODEL)

1. Appendix A of NUREG-0034 has been deleted.

8.2.9 CHANGES IN APPENDIX B (PLUTONIUM)

1. Appendix B of NUREG-0034 is now Appendix C.

2. Figure B-1 of NUREG-0034 has been deleted.

*3. Tables B-1 and B-2 of NUREG-0034 have been revised and expanded to include dosimetric effects.

4. A figure showing deposition fractions versus particle size has been added.

5. A section on genetic effects has been added.

6. The section on toxicity has been revised and expanded.

8.2.10 CHANGES IN APPENDIX C (INCIDENTS REPORTED TO DOT INVOLVING RADIOACTIVE MATERIALS)

1. Appendix C of NUREG-0034 is now Appendix F.

2. An introductory section has been added.

3. A figure showing the Incident Report form has been added.

8.2.11 CHANGES IN APPENDIX D (REGULATIONS)

1. Appendix D of NUREG-0034 is now Appendix B. No further changes were made.

8.2.12 CHANGES IN APPENDIX E (POPULATION DOSE FORMULAS FOR NORMAL TRANSPORT)

1. Appendix E of NUREG-0034 is now Appendix D.

*2. The methodology used to compute dose to crew, dose to surrounding population while moving, dose to population on the transport link, and dose while stopped has been revised. The revised equations were derived from first principles.

8.2.13 CHANGES IN APPENDIX F (PRODUCTION OF A NUCLEAR EXPLOSION BY AMATEURS)

1. Appendix F of NUREG-0034 has been deleted.

8.2.14 CHANGES IN APPENDIX G (SENSITIVITY ANALYSIS)

1. Appendix G of NUREG-0034 is now Appendix I.

2. The method used to analyze the sensitivities of the radiological risks to the parameters used in their determination has been revised.

8.2.15 CHANGES IN APPENDIX H (STATE AND LOCAL REGULATORY AGENCIES)

1. Appendix H of NUREG-0034 has been deleted.

8.2.16 NEW CHAPTERS AND APPENDICES

1. Chapter 8 has been added. This chapter discusses changes that have been incorporated since the draft version was published and addresses public comments in detail.

2. Appendix A has been added. This appendix discusses the development of the Standard Shipments Model used for the risk analysis in Chapters 4, 5, and 6.

3. Appendix E has been added. This appendix discusses the demographic model used in Chapters 4, 5, and 6.

4. Appendix G has been added. This appendix specifies the calculational scheme used for the accident calculations in Chapters 5 and 6.

5. Appendix H has been added. This appendix discusses the aircraft accident derating model introduced in Chapter 5.

6. Appendix J has been added. This appendix consists of copies of each of the comments received by NRC during the public review period.

7. Appendix K has been added. This appendix consists of copies of the comments received after a February 1977 meeting of the Working Group on Transportation of the Advisory Committee on Reactor Safeguards at which the February 1977 draft FES was discussed.

8.3 MAJOR CHANGES THAT HAVE RESULTED IN CHANGES IN CONCLUSIONS/ANALYSIS SINCE NUREG-0034

1. The incorporation of the shipment data from the 1975 shippers survey increased the number of packages by a factor of 4, the number of curies by a factor of 100, and the number of TI by a factor of 16. The net effect produced by these and the analysis changes was an increase in the annual normal LCF by a factor of 1.02 and in the annual accident LCF by a factor of 8.4.

2. The incorporation of the new demographic model changed population densities as follows:

	Population Density (km^{-2})	
	NUREG-0034 (Draft)	NUREG-0170
Rural	40	6
Suburban	400	719
Urban	4000	3861

3. The relative contributions of the various population subgroups to the normal risk differ from those in the Draft as a result of both the new standard shipments model and the new method of computing the normal dose, as outlined in Appendix D. The changes are evident in the following table:

Population Subgroup	Percent Contribution to Normal Risk	
	NUREG-0034 (Draft)	NUREG-0170
Passengers	9.03	23.8
Crew	0.88	32.1
Attendants	0.56	1.1
Handlers	6.1	17.8
Off-link	55.0	4.3
On-link	1.4	4.0
Stops	14.9	11.1
Storage	12.0	5.8

4. Estimates of maximum individual dose are included in Chapter 4 in an attempt to add additional perspective on the normal impact of radioactive material transport.

5. Export and import shipments were analyzed explicitly and were found to make only a small contribution to the total risk.

6. The results of the revised real-surface derating scheme for aircraft are compared below with that used in NUREG-0034:

Accident Severity Category	Fraction of Real-Surface Accidents of a Given Severity	
	NUREG-0034	NUREG-0170
I	0.57	0.447
II	0.16	0.447
III	0.099	0.0434
IV	0.077	0.0107
V	0.033	0.0279
VI	0.036	0.0194
VII	0.022	0.0046
VIII	0.003	0.0003

7. The aircraft accident rate in NUREG-0034 was 5.6×10^{-8} per mile for cargo aircraft and 1.8×10^{-8} per mile for passenger aircraft. The value used in this assessment is 2.3×10^{-8} per mile for all air modes.

8. The fraction of train accidents occurring in each population zone are revised as follows:

Accident Severity Category	NUREG-0034			NUREG-0170		
	Urban	Sub.	Rural	Urban	Sub.	Rural
I	0.1	0.45	0.45	0.8	0.1	0.1
II	0.1	0.45	0.45	0.8	0.1	0.1
III	0.1	0.45	0.45	0.3	0.4	0.3
IV	0.1	0.45	0.45	0.3	0.4	0.3
V	0.1	0.45	0.45	0.2	0.3	0.5
VI	0.1	0.45	0.45	0.1	0.2	0.7
VII	0.1	0.45	0.45	0.1	0.1	0.8
VIII	0.1	0.45	0.45	0.05	0.05	0.9

9. The values for release fractions for Type A and Type B packagings (not used for shipping plutonium) have been revised as indicated below:

Accident Severity Category	Type A Package		Type B Package	
	NUREG-0034	NUREG-0170	NUREG-0034	NUREG-0170
I	0	0	0	0
II	0	0.01	0	0
III	0	0.1	0	0.01
IV	0	1.0	0	0.1
V	0.1	1.0	0	1.0
VI	0.2	1.0	0	1.0
VII	0.5	1.0	0.1	1.0
VIII	1.0	1.0	0.5	1.0

In this assessment the containers are conservatively assumed to begin to fail just above the severity at which they were tested.

10. Three additional packaging categories, B-Pu-1975, B-Pu-1985, and Cask have been added. The release fractions for Type B-Pu containers reflect recent test data for plutonium shipping containers and apply only to plutonium shipments. The cask data allows for cracking of a massive cask with subsequent direct exposure hazards.

11. The atmospheric dispersion model was revised to consider dry deposition and to restrict upward diffusion of the debris cloud to 1400 meters. The net effect of this revision is to reduce the downwind concentrations of the transported material that is available for inhalation.

12. The dose calculations were modified to allow for dose resulting from the resuspension of deposited material.

13. An extreme urban population density of 15,444 persons/km^2 based on New York City census information was used in assessing the consequences of certain class VIII accidents in urban areas.

14. The dose calculations are now based on a standard dosimetric model, not on Pu-239 data. The dosimetric calculations are explained in Appendices A, D, and G.

15. The dose-probability calculation for early fatalities has been changed. The derivation of the equations used in the revised calculation is presented in Appendix G.

16. The combination of the revised standard shipments model and revised release fractions, aircraft accident rates, real-surface deratings (particularly classes VII and VIII), meteorology, dosimetry, population densities, etc., resulted in an increase in the overall accident LCF by a factor of 8.5 and a decrease in the accident LCF resulting from plutonium shipments by a factor of 8.4. The greatest contributions to the accident LCF are made by Po-210 and mixed fission/corrosion product shipments, each contributing approximately one-fourth of the total. Plutonium shipments account for about 15% of the total accident LCF. This result is significantly different from that of the draft version of this document, in which it appeared that plutonium shipments completely dominated the accident risk.

17. Because the shipments of plutonium do not dominate the accident risk as in NUREG-0034, shipments of all "high-hazard, dispersible" materials, including plutonium, are considered for the various alternatives that previously considered only plutonium. The criteria used to determine which dispersible material shipments are to be considered "high-hazard" are a rem-per-curie inhaled value greater than 10^6 and a quantity per shipment greater than 100 curies.

8.4 DISCUSSION OF COMMENTS RECEIVED DURING PUBLIC RESPONSE PERIOD

NUREG-0034 was issued in March 1976, and a public comment period ending May 17, 1976, was provided. Comments received during that period are compiled and presented in their entirety in Appendix J to this document. This section addresses each of the comments received individually. In order to make the reader's task easier, each comment is presented, followed by the staff response to that comment.

General Comments: 1

City of New York - Comment 1

"The rule-making proceeding to which this DES is addressed arises from a nationwide expansion of the nuclear material transportation program. However, even if the DES at issue were adequate (as it is not) as a generic environmental statement, if the rules purport to apply to transportation within and through New York City, there must be an additional DES prepared for shipments in and through New York City."

State of Georgia - Comment 7

"In addition to the general considerations of transportation of nuclear materials throughout the United States, specific consideration must also be addressed with regard to large metropolitan areas such as Atlanta, ports of entry, and other large transportation centers. NRC has a definite and specific responsibility in the development and application of proper procedures for the transportation of nuclear materials through such areas in order to insure the complete protection of the citizens of the area. Such procedures must be useable and acceptable by the States that are impacted."

State of Georgia - Comment 5

"In general, the EIS is too general and non-specific to be of much use as a planning tool for specific areas. As was stated in above, NRC has the obligation and responsibility to issue a report that is useable by the States."

Staff Response - The annual risk estimates in this report are made using average population density values of 3861, 719, and 6 persons per square kilometer, respectively, for urban, suburban, and rural areas. Appendix E shows that only 18 cities in the United States have population densities exceeding 3861 persons per square kilometer, including New York City, which in the 1970 census had an average urban density of 15,444 persons per square kilometer. This higher population density was used in the evaluation of severe accident consequences in Section 5.6 of this report. Since average urban population density is used in the risk analysis, the risk to individual urban areas is included in the total risk assessed.

General Comments: 2

ERDA - General Comment 1

"This document contains much pertinent information relative to NRC and the Department of Transportation regulations for the shipment of fissile and other radioactive material and reflects considerable work in summarizing information concerning personnel exposure limits and radiological effects. However, it was difficult to verify results presented due to incomplete discussion of the material in the text. Although we are familiar with the subject and the associated technology, we found the organization of the statement somewhat difficult to understand.

We would like to suggest that you may wish to revise the organization of the statement for better continuity."

State of Georgia - Comment 1

"The draft EIS deals with the transportation of all types of radioactive materials, including pharmaceutical as well as spent fuel. It is broad, general, and non-specific. Because of the way it is organized and presented, it is practically impossible to sort out the real issues and impacts associated with an area of prime interest such as the transportation of spent fuel. The NRC should separate out the issue of spent fuel and do a separate detailed and factual EIS on its transportation aspects."

Staff Response - The general discussion in Chapters 4 and 5 has been expanded, and more detailed derivations have been provided in Appendices D and G. It is hoped that these clarifications and reorganizations will enable the reader to extract the desired information. In all cases, impacts due to shipment of irradiated fuel are specifically delineated.

General Comments: 3

ERDA - General Comment 4

"Our staff also strongly recommends that a more thorough evaluation be given to the need for decontamination after an accident involving rupture of containment. The ingestion pathway discussed in Appendix A should be carefully evaluated for the radionuclides which may cause special problems."

Staff Response - Section 5.5 on contamination/decontamination has been added to Chapter 5. Ingestion problems are discussed in that section.

General Comments: 4

ERDA - General Comment 3

"Because of the subject matter of this statement, we would suggest that a glossary be added at the beginning of the statement. Some examples are transport index, half-life, effective half-life, latent cancer fatality, competent authority certification, and others. We feel that such an addition would be quite helpful to all readers. Furthermore, NRC might wish to consider the use of photographs in the statement to also assist the reader."

Staff Response - In view of the extensive references to source documents that include photographs and explanations of terms, neither photographs nor a glossary have been added to this document.

General Comments: 5

City of New York - Comment 4

"The DES purports to review a 30-year program but fails to include increases in nuclear shipments beyond 1985. Nor is there adequate basis for the DES's forecast of a 250% increase of shipments."

Staff Response - The DES does not "purport to review a 30-year program." The 30-year period mentioned on page ii refers only to the period during which cancers induced in 1975 would prove fatal. The basis for the projections to 1985 is discussed in Appendix A.

General Comments: 6

Mrs. Virginia Karstedt - Comment 3

"You are badly in need, it seems to me, of more current data. I ran an average of the dates for all references listed at ends of chapters. The average age of your data is 4 years. Some of your references date back to 1958. Yet you went ahead and published your draft without fresh material. It's just a rehash of old studies."

Staff Response - The technique to "average the dates of all references" to gauge the applicability of the references is totally invalid. The 1958 reference cited was used in an historical background section and is considered to be a standard reference. Current data from ongoing studies were used where available and applicable. This document is not a "rehash of old studies," since no generic transportation study of this sort has been issued previously. Data from many sources have been compiled for the report and each datum was carefully reviewed for validity and applicability before it was included.

General Comments: 7

City of New York - Comment 5a

"While the DES purports to be evaluating certain existing regulations, there is no attempt to deal with the critical issue of compliance with, and enforcement of those regulations. The NRC, in the course of its purportedly close supervision over shipments of nuclear materials, appears to have no accurate idea of how many shipments are made per year, where they go, by what route they go and to what extent their transport is in accord with applicable law. We submit that no proper assessment of the environmental impact of the nuclear transportation program can be made in the absence of both accurate data and an evaluation of the extent to which existing rules and regulations in fact achieve their purpose."

State of New York - Dept. of Environmental Conservation - General Comment 8

"Information should be added to the Draft Statement that clearly establishes the level of enforcement action being undertaken by the U.S. Department of Transportation, the Nuclear

Regulatory Commission and various states in connection with the transportation of radioactive materials. This information should include tabular material about the number of inspections relating to radioactive materials that have been undertaken and the type and number of enforcement actions that have been taken in connection with radioactive materials during the last five years. There should also be an indication of the number of inspections that are scheduled during the coming year."

State of New York - Dept. of Environmental Conservation - General Comment 24

"It is recommended that the environmental statement be expanded to include Federal monies expended, (1) in the development of regulations and (2) in the enforcement of regulations followed by a discussion as to the optimal amount of money that should be expended to effectively minimize the hazard to the Public from the transportation of radioactive materials."

Staff Response - The goal of the DES was to evaluate the environmental impact resulting from the shipment of radioactive materials. The data used were obtained by NRC in the course of its regulatory function as well as from other reliable sources. Compliance with regulations has been assumed in calculation of the impacts, with a conservative estimate made for the additional impact brought about by a level of noncompliance estimated from a limited amount of bad experience. Recent studies have shown relatively good compliance with those regulations directly affecting radiological impacts.

The costs involved with the inspection and regulation programs are not germane to this statement since the aim is to establish the extent of the environmental impact and the changes that would be realized for various alternative actions. The costs involved in regulation would be more appropriately included in the analyses associated with specific regulation changes resulting from this statement.

General Comments: 8

HEW - Comment 1

"We note that the June 1975 public comments on the proposed rulemaking concerning air transportation of radioactive materials are not included in the draft document."

Staff Response - Those comments are for consideration in the rule making portion of the proceedings, not the impact assessment portion.

General Comments: 9

State of New York - Dept. of Environmental Conservation - General Comment 4

"The draft statement should reference and thoroughly discuss the safety analyses performed for the development of spent fuel shipping containers and the accident parameters used to develop safety analyses."

Staff Response - The regulatory design criteria, including the Type B package accident parameters, are specified in 10 CFR Part 71. A reference to 10 CFR Part 71 in this context is included in Section 2.3 of the Final Statement.

General Comments: 10

State of Georgia - Comment 3

"With reference to accident analysis, the EIS seems to look at alternatives in a broad, general context and only related to the average exposure concept. It is questionable as to whether some of these same alternatives would still be valid if the maximum exposure concept were used."

Staff Response - The alternative impacts are also presented in terms of reduction in early fatalities. There is no reason to believe that any of the alternatives considered would reduce the population dose and at the same time increase the maximum individual exposure.

General Comments: 11

ERDA - General Comment 5

"We agree with the general conclusions of the statement that the risk from radioactive material shipments is low compared to other societal risks. However, we are concerned that the accident risk analysis overestimates the transportation accident risk and is too simplified to make valid comparisons of the relative risks between the various radioactive materials. The danger in this is that people might scale the accident risk results in an attempt to determine the shipping level at which the accident risk would become unacceptable. When and if the industry approaches this shipping level at some future time, the overestimation could lead to unwarranted concern over the accident risk."

Staff Response - In the absence of data or valid analysis, realistic but conservative assumptions were made. Wherever this was done, it was clearly stated. If newer data show the values used in the DES to be excessively conservative, the analysis can be updated. However, it would be improper to formulate a document to be used for decision making that involves public safety on unsubstantiated facts or "ballpark estimates."

General Comments: 12

State of New York - Dept. of Environmental Conservation - General Comment

"The various modes of transportation including options within each mode should be subjected to systematic analysis wherein all of the risks, (i.e., normal transportation; accidents and security consideration), are interrelated so that both the impact and a transportation strategy could be developed. The Draft Environmental Statement fails to perform this function and, therefore, does not provide a meaningful comparison of the benefits and risks of alternative transportation modes."

Staff Response - Chapter 6 addresses both the normal and accident risks quantitatively for each alternative evaluated. The analysis includes many of the most likely alternatives but not all possible permutations of actions that might be taken. The impact of specific changes in regulations can be addressed as they are proposed.

General Comments: 13

State of New York - Dept. of Environmental Conservation - General Comment 1

"In spite of low probability of a major release of plutonium, the severe consequences of the accident merit attention to the further analysis of the alternative transportation and packaging modes and security implications thereof in order to futher reduce the probability of plutonium release in an accident. Therefore, New York State suggests that the alternative modes of transporting plutonium be considered separately from other radionuclides. In such a separate review, the need for developing an 'air-safe' container for plutonium shipment must be considered as part of the requisite overall analysis of the environmental consequences (in normal and accident situations) of alternative modes of plutonium transportation and packaging and the security requirements associated therewith."

Staff Response - Shipment of plutonium is the specific subject of several recently issued or ongoing reports. The development of "air-safe" containers is also being considered and evaluated separately in connection with recent congressional action that caused NRC to prohibit plutonium air shipments pending development of such a container. However, it is appropriate to include plutonium with the other radionuclides in this generic statement since it is intended to form a picture of the industry as of mid-1975. Note that several alternatives considered impinge on plutonium shipments and represent activities currently under way relating to plutonium shipping safety.

General Comments: 14

State of New York - Dr. John Gofman - General Comment 1

"These comments will be limited to the subject of plutonium and its health hazards, in the context of the DES. The DES is totally unacceptable in its evaluation of the inhalation hazard of plutonium, since the errors in treatment of this subject are numerous and large. Consequently all the evaluations of the consequences of plutonium dispersal in the event of container failures are not only irrelevant to the true problem, but they do a severe disservice in grossly underestimating the true medical cost of such dispersals."

State of New York - Dr. Marvin Resnikoff - Comment 2

"We have examined certain parts of the DES dealing with toxicity of materials, containerization, dispersion, crash environments and risk analyses of various modes of transportation and it is our conclusion that the DES is a fatally defective document and, as such, cannot be relied upon as an accurate or adequate document by the Congress or the public."

City of New York - General Comment

"It is our view that the DES is fatally inadequate and thus cannot serve as a basis for determining the effectiveness of NRC's present rules governing the air transportation of radioactive materials and of possible alternatives to those rules."

Staff Response - Specific comments related to these general statements have been evaluated elsewhere. Where the comment had merit, an appropriate change in the document and/or analysis was made; otherwise the reason for not accepting the comment was given.

General Comments: 15

Dr. K. Z. Morgan - Comment 7

"There are too many rather arbitrary and unsubstantiated assumptions."

Dr. K. Z. Morgan - Comment 8

"There are serious inconsistencies between this and previous NRC reports and statements by NRC officials."

Staff Response - Without more specific reference to the assumptions or inconsistencies under discussion, no detailed answer to this comment can be provided.

General Comments: 16

ERDA - Comment 70

"It has been suggested that the report title be shortened to: 'The Transportation of Radioactive Materials.'"

Staff Response - The title of the report reflects the aims and limitation of the analysis as perceived by NRC.

DES Summary and Conclusions: 1

ERDA - Comment 1

"The first paragraph here gives the person-rem per year, but does not give the comparative person-rem per year in the U.S. from background radiation. We think it would be appropriate to make this explicit as the the conclusion on page v notes the small fraction contributed by the transportation phase. We did not find an explicit number anywhere in the text.

"We found no comparison of the excess exposure received by aircraft passengers and crew from cosmic radiation at flight elevation vs. the background radiation they would have received had they stayed on the ground. The comparison of this number with that arising from exposure from packages containing radioactive material carried in the aircraft should be constructive."

Staff Response - Background exposure and exposure due to high altitude flight have been added.

DES Summary and Conclusions: 2

ERDA - Comment 2

"Page ii, Paragraph 3a states, '. . .an aircraft carrying a bulk shipment of plutonium oxide. There are presently less than 100 bulk shipments of plutonium per year. . .'

"The terminology, 'bulk' shipments, may be construed to be loose or unpackaged. We are unaware of any such shipments of plutonium. We suggest that these statements be reevaluated since they may convey a connotation different from that intended in respect to shipment of plutonium."

Staff Response - The word "bulk" has been changed to "large."

DES Summary and Conclusions: 3

State of New York - Dr. Marvin Resnikoff - Comment 20b

"The specific origin of the Latent Cancer Fatalities figure (20 per year for 30 years) (p. ii), which allegedly could be produced from the DES' plutonium accident scenario, cannot be found anywhere. Throughout the numerical presentations the reader is forced to do detective work to find the computational framework (often apparently guesswork) utilized by the authors, often without success."

Staff Response - The value of 20 per year for 30 years merely expresses the latency-plateau model for cancer risk. The total number of cancers expected are 600 and they are assumed to appear over a 30-year plateau period following a latency period of some 10-15 years.

DES Summary and Conclusions: 4

ERDA - Comment 3

"It is not clear in the text, page II-25 [III-25], whether curve A, B, or C is used. If A has been used in the calculations, then it would be appropriate to state in 'e' that no medical precautions are taken."

Staff Response - Curve B, which assumes that "supportive medical treatment" is provided, was used and a clarifying statement has been added to FES Figure 3-2.

DES Summary and Conclusions: 5

ERDA - Comment 4

"Another alternative which could be considered is requiring the carrier to survey packages prior to acceptance or loading. If this check and balance had been in effect, we might not have experienced some of the notable exposures in aircraft transportation."

Staff Response - An evaluation of this alternative is now included.

DES Summary and Conclusions: 6

State of New York - Dept. of Environmental Conservation - Comment 10

"The Draft Statement indicates (p. iv) that a few individual transport workers whose radiation exposures exceed the limits established for members of the general public should be, and in most cases are, monitored and otherwise treated as radiation workers. There does not seem to be clear indication of when such transportation workers are to be treated as radiation workers. It is necessary that workers required by their job to work with radioactive materials and radiation, whether in a laboratory or on a loading platform, are dealt with in a consistent manner. Therefore, it is important that the class of transportation workers and work situations involving significant shipments of radioactive materials should be identified so appropriate radiation protection measures can be taken."

Staff Response - The matter of when, if ever, transportation workers should be considered to be occupationally exposed to radiation is being studied by the staffs of DOT and NRC. Such a policy decision may ultimately involve other agencies as well.

DES Detailed Summary: 1

Dr. K. Z. Morgan - Comment 5a

"On page XIX we find the statement, 'It is estimated that the total annual population exposure resulting from normal transport is about 9600 person-rem.' Such a statement is completely meaningless and valueless because the year is not indicated and there is no indication of whether this man-rem is to the total body, thyroid, trabecular bone, deep lung compartment, etc."

Staff Response - The person-rem estimate is stated as being based on "current shipping practices," which is specified on page i to be as of June 30, 1975. This assumption is discussed in greater detail on DES pages I-15 and I-19.

The organs involved are discussed in detail in Chapters 3 and 4. It is clear from those chapters that the estimated person-rem refers to whole-body exposure.

DES Detailed Summary: 2

Friends of the Earth - Comment 3

"We refer the NRC to the affidavits of Drs. John Gofman, Marvin Resnikoff and Karl Z. Morgan, prepared for the New York State Attorney General in his lawsuit against the U.S. government to halt air shipments of plutonium. The above are leading scientists with expertise in plutonium toxicity and dosimetry; the NRC figures of one fatality and sixteen latent fatalities are unsubstantiated by any expert studies or data and are therefore indefensible."

Staff Response - Although the three persons referred to have made statements relating to plutonium toxicity, their conclusions are at variance with other experts in the field. Because there is disagreement between NUREG-0034 results and those of the "experts" doesn't mean that the NUREG-0034 results are "indefensible." Accident calculations are based on the best information known to NRC.

DES Detailed Summary: 3

ERDA - Comment 5

"What is the basis for the statement 'A Factor of twenty decrease in accident risk and consequences seems attainable by this technique (change in physical form) for plutonium shipments.'? We agree with the principle but question the technical basis of this factor."

Staff Response - It is shown in Section 6.4 that a reduction of 0.005 LCF in total accident risks would result if it were possible to change the form of the plutonium in such a way that the respirable fraction were limited to 1 percent.

DES Detailed Summary: 4

Friends of the Earth - Comment 2

"We take issue here, as elsewhere, with the reprehensible practice of averaging radiation exposure over large populations and thus submerging individual health effects. This averaging is misleading in that it infers lower radiation releases than actually occur; it also ignores the very real health effects, short- and long-term, on the individual who is unfortunate enough to contract cancer or leukemia, suffer genetic mutations, or give birth to a deformed infant. For this individual the risk is one, e.g., certainty.

"One could compare this habit of averaging to the argument used by nuclear proponents in trying to refute public concern over plutonium toxicity. These individuals denigrate public concern by saying that perfectly uniform dispersal and ingestion of plutonium oxide is highly unlikely and therefore we should not worry about plutonium releases. Here, however, it is the NRC that is guilty of assuming - for their own purposes of underplaying the seriousness of radiation releases - that radiation resulting from an accident will be uniformly dispersed and uniformly received by vast populations numbering in the hundreds of thousands, even millions.

Nuclear opponents and critics have never assumed such perfect dispersal, and we therefore insist that the NRC not make a similar assumption, and discontinue its use of the term man-rem."

Dr. K. Z. Morgan - Comment 9

"Average cases and the standard or reference man data are used in estimating cancer risk. Don't the children, the persons with respiratory diseases, etc., count? It seems we should protect them as well as the healthy adult worker to whom the standard man data apply."

Staff Response - In the normal transportation case the dose to those persons surrounding the transport links, passengers, handlers, etc., is calculated making estimates in each case of the number of persons exposed. A package in normal transport does give a small dose to a lot of people, because of the nature of the transportation process.

Nowhere is the assumption of uniform dispersal made in the accident case. The dispersion model, a Gaussian diffusion model, is discussed in Chapter 5.

The BEIR statistics used for latent cancer fatality assessment are adjusted to account for differences in the sensitivity of the fetus, child, or adult with respect to radiation-caused carcinogenesis (WASH-1400, Appendix VI, page G-4, para. G-1.2).

The question of potential synergistic effects of respiratory disease and lung cancer is not specifically addressed. Two points concerning this question should be noted: (1) The BEIR values are acknowledged to have large uncertainties associated with them. They are average values, not absolute values. (2) The fact that persons with respiratory illnesses have a shorter life span anyway might very well offset any increase in their susceptibility to radiogenic lung cancer.

DES Detailed Summary: 5

Friends of the Earth - Comment 4

"We take strong exception to the statement in paragraph d that nuclear fuels produce lower levels of gaseous and solid pollutants - not because the statement is false but because it compares apples and oranges, e.g., fails to note that nuclear fuels do in fact produce pollutants that are qualitatively different and much more lethal, namely radioactive fission products, in normal operation, through waste accumulation, activation products, and in unplanned releases. Furthermore, the potential for large radiation releases is always present in all parts of the nuclear fuel cycle, normal operational releases aside."

Staff Response - Although the nuclear pollutants are qualitatively different and may be more lethal in concentrated form, one cannot ignore the relative quantities of pollutants introduced into the environment by the various methods of producing electricity. The comment does have some validity, however, in that the paragraph implies less pollution from nuclear fuels than from conventional fuels, which, while probably true, is not within the scope of this document and has been deleted.

DES Detailed Summary: 6

Department of Interior - Comment 1

"It would be helpful to summarize the proposed action more clearly at the outset of the environmental statement. We conclude that it is proposed to continue regulating the transport of radioactive materials under present Federal regulations, pending completion of further studies of the costs and effectiveness of alternate transportation systems. While these studies are referred to generally (i.e., page v, paragraph 3), we find no summary of the specific studies in progress or of their expected date of completion.

"The non-radiological consequences of accidents involving vehicles used solely for transport of radioactive materials are variously given as 'two injuries and less than one fatality each four years' (for example, page iii, page xx, page xxiii). It would be advisable to use the same terminology throughout. In addition, some indication should be given of what percentage of transport is by vehicles used solely for transport of radioactive materials; otherwise, the figures on non-radiological consequences of accidents have little or no meaning or relevance to an evaluation of overall risk to individuals."

Staff Response - This EIS does not refer to any specific proposed action. Rather, it is an evaluation of the current state of affairs and possible alternatives that might be applicable in the future.

The nonradiological effects are discussed in detail in Chapter 5. An estimate of the percentage transported by exclusive-use vehicles is included in that chapter.

DES Detailed Summary: 7

HEW - Comment 2

"As presently contained in the document, the detailed summary does not present the reader with a thorough examination of the probable effects expected to occur from a shipping accident involving radioactive materials. Information should be included in the final document on the individual effects of each of the various types of accidents that could happen, modes of shipment, and the identity and quantity of materials involved. These should be described with and without ameliorating actions and/or safeguards. Comparing the overall exposure to populations from accidents involving radioactive material to the overall exposure from other sources does not address the consequences of a shipment accident in absolute terms."

Staff Response - Some of the information is included in the summary section. More details relating to shipments, modes of transport, and accident effects are included in Chapter 5 and in the Standard Shipments shown in Chapter 1.

To provide the detail requested would increase the size of the document many times without providing any real increase in information. Certain accident scenarios with more severe consequences are considered explicitly, but most are treated implicitly in the accident risk estimate.

This gives the desired balance between detail and general treatment which seems necessary for a generic study.

DES Detailed Summary: 8

Mrs. Virginia Karstedt - Comment 2

"..., your statistical conclusions reported in the Summary and Conclusions at the beginning of the book do not include data about shipment of irradiated fuel from nuclear power plants. And your stated purpose of answering public concern about nuclear fuel cycle material is not answered."

Staff Response - The summary and conclusions sections include data from fuel cycle shipment from 1975 and best estimates of those in 1985.

DES Chapter I: 1

United Airlines - Comment 1

"This reference page states that the purpose of the publication is to assess the impact upon the environment from the transportation of radioactive materials, primarily by aircraft, etc.

"This would appear to indicate that an effort has been made to justify an increase in the allowable limits for air movement. We will need to be extra careful in reviewing future rule making actions."

Staff Response - NUREG-0034 is intended to evaluate the transportation of radioactive material, not justify changes. Changes in regulations may be considered based on conclusions on safety, security, or the cost/benefit ratio from NUREG-0034.

DES Chapter I: 2

State of New York - Comment 11

"The Draft Statement indicates (p. I-3) that updated shipment information will be available in time for use in the final version of the Statement. We urge that such shipping data be incorporated fully into the final Statement. The newer data, in other words, should be used not only to revise Tables I-2 and I-3 but also to recompute transport impacts and to reevaluate alternative transport modes in the event that the newer data warrant such effort. If this information significantly alters the results of the draft environmental statement, then NRC should issue another draft statement for comment prior to the issuance of a Final Environmental Statement."

Staff Response - The revised standard shipment model based on the new data is used throughout the Final Environmental Statement.

DES Chapter I: 3

State of New York - Comment 12

"This section should present quantitatively the various applications for which radioactive materials are used and the benefits to society from these applications."

Staff Response - Detailed analysis of the benefits arising from the use of radioactive materials is beyond the scope of this report. A statement of the uses for such materials is included to provide background information necessary to understand the breadth of the transportation industry. This statement deals only with the transportation of materials, not with the benefits derived from their uses.

DES Chapter I: 4

Department of the Interior - Comment 3

"Throughout the statement there is little information on the adequacy of regulations as applied to the transport of large-curie radiation sources that are stated to contain as much as hundreds of thousands of curies for use in large-scale sterilization operations (page I-9). These are described as consisting chiefly of the radioisotopes cobalt-60 and cesium-137. Large curie sources of up to 10,000 curies are also said to be shipped to cancer treatment centers both in the United States and abroad, with overseas transport by ship and domestic transport by truck or rail (page I-9, paragraph 2). However, we found little or no information on the size or weight of the casks, or particularly on the adequacy of protection afforded the transport of the large-curie radiation sources under existing regulations."

Staff Response - Specific information on size or weight of casks is not germane to the report. The size and weight of the cask are more a function of the type of radiation emitted from the contained radioactive material than of the total hazard of that material if released. The adequacy of large-quantity shipments of radioactive materials are explicitly considered (see Section 5.5).

DES Chapter I: 5

State of New York - Comment 13

"The DES uses a figure of 600,000 packages of radioactive material shipped annually. This differs from other estimates previously used, including an estimate of 800,000 packages cited by the U.S. Atomic Energy Commission on page 61 of WASH-1238, dated December 1972. The reason for using the 600,000 figure should be indicated."

Staff Response - The value of 600,000 was used as the best available information. The detailed PNL study indicated that the actual value is closer to 2.5 million, and that value is used in the final report.

DES Chapter I: 6

ERDA - Comment 6

"We suggest that these be revised to indicate the following: (1) there are no commercial reprocessing plants presently operating; (2) liquid high level wastes must be solidified within five years of production and (3) an acceptable waste disposal method, not just site approval, is needed before a permanent waste repository will be available."

Staff Response - A comment to the effect that there are currently no reprocessing plants has been added to the final report. Comments have also been added to reflect the current state of national radioactive waste management plans and the solidification requirement of Appendix F to 10 CFR Part 50.

DES Chapter I: 7

Friends of the Earth - Comment 5

"Paragraph 1 has an unfortunate error; the substitution of the word safeguards for the word security. Or is the NRC implying that highly radioactive spent fuel will never be the object of attempted diversion or sabotage because of its innate hazards? Or does the NRC mean that irradiated fuel needs no safeguarding, period?"

Staff Response - The context of the paragraph is safeguards, as is evidenced by reference to 10 CFR Part 73. Part 73 requirements do not include safeguarding of irradiated fuel because it is extremely unlikely that a thief could steal the plutonium from it. Security is a different subject, and the statement is never made that spent fuel could not be the target of attempted sabotage.

DES Chapter I: 8

HEW - Comment 3

"It is noted that the shipments listed and their modes of transport are representative of the radioisotope industry (Table I-1). There are no estimates for postal shipments, which probably use any and all modes of transportation. Although these are of small individual quantity, they may be large in volume."

Staff Response - "Limited" quantities of various materials shipped by the postal service are now included in the overall assessment and are explicitly mentioned in FES Table 1-1.

DES Chapter I: 9

ERDA - Comment 7

"Table I-1 lists shipments which include all nuclear fuel cycle material; however, the statement fails to address U-core, U_3O_8, normal and enriched UF_6, fresh and recycled fuel assemblies, and radioactive wastes. We suggest that these should be addressed in the statement.

"We also suggest that the category 'Low Level Wastes' shipped from 'Fuel Fabricator and Reprocessor' to 'Commercial Burial Site' by 'Truck or Rail' might be added to this table."

FEA - Comment 1

"The 'Standard Shipments' used in assessing potential environmental impacts include plutonium, but do not include enriched uranium. Although the concern expressed during the past year by public officials and others about the air shipment of special nuclear materials has emphasized plutonium, uranium has not been excluded. If the NRC is able to certify to the Joint Committee on Atomic Energy (JCAE) that a safe container for plutonium has been developed and tested which will withstand the crash of a high-flying aircraft, the public concern over air shipments could shift to enriched uranium. Accordingly, we suggest that low enriched uranium typically used in light water power reactors be included in the 'Standard Shipments' analyzed in NUREG-0034."

ERDA - Comment 8

"We suggest that the category 'Fresh Fuel and Radioactive Waste Shipments' be added."

Staff Response - The front-end fuel-cycle shipments are included in the revised standard shipments model. Low-level wastes have been added to FES Table 1-1 and are also included in the revised standard shipment model.

DES Chapter I: 10

HEW - Comment 4

"Weapons shipments and all shipments in government-owned vehicles are not considered. These omissions may have seriously affected the calculations presented in the statement."

City of New York - Comment 2

"The DES is made virtually worthless by its unexplained exclusion, as 'outside the scope of this document' (I-19), of all government shipments. The degree of such shipments is unstated, but they are undoubtedly substantial in number and in degree of radioactivity. The cumulative impact on the environment of all shipments to and from an area must be assessed in a proper ES. Clearly, no meaningful assessment of cumulative impact, either nationwide or in a given area, can be made if a substantial portion of the shipments are arbitrarily excluded and treated, in effect, as if they make no adverse contribution to the environment. There is thus a failure to make the required comprehensive and integrated assessment of the environmental risks associated with the transportation of nuclear materials."

EPA - Comment 5

"With the exception of weapons-related shipments where the country's security might be compromised, we cannot understand the exclusion of government transportation statistics. Since this group of statistics is surely a large collection, the public release of this information is not only desirable but could certainly aid in the assessment of the environmental impact created by the transportation of radioactive materials."

Staff Response - The DES was in error in stating that shipments in government-owned vehicles were excluded from its scope. The scope of the EIS is the same as the scope of the Radioactive Material Shipments Survey (BNWL-1972) on which it is based and excludes defense-oriented shipments of weapons and weapons components and other shipments in military vehicles. These shipments are excluded because they are outside the jurisdiction of NRC and are controlled by other requirements. Also, the need for such shipments is judged on a totally different basis because of national security considerations - an area outside the scope of the Statement.

DES Chapter I: 11

Department of the Interior - Comment 4

"Tabular data in Chapter I, that appear to provide comprehensive information for most classes of radioactive materials shipments, provide little or no information on the large-curie radiation sources, which appear to be among the potentially most hazardous materials shipped. For example, Table I-2 (page I-20) shows no shipment class having an average of more than 5,000 curies per package. We feel that comparable information, including the number of packages shipped annually in 1975 and 1985, should be provided for the teletherapy sources containing up to 10,000 curies of radioactivity and for the radiation sources that contain as much as hundreds of thousands of curies of activity, particularly in view of the fact that some of the large-curie sources are said to be shipped to locations abroad and by means of truck, rail, and ship. These shipments appear particularly important for inclusion in this evaluation because it is noted that 6,600 industrial 100-curie sources were estimated to be shipped in 1975 (Table I-2), but a single shipment of a radiation source containing hundreds of thousands of curies of radioactivity appears to be potentially as hazardous as thousands of the 100-curie-source shipments."

Staff Response - Large radiography or teletherapy sources are included in the revised standard shipment model.

DES Chapter I: 12

Transnuclear - Comment 1

"Table I-2 on page I-20 shows a total of 370 spent fuel packages per year in 1975 with a truck/rail split of 14.2/85.8 percent. However, the Baseline Shipment Information as shown on Table IV-1, page IV-11, shows 54 shipments by truck and 326 by rail for a total of 380. The percentage split in Table I-2 is compatible with the number of shipments in Table IV-1, so perhaps the 370 total packages per year is incorrect."

State of New York - Comment 6

"The last sentence of the middle paragraph states: 'The annual numbers of spent fuel shipment for 1975 and for 1985 are estimated to be be 370 and 3600 respectively.' The NYS Department of Transportation notes that the number of 370 shipments for 1975 appears to be too low . . ."

State of New York - Comment 14

"Table I-2 indicates that 85.5% of the estimated 370 spent fuel shipments transported in 1975 were shipped by rail and that the other 14.2 percent were moved by truck. This information does not agree with information provided to 'the State' regarding 186 motor truck shipments of spent fuel to the West Valley, New York reprocessing plant in 1975."

Staff Response - The value used for the analysis was 380 shipments per year. This number has been significantly revised, however, in the new standard shipments model, which is based on the 1975 survey information. This model is intended to be generic, i.e., applicable to all transportation in, into, and out of the U.S. but not to segments thereof; therefore, although it covers the impact of transportation for all facilities, it may not reflect the actual mode split on shipments to or from a specific facility.

DES Chapter I: 13

Mrs. Virginia Karstedt - Comment 1

"... yet in Table I-3, p. I-21 you have excluded fuel cycle shipments - stating in a footnote that 'this data is expected to be updated by a more extensive survey now in progress. In other words you are not including fuel cycle shipments in this study because you do not have necessary data."

Mrs. Virginia Karstedt - Comment 5

"P.S. I note that Table I-3, p. I-21 is based on a speech presented in 1974 concerning transportation of hazardous material in air commerce. Yet in the table you do not make this clear. It looks like those are all packages shipped by any mode."

Staff Response - Table I-3 is a summary table of gross shipment numbers. It was not used in either the normal or accident evaluation. All types of shipments, including fuel cycle shipments, were included in this assessment. Although the information was presented at an Air Commerce Conference, it represents overall industry data. The only shipments excluded were shipments of weapons and weapons components and shipments on military vehicles.

DES Chapter I: 14

Friends of the Earth - Comment 6

"If the subject of possible accidents in transport of radioactive materials were not so serious, one could be amused by the NRC's use of the geometric mean of the extremes in curies per package for shipments. The statement 'The geometric mean was chosen to avoid attaching undue significance to the relatively few large quantity shipments' could be re-phrased to read: . . . 'to avoid undue attention to the potential hazards from radioactive releases of those shipments exceeding the geometric mean.'

"On hardly needs to point out that accidents do not space themselves out for our convenience so as to select only small-quantity shipments. An accident is as likely to occur to a large package as to a small one. Does the NRC mean to infer that the health effects from dispersal of a 100-kilogram plutonium shipment (such as those that took place at Kennedy Airport up until last year) are negligible? That the likelihood of large quantities being dispersed is smaller than that for small quantities? In this particular stochastic game, the NRC has fallen flat on its face. One hopes that we do not need an accident involving plutonium to pull them to their feet."

Staff Response - The commenter implies that the use of a geometric mean is a deliberate attempt to cover up the consequences of accidents involving shipments of quantities greater than the geometric mean. On the contrary, accidents involving large-quantity shipments are considered explicitly as separate scenarios in the standard shipments model in both the draft and final versions of the EIS (see, for example, Section 5.6). The technique of using geometric means was used to estimate the total number of curies shipped for each type of radionuclide. The revised shipments model provides sufficient data to obviate use of that technique and instead uses the average value from the extensive survey data and explicitly includes large-quantity shipments.

DES Chapter I: 15

ERDA - Comments 9 & 10

"What is the basis for the statement that spent fuel shipments represent 'a significant transportation risk'? We could find nothing in Reference 7 to support this statement.

"What is the basis for and meaning of the statement that 'a similar risk occurs in the transport of high level radioactive wastes'?"

Staff Response - The implication is that these shipments are a significant transportation risk within the nuclear fuel cycle, not as compared to all other radioactive shipments. This is supported by both WASH-1238 and 1248. The statements in question have been deleted, however, and the detailed analysis of the revised standard shipments model (FES Appendix A) is used to specify which shipments represent the major parts of the small overall risk from all transportation.

DES Chapter I: 16

Dr. K. Z. Morgan - Comment 5

"On page I-24 we have another useless statement because of insufficient qualifications. I refer to, 'The total amount of Pu shipped annually is estimated to be 2000 kg.' Presumably, this was for 1974? From WASH-1327 we find that for a BWR-1.15 SGR fuel discharge after 120 days decay we have 574 kg of Pu. Thus the 2000 kg corresponds to only 2000/574 = 3.5 reactor discharges per year assuming 1000 MWe per reactor."

Staff Response - The 1975 shipments have been variously estimated as 2000 kg (NMIS) or 700 kg (PNL). WASH-1327 (GESMO) specifically addresses a 1990 equilibrium recycle situation (see page I-3, para. 4 of WASH-1327). Since there is currently no recycle and very little is projected for the early 1980's, the calculation indicated does not apply to the current shipments. Values used for plutonium in the revised standard shipments model are taken from the 1975 detailed survey performed by PNL.

State of New York - Dept. of Environmental Conservation - Comment 15

"The first sentence of the second paragraph (page I-25) refers to 'Figure I-2.' It appears that it should refer to 'Figure I-3.'"

Staff Response - The typographical error has been corrected.

DES Chapter II: 1

ERDA - General Comment 2

"In Chapter II (p. II-3) where it is stated that ERDA was created by the Energy Reorganization Act of 1974, it would be desirable at this point to describe the role of ERDA in authorizing packaging for use by contractors."

Staff Response - ERDA's special role in issuing package approvals has been explained in Section 2.2, "Regulatory Agencies."

DES Chapter II: 2

ERDA - Comment 11

"The statement is made that implies the NRC regulations regarding packaging of radioisotopes are included in 49 CFR 174-177, clarification of this is in order."

Staff Response - The correct reference, 10 CFR Part 71, is now cited.

DES Chapter II: 3

ERDA - Comment 12

"In the requirements stated for 49 CFR 173.395(c)(2), we suggest the wording on the U.S. Atomic Energy Commission be updated."

Staff Response - Since the phrase appears in a direct quote, it would be inappropriate to change it.

DES Chapter II: 4

City of New York - Comment V

"In addition, in order for the public and Congress to be able to evaluate a DES, it is essential for the DES to explain the assumptions made therein. The DES at issue is replete with unexplained assumptions and references to what unspecified 'experimental work' or 'private communication' has shown (see, for example, pp. II-9, II-10, V-14, V-24). It is also replete with reliance on undocumented and apparently unrequired and unenforced industry 'practice' (see, for example, pp. II-8 and II-30). Such reliance hardly provides assurance to the public that the NRC has adequately evaluated the environmental impact of the nuclear transportation program."

Staff Response - The "unspecified 'experimental work'" referred to by the commenter is covered by the reference stated earlier in the paragraphs in question. The "industry practices" are merely means of complying with the regulations. The NRC does not specify how to comply, only that one does comply with dose and packaging requirements.

DES Chapter III: 1

ERDA - Comment 13

"The sentence reads as though the range of a 'one MeV gamma' is 11 cm in tissue. We suggest that NRC might consider expanding the discussion to correct this impression."

Staff Response - The sentence in question has been rewritten to clarify the presentation of the concept of gamma-ray half-thickness.

DES Chapter III: 2

EPA - Comment 1

"Last paragraph: It should be noted that the length of time over which energy is absorbed is also critical to creating biological effects."

Staff Response - The discussion has been modified to mention the fact that dose protraction may affect the biological effect of exposure.

DES Chapter III: 3

ERDA - Comment 14

"The statement and the equation following Table III-1 are misleading. Theoretically, the equivalent biological effect can be achieved when the relative biological effectiveness (RBE) of the radiation for each exposure consequence is known. The quality factor (QF) is used primarily for radiation protection purposes and in our opinion is not adequate for the purposes of comparing exposure risks from the mixture of sources discussed in this paper.

"Furthermore, neither quality factor or relative biological effectiveness are defined; they are not equivalent and should not be used interchangeably, particularly when such diverse effects as acute death and lung cancer are considered. We also suggest that NRC might want to consider expanding the discussion of the rem to rad conversion."

Staff Response - The discussion of RBE and QF has been expanded.

DES Chapter III: 4

EPA - Comment 2

"Since there were 5.5 million examinations in 1972 using technetium and the most useful form cited was used a mere 120,000 times, it is not clear what happened with the other 5,380,000 examinations."

Staff Response - The discussion of radioisotope uses has been moved to FES Chapter 1, and it has been modified to refer to an American College of Radiology report that quantifies the use patterns for radiopharmaceuticals. The cited discrepancy has been corrected in the new text.

DES Chapter III: 5

ERDA - Comment 15

"Inhaled naturally-occurring alpha emitters include thorium daughters as well as radon daughters."

Staff Response - The discussion of naturally occurring radioactivity has been expanded to include more detailed information from additional references.

DES Chapter III: 6

HEW - Comment 5

"It is stated that the Biological Effects of Ionizing Radiation (BEIR) report was used in the Health Effects Model. Actually, the Health Effects Model used is that found in Appendix VI of the Reactor Safety Study (WASH-1400). WASH-1400 significantly modified the risk estimates contained in the BEIR report by introducing 'Dose Effectiveness Factors' (Table VI, 9-70, Appendix VI, WASH-1400). These factors do not access a straight linear extrapolation, (as does the BEIR report), making those risk estimates of low doses and dose rates used in the draft statement lower by a factor of five than those found in the BEIR report. It is erroneous to give the impression that the health effects calculated in this draft document would be equivalent to those that would be arrived at by using the BEIR report.

"Also, references are made to studies which seem to indicate that rodents exposed to radiation have longer life spans. It has been theorized that radiation creates a more sterile environment, thus reducing the probability of respiratory infection in rodents, increasing their life span in a radiation environment. We are of the opinion that the draft statement should clearly state the reasons for an increased life-span among the rodents, as well as mention the above cited hypothesis."

EPA - Comment 4

"EPA believes that use of the BEIR report in its unmodified form is the most reasonable model to use to calculate health effects in this statement at this time. Since the debate over the health effects model in WASH-1400 is still continuing, it is premature to base this analysis on WASH-1400 premises."

Staff Response - The WASH-1400 health effects model was used for convenience in referencing a large block of information and analysis in one source, but the dose-effectiveness factors in WASH-1400 were not used in the DES as alleged. The values in Table III-9 are derived as discussed in Section 9.3.2 of Appendix VI to WASH-1400 using population age-cohort adjustment. The section on the lengthening of the rodent life span has been deleted.

DES Chapter III: 7

EPA - Comment 3

"The statement, 'The dose limits proposed by NCRP and adopted by EPA . . .' is not correct. EPA is currently operating under the 1960 guidelines of the Federal Radiation Council (FRC). The EPA is currently working in an interagency effort to review and update the FRC guidelines; the NCRP dose limits are being consulted in this effort but have not been adopted."

HEW - Comment 6

"The source should be cited for the statement that declares that EPA has adopted the dose limits proposed by the National Council on Radiation Protection (NCRP). We are of the impression that EPA is in the process of reviewing these radiation standards but has not agreed to the limits proposed by NCRP."

Staff Response - The sentence has been revised to read "The dose limits proposed by NCRP, recommended as guidance for Federal agencies by FRC, and adopted for that purpose by the President of the United States on May 13, 1960, are tabulated in Table 3-6." Reference FR Doc. 60-4539 Filed May 17, 1960; 8:51 a.m.

DES Chapter III: 8

EPA - Comment 2

"We point out that EPA has proposed standards concerned with normal operations in the uranium fuel cycle (40 FR 23420) which include doses received during transportation of radioactive materials. These standards would limit individual doses to 25 mrem to the whole body. EPA believes that this will have little or no effect on the economics or operations of the transportation industry because, as it now exists, the dose levels appear to be less than 1 mrem per year, well below 25 mrem per year. The fact that EPA has formally proposed standards which would apply to the transportation of uranium fuel cycle materials and yet is not recognized in the draft statement is an oversight which should be corrected."

Staff Response - The EPA proposal in 40 FR 23420 has been incorporated into Section 3.5 of Chapter 3 and into Chapter 4.

DES Chapter III: 9

ERDA - Comment 9

"We suggest that this paragraph be rewritten since it implies that the MPC (air or water) is a unit of exposure rather than being based on the permissible exposure to critical organs."

Staff Response - The section on MPC has been rewritten to clarify the concepts of chronic exposure and critical organs.

DES Chapter III: 10

ERDA - Comment 17

"We suggest that the average or mean effect of radioactive transport be added to compare transport dose effect to background and medical dose effect."

Staff Response - The calculated effect of radioactive material transport has been added to FES Table 3-8.

DES Chapter III: 11

EPA - Comment 4

"We suggest rewriting the sentence beginning 'Technetium-99m can be given . . .' as, 'Technetium-99m can be given in relatively large amounts with little radiation exposure.' 'Relatively' emphasizes comparison with other isotopes and 'amounts' eliminates possible confusion resulting from using the word 'dose' which is used in a medical context rather than the radiological context in which it had previously been used."

HEW - Comment 7

"We suggest that line 12 in paragraph 2 read as follows: 'Technetium-99 can be given in rather large quantities with little radiation dose.' As presently used in the draft document, the word 'dose' refers to pharmaceutical dose (which in this instance is not the case). Also a discussion of the short half-life of Technetium-99 should be included in the final document as a means to support the above statement."

Staff Response - This section has been moved to FES Chapter 1 and rewritten to read "Relatively large amounts of Tc-99m can be administered with little radiation dose." Half-life information is included in the section.

DES Chapter III: 12

Friends of the Earth - Comment 7

"We question the reliance on the WASH-1400 health effects model. The Union of Concerned Scientists-Sierra Club critique of the Rasmussen reactor safety study has criticized the assumptions of low numbers of health effects posited by WASH-1400 on the grounds that the study assumed near-perfect evacuation of the metropolitan New York area within several hours, while simultaneously assuming that most of the population would be indoors or underground and therefore shielded from radiation. More recently, Dr. J. Martin Brown, Assistant Professor of Radiology at Stanford University School of Medicine has criticized WASH-1400 for neglecting to assess long-term cancer deaths from a reactor core meltdown (Rasmussen uses only immediate deaths of people in the immediate vicinity). Nor does Rasmussen calculate genetic disorders, thyroid disease, etc."

Staff Response - The only aspect of WASH-1400 health effects model that is used is that relating to response to dose. No evacuation or shielding is assumed, and long-term fatalities (from cancers) are specifically addressed. The question of genetic effects is discussed in Chapter 3 and thyroid cancer is considered in Chapters 3 and 5.

DES Chapter III: 13

HEW - Comment 8

"It should be noted that the use of pertechnetate for brain scanning is relatively low, amounting to 1.5 million administrations during 1972. The impact of other technetium compounds and kits as well as ^{67}Ga, ^{75}Se, and ^{133}Xe should also be considered."

Staff Response - The standard shipments model has been revised to include the recently available 1975 survey data. The text in question will be revised to reflect the newer model and the survey data from the American College of Radiology. This section has been moved to FES Chapter 1.

DES Chapter III: 14

HEW - Comment 9

"It is important that the basis for simplifying assumptions be documented, even if only briefly, since they can significantly influence the risk estimates."

Staff Response - The assumptions used are briefly outlined.

DES Chapter III: 15

ERDA - Comment 18

"We suggest that the phrase 'specific radionuclide' replace the phrase 'radioactive specie' which is used throughout. The latter phrase is confusing since it could refer to animals or plants.

Staff Response - The phrase in question has been changed to the suggested one.

DES Chapter III: 16

ERDA - Comment 19

"For PuO_8 (sic) we feel that the biological half-life in liver and bone, as well as in lung must be stated and identified.

"For Pu, the biological half-life listed is for the deep lung. The value for bone is 36,000 days. Using the isotopic composition and specific activities found in Appendix B, p. B-5 and the dose conversion factors from Table III-8, we find the following Pu dose conversion values, in rem/curie inhaled.

	Dose commitment over:	
	1y	50y
Lung	4.2×10^6 rem/Ci	1.1×10^7 rem/Ci
Bone	1.2×10^5	4.4×10^7

"We cannot agree with the value of 2×10^8 listed in Table III-7 for PuO_8 (sic). Conversion to rem/g yields 50 year dose commitment conversion factor of:

Lung	1.4×10^8 rem/g (inhaled)
Bone	5.4×10^8

"These values are closer but still do not agree with that listed in the table. We suggest that the data presented in the table be reevaluated in light of these comments."

Staff Response - The rem/curie values were based on a specific activity that did not include the β-emitter Pu-241. Thus the 2×10^6 rem/Ci was associated with a specific activity of 0.5 Ci/g. This has been revised to specifically account for the isotopic composition (including β-emitters) shown in Appendix B.

The biological half-life and effective half-life in bone are included in the ORNL code from which these data (which are also used in WASH-1400) were taken. Since the liver is not considered the critical organ for insoluble forms of Pu, it is not included.

DES Chapter III: 17

ERDA - Comment 20

"Is it not the relative risks that are to be compared and not the person-rem?"

Staff Response - The sentence has been rewritten to emphasize that the thrust is toward relative risk.

DES Chapter III: 18

HEW - Comment 10

"We do not agree with the statement made in paragraph one. Soluble Plutonium is listed in Table III-7 and represents a material that can enter the food chain. Since I-131 constitutes an inhalation hazard, it also represents a potential health threat to the food chain in the event that a dairy or truck farming area were to become contaminated."

Staff Response - As shown in DES Table III-7, the dose per curie ingested is 4 orders of magnitude lower than the dose per curie inhaled for plutonium. In addition, there are environmental dilution factors involved in resuspension, soil transport, and plant uptake that make the effect of ingested plutonium negligible as compared with inhaled plutonium, assuming a single accidental release (versus a continuing release).

The effects of I-131 on dairy products or cropland are addressed in the decontamination/ interdiction section which has been added to FES Chapter 5.

DES Chapter III: 19

Dr. K. Z. Morgan - Comment 3

"Table III-8 is given without explanation and I have reason to question its reliability. I was chairman from the beginning until 1972 of the Internal Dose Committee of ICRP that made such calculations and set the standards for all these radionuclides (and I was chairman of the NCRP internal dose committee for 20 years). Since 1972, I have been busy with research and teaching at Georgia Tech, so I am not completely up-to-date with the latest ICRP calculations. However, the following Table shows discrepancies I found in your table for Pu radionuclides in comparison with ICRP Committee 2 values as of 1974, and I doubt there have been substantial changes since then.

Values of Rem/Ci Given by NUREG-0034 and by ICRP

Plutonium Radionuclide	Table III-8 Values			Values Given by ICRP (1974)				
	Lung	Bone	Marrow	Lung	Bone*	Marrow	Liver	Ovaries
Pu-238	$3.1x10^8$	$7.6x10^8$	$1.3x10^6$	$3.1x10^8$	$4.0x10^9$	$6.7x10^3$	$3.6x10^8$	$1.7x10^8$
Pu-239	$2.0x10^8$	$8.7x10^8$	$1.5x10^6$	$2.9x10^8$	$4.6x10^9$	$4.4x10^3$	$4.1x10^8$	$2.0x10^8$
Pu-240	$2.0x10^8$	$8.7x10^8$	$1.5x10^6$	$3.0x10^8$	$4.7x10^9$	$7.6x10^3$	$4.1x10^8$	$2.0x10^8$
Pu-241	$5.8x10^5$	$1.7x10^7$	$3.2x10^4$	$5.5x10^5$	$9.8x10^7$	$1.3x10^3$	$8.3x10^6$	$4.4x10^6$

*This value is for trabecular bone. I do not know for what type of bone the Table III-8 is representative.

"From the above it is seen there are some significant discrepancies. For example, the bone risk (where most of the malignancies develop from Pu) is underestimated by a factor of 5. The risk to the liver and ovaries may be as great as that to the lungs, but they are not even considered. Surely some consideration should be given to the genetic risk."

State of New York - Dr. John Gofman - Comment 1

"The lung dose per curie inhaled is given as 2 x 10^8 in Table III-7 (for insoluble PuO_2). This value is manifestly incorrect. Gofman and Cohen agree that the dose is 2 x 10^9 rems per curie deposited. Correcting this, from deposited to inhaled, we should reduce the value fourfold. Therefore, the correct value is 5×10^8, which is 2-1/2 times as great a dose as presented in the DES. But this is only the beginning of the serious underestimate of dose from plutonium in the DES. All calculations of the DES are based upon the ICRP Model (Figure B-2 in Appendix B). That model makes the erroneous assumption that no plutonium is retained for long-term delivery of dose to the bronchial region, an assumption based upon no evidence whatever and totally in contradiction with evidence concerning the impairment of bronchial ciliary function in cigarette smokers and in non-smokers. When this is taken into account and when the small mass of the cancer-relevant bronchial tissue is taken into account, (one gram instead of the 570 grams of the whole lung), we end up with the following correction factors that must be applied to the DES estimates of dosage:

For cigarette smokers, dose must be multipled by 103 times,
For non-smokers, the dose must be multiplied by 8.2 times.

"Therefore, overall, incorporating these factors and the 2-1/2 factor above, the DES underestimates the dose for plutonium inhalation by 257.5 times for cigarette smokers and by 20.5 times for non-smokers. These errors, alone, are sufficient to invalidate all the consequences of dispersion estimated in the DES. But these are not the only serious errors concerning effects estimation."

State of New York - Dr. Marvin Resnikoff - Comment 18

"Another area of disagreement lies in the biological effectiveness (i.e., effect on tissue) of a given gram of plutonium. The DES uses a figure of 2.0×10^8 rems/curies. The NRC's WASH-1535 at Table II.G-10 presents a figure of 8.6×10^8 rems/curie. According to the USEPA (Id.), ICRP now uses 16.5×10^8 rems/curie for Pu-239. Since the DES relies on the Pu-239 value of 2.0×10^8 for its conversion calculation of the biological effectiveness of reactor type Pu (that shipped through a JFK) (Page B-4), it is clear that the danger of plutonium inhalation may be understated by the DES by over 8 times. At any rate, the resulting impact calculated from the 2.0×10^8 number cannot be considered a 'worst case' impact."

Staff Response - Table III-8 is taken (and referenced) from Appendix VI to WASH-1400. The values listed are for a single exposure to a log-normal particle size distribution with a mean size of 1.0 μm AMAD. The values cited by Dr. Morgan and Dr. Gofman represent chronic exposure to a uniform particle size of 1 μm, not a distribution, hence the larger dose per curie values in Dr. Morgan's tabulation.

The question of ciliary impairment has been addressed in rebuttals to Dr. Gofman's paper on Plutonium Cancer Hazards. In these rebuttals a strong argument is presented that Dr. Gofman has misinterpreted data on ciliary degradation and that his theory of lung clearance impairment leads one to the conclusion that all heavy smokers should be dead from respiratory blockage.

The question of "cancer-relevant tissue" is also addressed in rebuttals to Dr. Gofman's articles. It is merely a restatement of the so-called "hot-particle theory." Numerous agencies

(NAS, NRC, BEIR, NCRP, ICRP) and numerous reports have concluded that no experimental evidence has shown nonuniform lung deposition to be more hazardous than uniform deposition.

The statement that most Pu malignancies develop in bone is debatable. Bair has stated that no bone cancer has been reported in any animal specie after inhalation of $^{239}PuO_2$ (Biomedical Aspects of Plutonium, BNWL-SA-5230, 12/74) even though approximately 5 percent of the Pu eventually translocates to the skeleton. Cohen (Hazards of Plutonium Dispersal) suggests that the lung cancer risk from inhaled Pu is approximately a factor of 4 higher than bone cancer. Using information from WASH-1400, GESMO, and BEIR the cancer deaths per curie inhaled for lung and bone are roughly comparable (235 for lung and 258 for bone). The DES uses the WASH-1400 model.

The question of effects to the liver and ovaries are addressed by Bair (Biomedical Aspects of Plutonium). He states that bile duct tumors have occurred in experimental animals, but they also occurred in the control group (see DES Appendix B). He also states that only 0.05 percent of the concentration of Pu in the circulating blood deposits in the testes and 0.01 percent in the ovaries. It appears, therefore, that the stated ovary dose is the dose per curie deposited in the ovaries rather than the dose per curie inhaled. Since the gonadal deposition is so low, genetic effects from inhaled plutonium are considered to be negligible compared to other effects.

DES Chapter III: 20

ERDA - Comment 21

"The table [Table III-9] has not been correctly copied and adequately referenced. 'Whole body' is actually 'Total (excluding Thyroid).' Also the table contains those values used in WASH-1400 for external exposure. What was used in this analysis for internal exposure? The risk number shown for the thyroid is surely not a mortality estimate--morbidity maybe, but not mortality. Finally, if the estimates of Table III-9 are based on the absolute model, it should be so noted."

State of New York - Dr. Marvin Resnikoff - Comment 20

"The authors of the DES chose 22.2 LCF/million person-rem for lung cancer on the basis of the BEIR report (p. III-23). This number is smaller than that in a number of other reports. USEPA has assumed 50 LCF/million person rem. Dr. John Gofman reports that Cohen has used 39 LCF/million person-rem and assumed 762 LCF/million person-rem himself. From these data it can be clearly shown that the DES has understated the danger of plutonium inhalation by as much as 34 times."

State of New York - Dr. John Gofman - Comment 2

"In Table III-9 the DES estimates latent cancer fatalities as 22.2 deaths per 10^6 person-rems of exposure to the population. The data of reference 1 point to a more correct value of 762 deaths per 10^6 person-rems on the same calculation basis. Therefore, the DES estimate is some 34.3 times too low in its cancer estimate. If this underestimate of effect is combined with the underestimates of dose, we arrive finally at the following error estimates for the DES evaluation:

> "For cigarette smokers, effects must be 3533 times larger than DES estimates,
>
> For non-smokers, the effects must be multiplied by 281.3 times to correct the DES estimates.

"The final result of such corrections is to make the DES estimates totally meaningless as they stand in the report."

Staff Response - Table III-9 was not copied from WASH-1400; it was assembled using data in WASH-1400. WASH-1400 is referenced as the source for the information. The correct interpretation of the table is that exposure of one million person-rem to any of the specified organs would be expected to result in the specified number of cancer fatalities. Table III-9 is a combination of Tables VI-9-4 and VI-9-5 from WASH-1400. The BEIR report, which was the source for those tables, did not distinguish between the irradiation of an organ from an internal or external source in its overall statistics. The important item is the total radiation received by the various organs. The thyroid value of 13.4 per million person-rem is a mortality value based on discussion in paragraph 1 of Section 9.3.5 on page 9-26 of Appendix VI to WASH-1400 and on the expected thyroid cancer figure of 134.1 per million person-rem given in Table VI-9-8 on page 9-37 of the same appendix.

The value chosen for LCF for lung cancer from accidental exposure is based on an age-cohort-corrected version of the 1.3 per million person-rem per year as discussed in WASH-1400. Gofman's value of 762 LCF per million person-rem has been disputed by many experts in the field. The value used by Cohen and EPA are not age-cohort corrected.

DES Chapter III: 21

ERDA - Comment 22

"This figure was taken from p. 9-7 of WASH-1400 Appendix VI. However, the referenced figure does not contain a curve for alpha emitters. Any subsequent argument pertaining to acute effects (death) of alpha emitter inhalation is unsupportable without these data and suggest that NRC might wish to include these data."

Staff Response - The curve for α-emitters in Figure III-2 has been replaced in FES Figure 3-3 with a new curve from Reference 3-20.

DES Chapter IV: 1

EPA - Comment 5

"It is stated that tiers 6, 7, and 8 in Figure IV-3 schematically illustrate the procedure that the FAA employed to arrive at the various dose estimates in their assessment, reference IV-2 in the statement. However, tiers 7 and 8 do not appear in Figure IV-3. They should be added in the final statement."

Staff Response - Figure IV-3 has been deleted.

DES Chapter IV: 2

ERDA - Comment 23

"Table IV-2 gives population dose to crew and passengers from packages. We suggest that it also include the differential received by same populations as a result of cosmic radiation at flight altitudes. Such a number would be several times the 1400 for Passengers-I* and many times the Crew-I* numbers."

Staff Response - Comparison of dose from cosmic radiation with that from radioactive material shipments has now been included.

DES Chapter IV: 3

ERDA - Comment 24

"There is inconsistency between PuO_2 shipping distance noted in this table and that noted in Table V-10 on p. V-37."

Staff Response - The inconsistency has been corrected.

DES Chapter IV: 4

ERDA - Comment 25

"Person-rem/yr are calculated on this and following pages. We think it appropriate that background exposure doses also be calculated and presented for comparison. For example, the 5042 person-rem/yr is a big number to the layman or the person taking data out of context. However, it becomes small when compared to the population background exposure of 22.5 million person-rem/yr."

Staff Response - Background population exposure has been added.

Department of the Interior - Comment 3

"Several statements suggest that the study is based on surprisingly incomplete information in some important areas pertinent to transport of radioactive materials. For example, it is stated: 'While no specific information is at hand to suggest that radioactive materials are not shipped on passenger trains, no evidence of such use was discovered in an informal survey of the industry' (Page IV-31, paragraph 1). This suggests that the facts now available to the staff provide no information on whether or not radioactive materials are shipped on passenger trains. It is also stated that 'it is suspected that barge may be a method for transport of new and spent fuel to reactors and reprocessors located on appropriate waterways' (page IV-34, paragraph D.4-1). This lack of certainty on the part of the Nuclear Regulatory Commission regarding even the basic mode of transport in use for such materials does not provide reassurance that transport of radioactive materials is being carefully regulated in all cases."

State of New York - Dr. Marvin Resnikoff - Comment 37

"The alternative of transporting materials by water is given only minimal consideration in Chapter IV, Section D.4, page IV-34. No information is given about the present volume of material shipped by water. It seems clear that in certain localities, water transport may indeed be an alternative to conventional inter-city ground transport modes, and might result in significant reductions in exposure in both normal and accident situations. Although plutonium is the major contributor to accident latent cancer fatalities, it has a long half-life. Thus the shipment of plutonium by water may be economically feasible as well."

EPA - Comment 6

"We feel that the water transport discussion was not thorough enough. The only reason cited for this treatment is a 'paucity of information' concerning water transport. However, the discussion in the draft statement on the manufacture of floating nuclear power plants (NUREG 75/113) provides a brief but much more adequate discussion of the subject. If it is believed that a projection to 1985 is too uncertain this is understandable and should be so stated, but a more thorough discussion would be more informative for the public and would not as likely appear to be a sidestepping of the issue. Therefore, further basic discussion of water transport and an explanation for its exclusion in the further analyses is warranted."

Staff Response - Shipments on passenger trains consist only of a few exempt postal shipments, and their contribution is negligible. Based on the results of the 1975 survey, water transportation is a very small portion of the total shipping industry. Water transportation is not practical for many materials (radiopharmaceuticals, etc.) because of the time required for the shipment. Water transport is also impractical for many other materials because of the lack of canals or waterways in the inland United States. To the extent that this mode is viable, it has been discussed in Chapter 4 and included as an alternative in Chapter 6.

DES Chapter IV: 6

ERDA - Comment 26

"It is assumed that there will be a two-hour 'storage' period associated with time spent in rail yards. Is this a realistic figure, particularly where interline transfer is required, or are these transfers taken into account in arriving at this figure?"

Staff Response - The rail yard storage time per trip has been changed to 24 hours based on testimony given at the Interstate Commerce Commission hearings regarding special trains for transport of irradiated nuclear fuel and wastes.

DES Chapter IV: 7

ERDA - Comment 27

"We feel that transport index system can be based on dosage from the package or the maximum number of packages considering criticality. Hence, the label does not inform as to which of two potential hazards exists. This could be important in accident recovery.

"Likewise, the terms Type A, Type B, or large quantity are meaningless to all but a very few persons. Some improvement might be obtained if the labels provided explicit relevant information. We suggest that NRC may wish to study this suggestion as an 'alternative' toward reducing mislabeling and mishandling occurrences."

Babcock and Wilcox - Comment 1

"The DES assumed that dose rates were proportional to the transport index. While this is true for non-fissile material, it is not so in the case of plutonium, where the transport index is derived from criticality considerations. It is felt that the exposure rate is the correct number to use, and it is not clear that this number was used in the DES. (See Page IV-42, for example.) Experience has shown the exposure to be about 1 mr/hr at one meter from a container of PuO_2. Thus, the transport index of 5 that was applied to shipments of PuO_2 in the DES is too large by a factor of five."

Staff Response - The use of fissile TI to predict normal radiation dose is clearly conservative (49 CFR 173.389(i)). Since actual radiation data were not available and since fissile materials are small contributors to normal dose even with fissile TI, that approach has been retained.

DES Chapter IV: 8

ERDA - Comment 28

"Since 10% of the incidents that involve release are in the Type A category and that these packagings are relatively inexpensive, it seems reasonable that requiring crush and puncture resistance characteristic of service conditions be explored as an alternative."

Staff Response - Not 10%, but virtually all incidents in which there are releases of radioactive material involve packages that are not designed against accidents. These are designed to provide protection against a reasonable level of crush and puncture conditions. To protect some two million packages against a very unlikely higher level of puncture and crush does not appear reasonable considering the limited consequences of incidents involving such packages.

DES Chapter IV: 9

EPA - Comment 7

"In the second paragraph of Section F.3, there is no factual basis cited for the statements leading to the 0.5 mrem/year 'expected' dose rate. This section needs to be more thoroughly documented to indicate which radionuclides were considered and in what proportions. Further, information on whether certain types of packages are damaged more frequently than others and, if so, which, is certainly of importance to the analysis of this section."

Staff Response - Section 4.5 of the FES has been rewritten, and exposures that were estimated using release data from actual shipping experience have been incorporated.

DES Chapter IV: 10

EPA - Comment 8

"The method of modifying equation 2 to arrive at the given equation is not clear, further elucidation is requested.

"If there are records indicating 'an average of 5 losses per year over the last 9 years,' it seems there might also be records indicating for how long these packages were lost. Such information would eliminate another estimate, i.e., the '7-days lost' figure, to allow a more precise appraisal of possible population doses."

Staff Response - The equation on page IV-42 used the integrated form of equation (2) where K takes the form of K $e^{-\lambda t}$ (λ = decay constant and t = time of exposure). Thus

$$\text{Dose} = 3.7 \times 10^{-7} \times P \times TI \times \int_0^T e^{-\lambda t} dt$$

where T = total time of package loss

λ = decay constant for material

This treatment has been modified to use the updated equations now provided in FES Appendix D. In addition, a loss-time figure of 14 days based on incidents reported since December 1975 has been used in the FES.

DES Chapter IV: 11

ERDA - Comment 30

"The subject of this section and that of Section D.4 (page IV-34) might well be considered in light of the prospect of using ferry barge shipments to circumnavigate cities or states which embargo nuclear shipments or areas where rail carriers are refusing to haul nuclear shipments. We do not feel that the regulations contemplated the casual public in such proximity to nuclear shipments, particularly spent fuel casks, for the typical time period involved. We feel that this situation lends itself to be analyzed in the draft."

Staff Response - Barge shipments are considered in more detail in the FES. It should be noted, however, that there are only a few current or potential sites that are serviceable by large-scale barge traffic. The rail carriers have not refused to carry nuclear-shipments; rather they have requested that some shipments be made by special trains. This restriction would not avoid casual public exposure.

DES Chapter IV: 12

HEW - Comment 11

"Page IV-43, item 7 indicates that a few individual transportation workers might possibly be exposed to radiation limits which exceed those established for the public. The draft document devotes little attention to the problems of identifying, monitoring, and controlling the exposure to 'truckers', 'handlers' and others."

State of Georgia - Comment 2

"Throughout the document, the dose estimates are related to the average exposure to population in man-rems. The NRC should also include dose values based on the maximum exposure to individuals."

EPA - General Comment 1

"There is a lack of analysis pertaining to individual doses to passengers from normal shipments on aircraft. The only mention of the problem is in Table IV-2 where an unacceptably high maximum dose of 340 mrem/year and an average dose of 60 mrem/year are given. Doses of this magnitude to individuals, which are large fractions of the FRC guidance, are the most significant impact from normal air shipments. As EPA recommended to the FAA and pointed out in its document, 'Considerations for Control of Radiation Exposures to Personnel from Shipments of Radioactive Materials on Passenger Aircraft' (December 1974), the population doses are small and can probably be considered insignificant. However, the exposures to individual passengers are unacceptably high considering there are cost-effective measures which can be taken to reduce them. Several alternatives were addressed in the report and it was found that at least one cost-effective method is readily available. EPA recommended to FAA that a dose limit of 0.5 mrem per hour at seat level be established to provide protection of aircraft passengers.

EPA believes, therefore, that this subject must be addressed by NRC in much greater detail in the final statement and that EPA's recommendations must be considered."

EPA - Comment 9

"The discussion shows that it is currently possible for workers to exceed 500 mrem/year simply handling shipments. It is clear that if the number of shipments increase as they are projected to do that these workers will routinely exceed 500 mrem/year. Any provisions which have been made to prevent this from occurring should be indicated. Furthermore, if the doses mentioned on p. IV-44 do not include unnecessary doses (e.g., sitting on or standing near radioactive cargo), which they apparently do not, the problem becomes worse than estimated on p. IV-44. We believe that if unnecessary exposures are indeed a fact of life, they should be included in the environmental impact assessment. Any plans underway to mitigate or eliminate these unnecessary exposures would be of interest also."

Staff Response - The question of maximum individual doses from normal transport is now addressed in FES Chapter 4, and EPA's recommendation is considered in FES Chapter 6.

DES Chapter IV: 13

EPA - Comment 16

"In the 'Dose to Crew' equation the 'D_c' factor is unnecessary. Its inclusion squares the dose rate."

Staff Response - This typographical error has been corrected.

DES Chapter IV: 14

HEW - Comment 12

"The average individual dose from transportation is stated as 0.5 mrem/year. This is a factor of 2, not 20 less than the average per capita dose from radiopharmaceuticals (Table III-3)."

Staff Response - This typographical error has been corrected.

DES Chapter IV: 15

Dr. K. Z. Morgan - Comment 10

"The man-rem dose for normal and accident operations should be integrated over the entire population for all age groups and for all dose rates. Arbitrary cut-offs, and boundary assumptions lead to serious underestimates of the risk."

Staff Response - The dose for accidental or normal transport is integrated over all age groups. The only dose-rate restrictions are those imposed in line-of-sight distance for direct exposure and the finite distance of debris cloud travel (100 km) in the accident case. This procedure results in an accumulated 50-year lung dose of less than 200 person-rem (for a plutonium release) which is negligible.

DES Chapter IV: 16

ERDA - Comment 29b

"However, some of the more notable incidents have derived from packaging errors. We do not feel that this section discusses this matter in proportion to its importance -- either as to requirements or as to cost-benefit or corrective action. It is implied elsewhere that a preconsignment survey of the package would be beneficial in reducing labeling errors. However, the benefit of a quality assurance over-check as to labeling and proper packaging and closure should be considered as an alternate."

State of New York - Skinner/Willen - Comment 51

"Many accident modes within each transportation pathway have been overlooked. Such likely occurrences as fork lift puncture and container leakage are not treated in each pathway."

State of New York - Skinner/Willen - Comment 52

"No discussion in the Draft Impact Statement can be found relating to errors in record-keeping, radiation monitor errors, container maintenance hazards, and other miscellaneous causes of inadvertant over exposure to the public during transportation."

Staff Response - The subject of packaging errors is addressed in more detail in this revised version.

DES Chapter V: 1

Friends of the Earth - Comment 8

"We dissent from the statement that 'The most severe accidents are generally the least likely to occur' as yet another departure from logic and from knowledge of stochastic events. If the NRC wishes to persist in this type of argument, they should provide us with the mathematical model supporting this position. Similarly, they refer to 'The complete logic model' of accident sequences leading to an environmental impact. A complete logic model is by definition impossible, since if all accident causes and sequences could be articulated, in theory all accidents could be foreseen and avoided. What disturbs us are those sequences that will be left out of the logic model and therefore are unknown."

State of New York - Dept. of Environmental Conservation - General Comment 16

"While the use of average exposure is reasonable to predict the effects resulting from normal transportation, the use of the estimated average accident risks can be misleading. The low average accident risk results from taking the very low accident risks associated with the large number (some 70% of total shipment) of radiopharmaceutical shipments and distorts the risks associated with the transportation of plutonium."

Staff Response - Regarding the commenter's objection to the statement "The most severe accidents are generally the least likely to occur," accident statistics show that this is, in fact, the case. Although the average annual risk could be misleading if dealt with in isolation, consequences of severe accidents are also considered in that "worst case" results are listed with their respective occurrence probabilities.

DES Chapter V: 2

ERDA - Comment 31-1

"We assume this equation was used to calculate accident risks. We have several questions on the methods used to develop numerical values for input into the equation. A primary concern is the term D_{ij} (estimated release fraction for the type of shipment being considered and for the accident severity class). The method of development of D_{ij} appears to be oversimplified. Release fractions used for each accident severity class are presented in Table V-6 (page V-25). Questions are raised for both the values used and the use of the release fraction in the analysis. The statement is made (page V-24) that 'Model 1 would be an accurate model if packaging were not better than required by present standards.' We disagree that it would be accurate; experience indicates that not all material will get out and become dispersed when a package is breached. We are not sure of the basis for Model II. It was our understanding that the reference testing was under impact conditions. If so, how does one apply the results to, e.g., puncture conditions?"

Staff Response - The release fraction model has been revised to incorporate more recent Sandia Laboratory container test data.

The reviewer is correct in noting that the referenced Sandia tests were impact tests. However, since the initial report, further tests involving fire, crush, puncture, impact, and immersion have been conducted, and these results have been taken into account in the FES.

DES Chapter V: 3

ERDA - Comment 31-2

"Does a category VII accident in air transport involve the same forces as a category VII accident in truck transport? If not, we would expect different release fractions for different modes (since the same container could be used in any mode).

"We would not, in general, expect the same release fraction from an accident involving a category VII impact and one involving a category V impact and a category III fire. According to Figure V-6 (Page V-9) the latter is also a category VII accident. Whether or not a category III fire will contribute to a release depends on specific package characteristics and specific contents characteristics."

Staff Response - The severity categories were assigned based on the forces estimated to produce a given release. Thus, a category VII truck accident is equivalent to a category VII plane accident in terms of amount of material released.

The model does not consider category V impacts or category III fires separately. It does consider category V, etc., accidents that can involve various combinations of impact force and fire duration. Thus, as discussed above, the severity classification scheme does postulate a given release fraction for a given severity accident, regardless of the combination of forces that cause the accident of that severity to occur. The use of a simple set of accident severity categories for several different transport modes is not new (see W. A. Brobst, Nuclear News, May 1973).

DES Chapter V: 4

Dr. K. Z. Morgan - Comment 6

"I believe the severity of aircrash assumed in this report comes far short of the worst case."

Staff Response - The minimum accident impact velocity on an unyielding surface for a class VIII accident in which any accompanying fire lasts no longer than 30 minutes is 256 feet/sec (375 mi/hr). This is a factor of 3 greater than the impact velocity required for flight recorder design (80-90 feet/sec). Thus, the minimum impact energy for a package involved in a class VIII aircraft accident is a factor of 10 greater than that for flight recorders that are designed to survive intact in all but the worst air crashes.

DES Chapter V: 5

ERDA - Comment 31-3

"It is also not clear how the normalized population dose (K_i in Equation (1)) is obtained. We know it involves figure V-11 but there is no reference as to source of figure V-11 nor how the curve was developed."

Staff Response - Figure V-11 has been simplified for the FES (Figure 5-7). The function represented by the curve is curies inhaled per curie released versus area. When it is integrated over an area containing a uniform population density and combined with a rem/curie inhaled value for a particular isotope, a value of person-rem/curie released is obtained. This is the K_{ij} in Equation 1. This explanation has been clarified and Appendix G has been added to further explain Equation (1).

DES Chapter V: 6

ERDA - Comment 69B

"There is a VII just above II and a III next to II. Should they not both be III?"

EPA - Comment 17

"The squares listed for the following figures are apparently mislabeled: Figure V-6; 0-0.5 hour fire, 30-55 mph and, 0.5-1 hour fire, 11-30 mph; Figure V-20: 1-1.5 hour fire, 40-60 mph."

Staff Response - The typographical errors have been corrected.

DES Chapter V: 7

State of New York - Dept. of Environmental Conservation - Comment 16

"The basis is not provided for the distribution of accidents among the various population densities for each of the transportation modes considered. Although some description of the basis for the fractions used for aircraft accidents is provided, almost no basis is provided for expecting the low severity truck accidents to occur mainly in urban areas. If these assumptions are based on a statistical analysis, that analysis should be identified."

Staff Response - The subsections on each of the transport modes describe the fractional breakdown for accidents in various population zones and the rationale behind the values assigned. No statistical analysis was performed to arrive at those values.

DES Chapter V: 8

ERDA - Comment 32

"A fire temperature of 1875 F is referenced. We wonder if it would not be appropriate to discuss the 1475 F used in container (MC 0529, 10 CFR 71, etc.) and the impact of the difference."

Staff Response - The 1875 F fire temperature should be 1850 F; this correction has been made. The 1850 F value was used to facilitate comparison with the data of Clarke et al. Since the fire damage is usually taken to be proportional to the temperature-time product, the fire duration may be scaled accordingly. This correction is now included in FES Chapter 5.

DES Chapter V: 9

State of New York - Dr. Marvin Resnikoff - Comment 9

"Nothing in the text of the DES indicates how the authors established accident type classifications on the basis of papers by 'Clarke et al.' (p. V-60). Since the NRC has made the work of Clarke et al. central to the determination of these 'type classes', specific discussion of all relevant portions of that material must be provided if this part of the DES is to have any validity."

City of New York - Comment VI

"At pages V-8 through V-15, there, the probability of spillage model which purports to calculate accident statistics, takes accident data not from actual aircraft accidents but from Clarke's model, based upon laboratory simulations of crashes on unyielding surfaces. Clarke's results are then modified by an unexplained process of 'engineering judgment' (at page V-13 an explanation is included which provides no proofs nor any basis for the assumptions made). No attempt is made in this analysis to use actual aircraft collision data in a study similar to that performed by Bovet, 'Preliminary Analysis of Tanker Collisions' D. M. Bovet. Reported by U.S. Coast Guard Office of Research and Development, November 30, 1970, or Monorksy, 'An Analysis of Ship Collisions with Reference to Protection of Nuclear Power Plants,' Journal of Ship Research, October 1959."

Staff Response - Clarke et al. use a method of accident classification based on five categories that used actual data where available. The authors of the Clarke document were asked to provide similar probabilities for an eight-category analysis. This rationale is specified in Section B.1 of the DES.

DES Chapter V: 10

City of New York - Comment 6-3

"The accident classification scheme improperly relates severity of an accident to fire duration and speed of impact. It fails to evaluate crush and puncture damage."

State of New York - Dr. Marvin Resnikoff - Comment 8

"The DES presents an abbreviated analysis for the complex and controversial area of accident environments. The authors of the DES consider only that damage inflicted on the containers by assumed fire and speed of impact factors and do not consider crush and puncture damage, the very damage mechanisms deemed to be so significant in the earlier Sandia report which was placed on the record of the State's case by the defendants themselves (Def. Aff. Nussbaumer, Exh. C, D and F)."

Staff Response - The categorization of aircraft accident severity by fire duration and impact force is an accepted technique. Crush and puncture were not included in the aircraft analysis because the results of Clarke et al. showed that, for aircraft accidents, the effects of impact and fire are much more significant than crush and puncture. Crush and puncture were considered in the evaluation of truck and rail accidents in Sections B.2 and B.4 of Chapter V (FES Sections 5.2.2.2 and 5.2.2.4).

DES Chapter V: 11

EPA - Comment 10

"The scheme of the de-rating of aircraft accidents seems somewhat unrealistic in one sense and quite arbitrary in another. First, airline routes do not blanket the entire country uniformly, especially flights carrying radioactive materials. It would seem much more realistic to determine the proportion of flights carrying radioactive cargo over the various land surfaces and then de-rate the accidents. Second, the reasons for choosing the number of accident severity classes by which accidents are de-rated are not apparent. The arbitrary nature of the statements brings them into immediate question."

Friends of the Earth - Comment 9

"Paragraph one states that 'only 10 percent of the land area of the United States could be considered as "unyielding surfaces" such as rock, concrete, or rock covered by soil. However, it should be pointed out that if air transportation is utilized to any great degree in the future (something we strongly oppose), this will mean a larger number of shipments departing from and arriving by air over concrete air strips. Thus, a large percent of shipments would be at risk."

Staff Response - The explanation of the derating scheme has been expanded and included as FES Appendix H. The data used for surface occurrence probability are based on actual air carrier flight paths. It should be pointed out that a concrete runway is not an unyielding surface, and very few air crashes at a velocity at which derating is important occur on runways.

DES Chapter V: 12

Friends of the Earth - Comment 10

"Paragraph three states that accidents of severity VII or VIII are expected to occur randomly. If so, then how does the NRC justify its statement (see above, Chapter V, pp. V-2, 3) that the most severe accidents are the least likely to occur? And how does the NRC justify non-random dispersal of radioactive materials?"

Staff Response - Aircraft speeds in takeoff and landing accidents are considerably smaller and altitudes are considerably lower than in inflight accidents. Category VII and VIII accidents, being inflight accidents, occur at random locations, in contrast to the less severe accidents, which would be expected to occur near airports.

DES Chapter V: 13

State of New York - Skinner/Willen - Comment 50

"No discussion appears in the alternatives section concerning the impact of facility location on the severity of accidents and the probability of their occurrence."

City of New York - Comment 6(3)(b)

"The accident classification scheme fails to consider population density as a contributing factor to accident severity."

Staff Response - Accident consequence, not severity, is a function of accident location (i.e., population density). It is not clear that the specific location of facilities would have any effect on accident severity.

DES Chapter V: 14

ERDA - Comment 33

"Crush forces are load dependent. Therefore, if, for example, a shipment is made in a sole use vehicle which contains only a few small radioactive material packages the crush force severity categories (e.g., category VIII, 5% of accidents involve a crush force greater than 500,000 pounds) are likely to be incorrect.

"Also it would be appropriate to define the phrase 'crush force.'"

Staff Response - The reviewer has misquoted the percentage of category VIII truck accidents. Table V-2 (FES Table 5-3) states it is 0.0015 percent, not 5 percent. We agree that the number of packages and package loading configurations is important. However, this effect is very difficult to treat quantitatively because of the wide variation in loading schemes. This problem is discussed in the text.

DES Chapter V: 15

State of New York - Dept. of Environmental Conservation - Comment 17

"This section indicates that in the case of accidents involving motor carriers the dominant factors in the determination of accident severity are crush and fire. Currently, packaging standards do not include crush specifications. It is recommended that the responsible regulatory agencies consider implementation of a crush standard."

Staff Response - Crush force standards designed to simulate the normal transport environment for Type A packages are specified in Appendix A to 10 CFR Part 71. Regulatory agencies are currently considering the introduction of crush standards for Type B packages.

DES Chapter V: 16

State of New York - Dept. of Environmental Conservation - Comment 20

"The first sentence of the last paragraph refers to 'Table V-2.' It appears that it should refer to 'Table V-6.'"

ERDA - Comment 69C

"Should it not be Table V-6?"

Staff Response - The typographical error has been corrected.

DES Chapter V: 17

EPA - Comment 2

"With regard to transportation accident analysis, the relationship of the shipping package test requirements and the performance of the packaging under various accident categories has not been established to our knowledge. Thus, the information on failure rates and release fractions are presented in Table V and the conclusions drawn are based solely on engineering judgment. This fact should be indicated in the final statement."

EPA - Comment 11

"EPA previously stated and still believes that a technical analysis should be performed relating packaging test requirements to the forces a package may experience in an actual accident environment since primary protection in transportation is currently provided by the packaging itself. Special attention would be given to the probable extent of damage expected to be suffered by the package and the resulting quantity of radioactive materials which may be released to the environment under the various accident conditions. In developing this analysis, it is important to use as much test data as possible rather than relying on unverified engineering models. EPA is encouraged that data is now being gathered from actual tests, however, it appears that insufficient data makes it too early to use 'Model II' in Table V-6. In our opinion, Model I should be used as the basis for the risk assessment at this time, with Model II used only as a comparison."

Staff Response - The release fraction model has been revised to incorporate the recently available Sandia Laboratories' data. This model is discussed in Section B.6 of DES Chapter V (FES Section 5.2.6).

DES Chapter V: 18

Friends of the Earth - Comment 11

"NRC states that present shipping containers exceed required standards, apparently in reference to the Sandia Laboratories tests comparing severity of the thirty-foot drop onto an unyielding surface to a 2,000-foot drop onto hard prairie. The parameter excluded here is the 2,000-foot drop onto a hard surface, e.g., the surface of airports, which by the NRC's own standards, would therefore exceed both of the aforementioned tests."

Staff Response - There have been more recent impact tests on plutonium shipping containers performed at Sandia onto unyielding surfaces (steel over reinforced concrete). The implication that all aircraft accidents occur on runway surfaces and that all runways are unyielding surfaces is incorrect. The Sandia container tests involved impacts at speeds much greater than would be achieved in a 2000-foot drop.

DES Chapter V: 19

State of New York - Dr. Marvin Resnikoff - Comment 4

"Whether or not plutonium powder will escape its container during an air accident is dependent on two factors, the strength of the container and the severity of the accident environment. Considering the first of these, the DES makes only a passing reference to the wealth of material available as a result of the work done by Sandia Laboratories, and others, as well as a great deal of data supplied by the many experts appearing in the case of State of New York v. Nuclear Regulatory Commission, et al., United States District Court for the Southern District of New York (75 Civ. 2121 [WCC]). No data whatsoever can be found in the DES to dispute the criticism in the affidavits previously filed by the State in that case and in the Nuclear Regulatory Commission ('NRC') proceeding on transportation noticed at 40 Fed Reg. 23768."

State of New York - Dr. Marvin Resnikoff - Comment 5

"It has been determined under performance test conditions that the integrity of these containers are breached by levels of test crash environment intensity which are significantly less severe than actual air crash environments (Def. Aff., Nussbaumer, Exh. D; Pl. Aff., Pinkel, p. 6; Resnikoff, [6/12/75], p. 3). In fact, during test drops done for NRC at speeds of only 130 feet per second, even the inner pressure vessels were caused to leak (P. Aff., Resnikoff [6/12/75], p. 3; Def. Aff., Nussbaumer, Exh. D.). The Sandia Laboratory Report, 'Special Tests for Plutonium Shipping Containers,' annexed to the Nussbaumer affidavit as Exhibit D, candidly admits that, if impact speeds were raised to 150 feet per second, spillage of nuclear material is likely (Pl. Aff., Pinkel, p. 6; Def. Aff., Nussbaumer, Exh. D). Yet the DES classification scheme for accident severity categories assumes that no material will leak from cannisters in such accidents. Hence, these assumptions in the DES directly contradict the earlier affidavits of defendants submitted to the Federal District Court and the NRC."

State of New York - Dr. Marvin Resnikoff - Comment 7

"Cannister strength is lightly treated by the DES on pages V-24, 25, and 26 and VI-48 and 49. At this late date the NRC admits that 'only a limited number of containers [have been] tested.' The DES assumes that 'Model I' packaging (that is cannisters meeting current regulations) would fail (p. V-12). As to cannister 'Model II', which is deemed by the NRC to be a conservative approximation of 'real containers in an accident environment' (VI-26), and hence the critical link for NRC's allegations as to safety of containerization, the authors rely on unspecified 'personal communications' for substantiation of their various assumptions. This totally undermines the validity of this analysis for the purposes of this DES. The authors arbitrarily define fractions of plutonium powder shipments which will be released in the event of an air accident of a given severity class. Of the two references presented to support these arbitrary assumptions, one (9) (p. V-24) is a private communication. A 'private communication' is also referred to earlier on page V-14 in regard to population densities across the country. 'Private communications' are a highly suspect source for a very important parameter for study of this area. No specific data is ever identified as stemming from this 'personal communication'; and hence, no basis is given for the authors assumptions as to accident severity classes and release model fractions. These models are unverifiable and, as a result, highly questionable, to say the least."

Staff Response - The most recently available shipping container data have been used in the FES. It should also be pointed out that the breach of a container does not necessarily result in release of all or part of the contents and that release of contents does not necessarily imply aerosolization of all or part of the released materials. Since no data base ever includes all possible data, some degree of engineering judgment is required. The Sandia Laboratory report, "Special Tests for Plutonium Shipping Containers," was seriously misquoted by Dr. Resnikoff. It does not say "if impact speeds were raised to 150 feet per sec, spillage of nuclear material is likely." What it did conclude was: "It appears that any increase in impact velocity for the SP 5795 and L-10 containers would seriously damage the vent valves in the top of the pressure vessels and might permit loss of contained liquid." And in the fire tests, "The 6M container failed to retain the solution which leaked from the bottle inside the pressure vessel. The leakage referred in both cases to liquid contents. Referring to the 6M, the report went on to say "Had there been a metal or oxide contained within the pressure vessel, it appears that there would have been no leakage from the pressure vessel." The 1975 Survey data indicated that virtually all plutonium shipments in 1975 were in metal or oxide form. Furthermore,, 10 CFR § 71.42 requires that, after June 17, 1978, all plutonium in excess of 20 curies per package must be shipped as a solid.

DES Chapter V: 20

State of New York - Dr. Marvin Resnikoff - Comment 6

"No thought has been given to the potential of penetration damage due to shrapnel-like fragments of disintegrating airplane components resulting from an air accident (Pl. Aff., Pinkel, p. 7). Dr. Chapman, formerly of the Cornell Aeronautical Laboratory, is in agreement with Mr. Pinkel and Dr. Resnikoff when he concludes that, given the present containers, there is little assurance of containment of materials in air crash environments, which are clearly more severe, more complex and of greater impact than accidents in other modes of transport (Pl. Aff., Chapman, pp. 2-3; see also Pinkel, Resnikoff). The containers now in use by the NRC, their agents and licensees are clearly not designed from a complete knowledge of the air crash environment and continued use of such containers in air transport jeopardizes human life (Pl. Aff., Pinkel, p. 10)."

Staff Response - The analysis of air crash environments by Clarke et al. (SAND 74-0001) concluded that damage by shrapnel impacts that might puncture the container was an order of magnitude less likely than damage by the overall container impact.

DES Chapter V: 21

ERDA - Comment 34

"From this statement and the discussion near the top of page III-17, the reader is left with a confused picture. Is the calculation for ^{131}I and ^{137}Cs release consequences based on the milk path or on the inhalation path only? The statements in Chapter III imply that only the inhalation was included in which case the consequences for ^{131}I and ^{137}Cs releases are underestimated. This should be clarified in the final statement."

Staff Response - The part of Section C that conflicts with Chapter III has been deleted. The current model does consider only inhalation doses for I-131 and Cs-137. This is justified in the case of I-131 by assuming that affected milk or crops will be impounded for 60-80 days to permit decay (for I-131) or destroyed (for Cs-137). Hence, minimal ingestion would occur. This assumption is reasonable because of the relatively small quantities of material released.

DES Chapter V: 22

HEW - Comment 13

"This represents two cycles incorporated into one and is usually referred to as 'grass-cow-milk-man' and 'grass-cow-man' cycles."

Staff Response - The phrase in question has been deleted.

DES Chapter V: 23

Friends of the Earth - Comment 12

"We disagree with the statement that 'Consequences to the aquatic environment are less well understood than for the land.' At least one thing is known about living organisms in aquatic environments, namely that they concentrate radionuclides in their flesh (and bones, if they are bony fish), and that these concentrations can easily end up in the food chain that terminates with man. It is also quite obvious that radioactive spills in water are irreversible and cannot be cleaned up, unlike contamination of buildings, solid materials, etc. Consequently, radioactive contamination of bodies of water and of aquatic organisms is likely to be highly detrimental to non-human species of plants and animals, whereas radioactivity released into air can be more injurious to human beings through ingestion or high whole-body doses from gamma radiation."

Department Of The Interior - Comment 5

"The report does not specifically analyze consequences of accidents resulting in significant quantities of radioactive materials entering surface waters. While the probability of such occurrences would no doubt be very low, such an analysis might still be desirable to determine if conditions could arise requiring emergency measures to protect public water supplies."

Staff Response - The commenter disagrees with a statement that "consequences to the aquatic environment are less well understood . . ." because it is known that fish concentrate radioactivity in their flesh and bones. In order for them to do so they have to ingest some radioactivity either through water or food. Many radioactive materials, including plutonium dioxide, are comparatively insoluble in water. It is difficult to imagine an accident of such severity that the entire contents of the container would be spilled into the water except possibly for Type A packages. These are primarily radiopharmaceuticals that have very short half-lives. For Type B package incidents, packages would normally be recovered. A single radioactive spill in the ocean depths would soon be diluted to safe levels. In the interim, restrictions requiring monitoring of fish taken from the contaminated water, in much the same way as was done for deer taken by hunters from the grounds of the Savannah River Plant, would minimize the direct impact to man. The low frequency of transportation accidents involving radioactive material shipments and the very small probability that such an accident would occur over water reduces any danger of significant contamination of water and the associated aquatic food chain to a very low level.

DES Chapter V: 24

State of New York - Dr. Marvin Resnikoff - Comment 16

"The DES assumes 10,000 people/square mile to be a 'High Population Density' (P. V-30). Examination, however, of the Tri-State Regional Planning Commission 1970 Census population distribution shows that there are only a few square miles within a zone of maximum impact in

New York City with 10,000 persons or less (Pl. Aff. Skinner-Wang sworn June 13, 1975, exhibit 7). The Skinner-Wang affidavit utilizes 40,000 persons/square mile as a more representative value for a 'worst case' accident at JFK. According to that affidavit a four-fold increase in the population density would result in a four-fold increase in the impact presented in figure V-12 and V-13 of the DES."

State of New York - Dr. Marvin Resnikoff - Comment 25

"Although many variables have been mentioned herein as being underestimates, only one of these, population density, is analyzed in the DES for sensitivity in the accident scenarios. As mentioned before (Pl. Aff. Skinner-Wang, sworn June 13, 1975, Table A) we maintain that 40,000 people/square mile is a more representative population density for the New York City region imperiled by plutonium air shipments. This represents a 400% increase over the baseline population density (10,000/mile) NOT 10% as the DES assumes."

Staff Response - In terms of population density in the United States, New York City is a singularity. The assumed urban density of 10,000/mi^2 includes 90 percent of the "cities" in the U.S. with populations greater than 100,000. The worst-case analysis in the final environmental statement includes an analysis of an area with a population density of 40,000 people per square mile.

DES Chapter V: 25

ERDA - Comment 35

"There is no discussion or reference to explain the model used to calculate the area enclosed by isopleths. When area as large $10^4 km^2$ is involved (see figure VII), the model used for this calculation is very much of interest since this area exceeds by more than four orders of magnitude the areas plotted in Meteorology and Atomic Energy. Also, such a large area would depend more on regional than on local meteorology. The atmospheric stability and wind speed should be mentioned as well as the method by which values of the dispersion parameters σ_y and σ_z are determined."

State of New York - Dr. Marvin Resnikoff - Comment 12

"Both Robert Barker of the NRC (Def. Aff. sworn May 30, 1975) and Dr. Marvin Resnikoff (Pl. Aff. sworn April 25, 1975 and June 2, 1975) (one of the deponents herein) utilized Gaussian models with full explanation of the input parameters and sensitivity thereto. The DES, inconsistent with the analysis of the NRC's own expert, Barker, does not even explain these differences in approach between the DES and the Gaussian analyses. The discussion of contradictions later in these comments shows that the DES predicts 617 Latent Cancer Fatalities, Barker 15,000, and Resnikoff 107,000. Since the DES arrives at conclusions different than either of those models, some explanation is required before the DES can possibly be relied on as having any validity."

State of New York - Dr. Marvin Resnikoff - Comment 13

"Dispersion is also dependent on the meteorological conditions assumed. Calm weather increases the amount of individual dosages and turbulent conditions decrease dosages. In the DES the authors state: 'A year or more of data record (sic) for these parameters is used in the model which was obtained at two different locations' (p. V-29-30). Neither the data recorded nor the locations studied were presented; yet these factors quite obviously have tremendous impact on the conclusions presented in Figure V-10. Such data were presented by Barker (Def. Aff. p. 17 and exhibits) and Resnikoff (Pl. Aff. April 25, 1975 Table 2). Once again this omission precludes reproduction of the DES's conclusions by the reader. The DES's use of only average conditions from the 'year or more of data' recorded does not present scenarios capable of producing 'worst-case accident consequences' found in figures V-11 and V-12."

Staff Response - The dispersion analysis that was used in the DES is explained in Section C of Chapter V. Contrary to the allegations of the commenter, atmospheric dispersion is calculated using a Gaussian plume model and a substantial set of actually measured meteorological data; the 95th percentile values were chosen for use in the dose calculation rather than the average. Using 95th percentile data provides a good approximation to worst-case meteorology. The meteorological data were gathered at meteorological stations in Savannah River, Georgia, and White Sands, New Mexico. The authors acknowledge that diffusion models are not as accurate at large distances such as 100 km as they are at smaller distances from the release site. The discussion of the atmospheric dispersion model used in the DES has been expanded in the FES.

DES Chapter V: 26

Friends of the Earth - Comment 13

"In paragraph three, the NRC states certain population densities as their method of calculating person-rems from accidents involving radioactive materials, and then states that 98% of the U.S. area has a population density lower than any of these densities. However, they have overlooked the fact that insofar as air transportation is involved, most airports are located in metropolitan areas, particularly those of the heavily populated northeast where a good proportion of existing nuclear facilities are now located. Since only 25 states have no commercial nuclear reactors, it hardly matters what their population densities are. It is the population density in the areas near nuclear facilities that count."

Staff Response - The population densities of 90 percent of all U.S. cities with populations greater than 100,000 are less than that value used to represent urban areas in the DES. In addition, most airports are located near, not in metropolitan areas. If nuclear power reactors are meant to be "existing nuclear facilities," the criticism has little validity since no shipments to and from nuclear reactors are made by aircraft. Not all shipments considered by the DES use the air mode, but any shipment between two locations must pass over the intervening territory where accidents can and do occur. This is the reason that lower population densities areas were considered in the DES.

DES Chapter V: 27

ERDA - Comment 36

"Figure V-10 is self-explanatory although the normalization dose value of 0.8 rem seems odd and there is no explanation of it in the text. This figure, however, and figure V-11 on page V-38 are inconsistent. From figure V-10 the 10-meter release height curve yields a value of 4×10^6 m^2 at the 95 percentile. Thus, the area enclosed by the 8×10^{-4} rem per gm of ^{239}Pu released is 4×10^6 m^2. In figure V-11, however, the ordinate corresponding to 4×10^6 m^2 is 9×10^{-3} rem/gm of ^{239}Pu released. This discrepancy should be corrected."

Staff Response - Figure V-10 has been deleted, and Figure V-11 has been redrawn (FES Figure 5-7) to accommodate changes in the atmospheric dispersion model.

DES Chapter V: 28

State of New York - Dr. Marvin Resnikoff - Comment 3

"For the purposes of the DES the authors assumed an air shipment of plutonium with a size of four packages containing five kilograms each for a total of 20 kgs. (Tables V-13, V-12, V-7.). Actual practice seems to indicate that larger sized shipments are more realistic. For instance, two JFK PuO_2 shipments on July 29, 1974 and February 24, 1975 weighed 48.3 kilograms and 45.1 kilograms respectively, each more than twice the size assumed by the DES. This assumption undercuts the credibility of the 'worst-case' scenario."

Dr. K. Z. Morgan - Comment 2

"Table V-7, V-12, and V-13 are good examples of an attempt to give the impression of a very conservative consideration of the problem and an evaluation of the 'worst case accident' and yet your worst case assumes a shipment of only 20 kg of Pu when it is an established fact that larger Pu shipments have passed through some of our airports. When the reader notes such tactics used to depreciate the risks, he is inclined to question the credibility of the rest of report."

Staff Response - The revised standard shipment model includes explicitly a 100 kg (6000 Ci) shipment of $Pu^{239}O_2$, which passed through New York City during late 1974.

DES Chapter V: 29

ERDA - Comment 37

"In the last sentence a cloud height of 10 meters was assumed; however, we feel that atmospheric stability and wind speed assumption should be made and stated."

State of New York - Dr. Marvin Resnikoff - Comment 43

"For a diffusion model used to assess the consequences of release of radioactive materials, figure V-10, page V-31, what release height figures are used; and why are these chosen for each mode?"

State of New York - Dr. Marvin Resnikoff - Comment 46

"In the release consequences analysis (Chapter V, section E, page V-43), how do worst-case release heights vary from one mode of transportation to another (e.g., truck or helicopter accidents)?"

Staff Response - The weather conditions used in the analysis were 95th percentile values as discussed in the expanded section on the meteorological model. The 10-m release height was chosen for the reasons discussed in Section 5.3 and was used for all modes of transport and all releases.

DES Chapter V: 30

State of New York - Dr. Marvin Resnikoff - Comment 11

"The degree to which the public would become exposed to plutonium powder in the event of an air accident is dependent on the parameters discussed earlier and on several others as well; dispersion is one of them. The DES presents an almost incomprehensible complex of figures and explanations on this topic. A number of factors necessary for the reader's reproduction of the conclusions as to dispersion are omitted or inadequately described. The basic input term of deposition velocity, necessary for standard Gaussian analyses, is completely missing. Apparently Figure V-11, 'Specific Dose vs. Area,' is important to the DES's determination of areas which would be covered by plutonium powder after an accident. The term, Specific Dose (rem/gm), is depicted as varying with the area enclosing such a dose. This is an internally inconsistent concept (rems/gram of plutonium does not vary - it is a constant). Yet the concept becomes, by the use of other vague factors, the basis for figures V-12 and V-13, which set forth the number of people affected. Because of the inconsistencies and lack of descriptive information contained in the DES on this issue, we have been precluded from further comment on this analysis."

State of New York - Dr. Marvin Resnikoff - Comment 14

"Resuspension of the powder once it has settled out of the atmosphere onto buildings, vehicles, roads, etc., will plague decontamination and evacuation efforts and increase exposures to the public. The DES states only that 'the contribution to the total dose from cloud shine, ground shine, and resuspension can be obtained by the application of established factors to the results shown in figure V-11 . . .' (p. V-39). No use or actual application of these highly important 'factors is to be found in the DES."

Dr. K. Z. Morgan - Comment 1

"Here I read 'The Contribution to the Total Dose from Cloudshine, Groundshine, and Resuspension can be obtained by the application of established factors to the results shown in Fig. V-11. For ^{239}Pu and other isotopes of interest, these radiation effects are negligible . . .'

"I believe one has to be a bit naive to assume resuspension makes a negligible contribution to the human Pu dose. For example, several papers at the IAEA San Francisco meeting (November 1975), indicated the importance of resuspension. Here Romney (University of California) indicated that small particles of Pu are rapidly blown away from the source, and when resuspended they are deposited on plants that are eaten by animals and man. Most of the Pu found in vegetation got there by resuspension of dust. Jakublick (of Germany) indicated this PuO_2 on the soil migrates 100 times faster than soluble Pu (e.g. nitrate). Bondietti (of ORNL) indicated the Pu in soil forms complexes that are much more available for uptake by plants and animals. Becker (of EPA) suggested that the action of microorganisms in the soil may render this Pu available for uptake. McLendon (Savannah River Plant) found a high concentration of Pu in plants (1/10 that of core samples). This all suggests we cannot disregard the Pu in the soil where, in time, it may be transformed such that its fractional uptake by the human body may increase from 10^{-6} to 10^{-2}."

Staff Response - Deposition velocity and resuspension have been included in the dosimetric model both from a surface contamination and inhalation dose point of view. The typographical error on Figure V-11 has been corrected.

The commenter has significantly overstated the ingestion hazard for plutonium. The ingestion hazard is low because of several factors: GI tract absorption factors vary from 10^{-2} to 10^{-6}; resuspension factors are on the order of $10^{-4}\ m^{-1}$; soil transport and plant uptake of insoluble plutonium are very low. The dose commitment from ingested plutonium is several orders of magnitude lower than that due to inhaled plutonium, if a single accidental release is postulated.

DES Chapter V: 31

ERDA - Comment 38

"We do not understand the shape of this curve. The dose should be proportional to the atmospheric dilution factor, E/Q or x/Q' and the area as a function of x/Q' as plotted in Meteorology and Atomic Energy has a concave shape to it, whereas this one (figure V-11) is convex. Since no model is described or referenced, it is impossible to check. As previously noted, we suggest that the source of this figure and how the curve was developed be referenced."

Staff Response - Several items are germane to this comment: (1) The reference is apparently to Figure A-8 on page 414 in Meteorology and Atomic Energy. This is function $\chi\bar{U}/Q'$ not χ/Q'. (2) Figure A-8 assumes a ground-level release; Figure V-11 in the DES assumes a 10-m release height. (3) Figure A-8 assumes no initial dilution; Figure V-11 assumes the initial dilution in the 10-m cloud. (4) The curves in Figure A-8 are specific to wind speed and Pasquill stability category; Figure V-11 results from a Monte Carlo compilation of many combinations of wind speed and Pasquill category. The net result of these differences, especially the initial cloud height and initial source dilution makes Figure V-11 compatible with Figure A-8.

DES Chapter V: 32

ERDA - Comment 39

"A computer code is mentioned. Which code is it? Is it documented? There is an ANSI Standard for computer codes which if followed gives the reader some assurance that the code has been reviewed and checked for accuracy. Has this been done for the codes used in this document?"

Staff Response - The computer code referred to is the one that performs the Monte Carlo Gaussian calculations. The code is not adequately documented in unclassified literature, so the explanation of the calculation in Section C (FES Section 5.3) has been expanded to describe the calculations.

The ANSI standards review is strictly devoted to computer format, not theoretical basis. Hence, a review of that sort carries no implication of calculational accuracy.

DES Chapter V: 33

State of New York - Dr. Marvin Resnikoff - Comment 15

"Plutonium powder comes in various size gradations, depending on the source, some being more likely to settle in the lung than others. The more plutonium which settles in the lung, the greater the degree of risk of lung cancer. The authors of the DES assume 20% will be a candidate for deposition on the basis of particle size gradation of Fast Flux Test Facility ('FFTF') feed material (p. V-40) stated by the DES to be 20% respirable. However, plutonium oxide shipments through JFK in 1974 and 1975 (p. V-43) were admitted by the NRC to be 40% respirable. Indeed even the DES assumption of 40% respirability for JFK shipments is far too low as the authors have based that figure on a statistical construct of a 3.3 micron mean size of particles in those shipments. However, uncontested information in the record of the State's case against the NRC indicates that the range of particle size (.92 - 1.12 microns) did not include 3.3 micron particles at all, much less a mean particle size of 3.3 microns (Pl. Aff. Skinner, Appendix B). Since particles below 3.3 microns are '. . .considered to be respirable and candidates for deposition in the pulmonary tissue. . .' (p. V-40), it is accurate to say that 100% of the JFK shipments were candidates for lung deposition. Use of a 20% respirability figure represents a significant underestimate of plutonium's dangers. Again the DES proves to be a document replete with invalid assumptions."

ERDA - Comment 40

"We do not feel that taking 20% respirable as a median for 10% and 40% is conservative."

Staff Response - The value of 0.92 to 1.12 μm size is a mean value obtained by a measurement technique that examines the bulk surface characteristics of the particles. For biological response studies the characteristics of the mass distribution of plutonium with size was required. The information was inferred from the surface-related data using standard techniques. To assert that there were no particles larger than 1.12 μm or that biological data related to that diameter are those to be used is incorrect.

According to the ICRP Lung Dynamic Task Group analysis, particles of mean size 0.92 to 1.12 microns would be deposited between 20 percent and 30 percent in the pulmonary region, not 100 percent as alleged by the commenter.

The 20 percent respirable assumption is considered to be a conservative mean value because it is at the upper end of the data representing PuO_2 of U.S. manufacture, even though the value is below that of shipments that arrived at JFK in 1974 and 1975.

DES Chapter V: 34

Dr. K. Z. Morgan - Comment 10

"The ICRP lung model is used improperly. If the 750 ml lung tidal volume curve had been used (for the child) instead of the 2150 ml curve, it would be noted that about 28% and not 14% of the particles of 3 microns mean size distribution are retained in the lower pulmonary compartment of the lungs, and in either case (for the child or the adult) the larger Pu dust particles should not be neglected in the calculations of risk."

Staff Response - We believe the ICRP lung model is used properly for a 1-micron AMAD particle. The pulmonary deposition increase from a tidal volume of 750 ml to one of 2150 ml is small at this diameter (0.25 at 750 ml versus 0.23 at 2150 ml). If a 3.0-micron AMAD particle is assumed, the change is more significant (0.30 at 750 ml versus 0.20 at 2150 ml). Numbers are cited from Table 1 of "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract" (ICRP Task Group II report).

The effect of larger Pu particles, which settle principally in the nasopharyngeal and tracheobronchial regions, is negligible because of their rapid mucociliary clearance to the GI tract (biological half-times on the order of a few minutes to a few hours).

DES Chapter V: 35

ERDA - Comment 41

"No support or descriptions are given for either of the two components in the 'third factor.' The statement 'For plutonium this fraction is approximately 11/24' is unsupported as is the statement 'ratios of irradiation rates and clearance rates. . .this factor is approximately unity for plutonium.' A geometric standard deviation of 3 (footnote) signifies a very wide range of particle sizes, and a most difficult aerosol from which to derive 'irradiation rates.' This lack of information renders the entire remainder of this section unsubstantiated and therefore of little value. We strongly suggest that additional information be supplied.

"Also, we would like to know what is the significance of 11 and 24 in the fraction 11/24 and is there any reference for these figures."

Staff Response - The "third factor" is the particle size distribution factor, which accounts for the fact that the actual plutonium particle size encountered is larger than the size used in the dosimetric calculations. This value, 11/24, is derived using the upper curve on Figure V-12 as a probable "realistic value" for respirability (11%) and comparing this value with the maximum value (24%) used in the dosimetric model. The section has been rewritten to clarify this point.

The geometric standard deviation of 3 was taken as a likely upper limit value for a JFK shipment in order to estimate its respirable fraction. This shipment was not used in the calculations in Chapter V.

DES Chapter V: 36

ERDA - Comment 42

"Radionuclide name is missing on first line. We assume this should be ^{239}Pu."

State of New York - Dept. of Environmental Conservation - Comment 21

"Table V-11 does not identify the first radionuclide on the list. It appears that it should specify Plutonium."

Staff Response - Table V-11 has been completely rewritten to reflect the revised standard shipment model. It now appears in FES Appendix A as Table A-6.

DES Chapter V: 37

State of New York - Dept. of Environmental Conservation - Comment 18

"These tables should include the consequences of accidents involving spent fuel."

Staff Response - Spent fuel has been added because of the large amount of interest in the consequences of transportation of that material.

DES Chapter V: 38

State of New York - Dr. Marvin Resnikoff - Comment 23

"Another significant underestimate in impact consequences can be found in Table V-13's use of the 'Integrated 1 year dose' factor. Instead of presenting the number of people who would have suffered irradiation over their 50-year adult lifetime, the DES presents a smaller number on the basis of only a 1 year dose. The text of the DES does not describe how this integration was done, which precludes adequate analysis by ourselves at this time."

Staff Response - The 50-year doses were omitted from Table V-13 because the emphasis in that table is on the early effects from the irradiation; 50-year dose commitments (in terms of integrated population dose) may be found in Table V-12.

DES Chapter V: 39

State of New York - Dr. Marvin Resnikoff - Comment 21

"Of interest as well is the DES's use of cutoff points for the production of LCF's from population exposure. Standard epidemiological analysis utilizes the formulas described above (LCFs/10^6 person-rems) based on the whole population exposed. This method is necessary to integrate the natural variability of people's response to carcinogens. Although the DES uses the above epidemiological tool, it applies that tool only to a part of the population, that part which has sustained more than a given dose, thereby eliminating a significant number of exposed persons (or person-rems) from consideration. Table V-13 employs a cutoff of 15 rem. That part of the exposed population, perhaps millions of people who, receiving less than 15 rem, are excluded from epidemiological consideration i.e., they are deemed by the DES as not being potential cancer victims. Such a method is contrary to standard epidemiological practice (as utilized in the Skinner-Wang affidavit of June 13, 1975, Exhibit 1). The method employed by the DES significantly reduces the impact of a dispersion accident."

State of New York - Dr. Marvin Resnikoff - Comment 22

"A similar cutoff or threshold was applied to calculations underlying figure V-10. The cutoff of .8 rem was used for depicting the area enclosing populations dosed at that level. Since this figure is based on a one kilogram release and the DES worst case scenario was based on a 20 kg release, one can readily see that the actual cutoff is not .8 but actually (1) 20 x (0.8) or 16 rems or (.5) (20) x (.8) or 8 rems depending on the fraction of a shipment released (p. V-25)."

Staff Response - The only "cutoff" used in Table V-13 was the restriction of plume propagation to a maximum area of 10^9 m^2. This allows doses of order hundredths of millirem. Table V-13 merely lists 15 rem as a benchmark point since it is an NCRP recommended limit. The same misinterpretation was apparently used on Figure V-10. This figure was merely presented as being illustrative, not as one end or the other of the dose spectrum analyzed. It has been deleted from the final report.

DES Chapter V: 40

State of New York - Dept. of Environmental Conservation - Comment 19

"For the 20 kg Pu Case, the number of persons receiving doses greater than 15 rem, 10^4 rem, and 10^5 rem are listed. Since the number of persons receiving a dose greater than 15 rem is several orders of magnitude greater than those receiving a dose greater than 10^4 rem, the number of persons receiving doses at intermediate levels should be provided."

Staff Response - Table V-13 is not meant to show the entire dose spectrum; 15 rem was selected because it is a regulatory organ dose guideline, and 10,000 and 100,000 rem were chosen because of their particular health effect implications as discussed in Chapter V.

DES Chapter V: 41

State of New York - Dr. Marvin Resnikoff - Comment 17

"Radioactive material has a normal decay half-life of the material itself. In addition, when a radioactive material is taken up by the body, natural biological processes can expel a part of that uptake. The rate at which the expulsion takes place is known as the biological half-life. For the purposes of the DES the authors chose 500 days (page III-16). This assumption appears to be a significant underestimate. In the appendix to the DES (page B-7), the authors admit the '. . .lung clearance half-time' is 200-1,000 days. In order to obtain the worst-case scenario as described in figures V-12 and V-13, the authors should have used 1,000 days, not 500. There is significant authority for the use of such a value. The U.S. Environmental Protection Agency ('EPA') reports in its publication, 'Environmental Analysis of the Uranium Fuel Cycle, Part III - Nuclear Fuel Reprocessing,' 520/19-73003-D, that the new International Commission on Radiation Protection ('ICRP') lung model assumes a 1,000 day half-life as does the NRC's WASH-1535 'LMFBR Program Environmental Statement' in that document's Table II.G-9."

Staff Response - The actual value used for PuO_2 lung clearance half-time was 1,000 days as per WASH-1400 for category Y pulmonary clearance. This value is used to generate the value of 2×10^8 rem/curie; hence, it does in fact represent the "worst-case" clearance time.

DES Chapter V: 42

State of New York - Dr. Marvin Resnikoff - Comment 10

"It is significant that the earlier analysis by Resnikoff (Pl. Aff. April 25 and June 12, 1975), which only assumed 1/16 of the DES 'worst-case' release, resulted in the tens of thousands of Latent Cancer Fatalities ('LCF's'). Had he used a 20 kilogram release instead, hundreds of thousands of people would have become LCF's in all three cases of meteorological stability. (See Pl. Aff. Resnikoff, April 25, 1975, Appendix B.)"

State of New York - Dr. Marvin Resnikoff - Comment 29

"The DES presents accident impact conclusions which, in part because of the nature of the assumptions used, were smaller than those previously claimed by the NRC in the NRC affidavit by Barker (p. 5-12). Unfortunately lack of clarity and documentation in the DES precludes complete comprehension of all the origins of these discrepancies. Therefore preliminary analyses were made using known dispersion models with the major known impact assumptions used in the DES."

State of New York - Dr. Marvin Resnikoff - Comment 32

"Because of the lack of clarity and specifics in the DES model, we were unable to use that model and we utilized the Barker model instead, changing only the amount of plutonium oxide released. The Barker model originally used a release of approximately 1.25 kgs (page 1 BNL memo). We changed this amount to the amount utilized in the DES, 10 kgs. All other inputs were kept the same. This changed the value of latent cancer fatalities of 15,000 people which the Barker model predicted in Table No. 6 of the BNL memo (Pl. Aff. Skinner-Wang, sworn to June 13, 1975, Table A) to an astounding total of 53,000 people. The DES on the other hand, on page ii, predicted only 617 fatalities. The only possible explanation for this conflict lies in the many assumptions used by the DES which remain secret and unavailable for scrutiny by Congress or the public."

State of New York - Dr. Marvin Resnikoff - Comment 36

"Assuming GESMO utilized the worst-case conditions, stability Class F (Case B in Pl. Aff. Resnikoff, Table 2), over 1.4 million people would be exposed in the dispersion arc to 54 rems or more. On the other hand, the DES states in table V-13 that only 280,600 persons are being exposed to 15 rems or more. This massive inconsistency between the DES and other NRC documents totally undercuts the validity of the health effects model of the DES for air transport of plutonium."

Staff Response - The alleged massive inconsistencies between computation using other dispersion and dosimetric computational schemes are largely a function of varying input data such as assumed population density, assumed respirability, assumed Pasquill stability category, assumed material toxicity. The factor of 5 between the DES and GESMO models could be accounted for by any of these and may not be inconsistent when taken in context. In other words, the GESMO assumption may be for different circumstances than the DES assumption. If the Resnikoff assumptions are used in the DES model, a value of 4.0×10^6 is obtained. It is believed that the assumptions used in the DES analysis are more valid, and hence they are employed.

DES Chapter V: 43

ERDA - Comment 43

"Delete the word 'physiological' since it is meaningless as used here."

Staff Response - The phrase in question has been deleted.

DES Chapter V: 44

ERDA - Comment 44

"We suggest that Equation (1) should be given or referenced."

Staff Response - Equation (1) is given on DES page V-1. The FES refers the reader to Appendix G for more detailed equations and the method by which risk is calculated.

DES Chapter V: 45

ERDA - Comment 46

"The risk reported in this table of accidents in the shipment of PuO_2 is (for the same annual shipment quantity) at least four orders of magnitude greater than that found in a detailed assessment of the risk of shipping plutonium by truck. (T. I. McSweeney, R. J. Hall, et al., 'An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck,' BNWL-1846, Battelle Pacific Northwest Laboratories, Richland, Washington, August 1975).

"We feel that this is extreme conservatism in the accident risk analysis."

Staff Response - There are numerous differences in analytical methodology between BNWL-1846 and NUREG-0034. The area of principal difference appears to be in the release fraction model and in the aerosolization model. In both of these cases, the BNWL values are orders of magnitude lower than those used for NUREG-0034. Available data should be used to predict release fractions. That data base forms the basis for the DES release model.

DES Chapter V: 46

Friends of the Earth - Comment 14

"NRC inexplicably says that the risk of plutonium accidents goes down in the 1985 projections. We would like to inquire: why? How can this statement be justified, in view of the government's determination to proceed with experimental, and later commercial, plutonium recycle and the fast breeder plutonium economy? It is not unreasonable to assume that greater use and transport of plutonium increases the risk of accidents due to plutonium release (or diversion)."

Staff Response - The statement was that the percentage of the risk due to plutonium accidents decreased slightly; the actual risk increased, but the percentage of the total risk caused by plutonium shipments actually decreased. The question is now academic, however, because the standard shipment model has been revised using the 1975 survey data.

DES Chapter V: 47

State of New York - Dr. Marvin. Resnikoff - Comment 19

"Recycle of plutonium in today's light water reactor fuels will increase the concentrations of certain isotopes of plutonium in any shipments by air as shown below:

Plutonium Constituents

Constituent	DES (B-5)	JFK*	WASH-1327**
Pu-238	1.9%	0.6%	4%
Pu-239	63.0%	72.0%	43%
Pu-240	19.0%	18.7%	26%
Pu-241	12.0%	7.0%	15%
Pu-242	3.8%	1.6%	11%
Am-241	0.6%		1%
Rems/curie	10.6×10^6	39×10^6	83×10^6

(See April 25, 1976 Resnikoff affidavit - table 2 for calculations of Rems/curie)

"These increases mean that the latent cancer danger of plutonium powder will increase by about 100% when plutonium recycle matures. This effect has not been taken into account in tables V-16 and V-17 of the DES."

Staff Response - The effect of isotopes other than Pu-239 in recycle fuel or discharged LWR fuel is discussed in DES Appendix B (FES Appendix C). The numbers derived there are used for the 1985 plutonium toxicity values.

DES Chapter V: 48

HEW - Comment 14

"The statement does not project the latent cancer fatalities (LCF) or early fatalities (EF) to the year 1985. Although exposure is projected to increase by a factor of approximately 3 from 9589 (1975) to 28,590 (1985), this suggests the LCF could increase from 1.2 in 1975 to 3.6 in 1985 as a result of normal transport only. Assuming the increase of a factor of 3 and an essentially equivalent population exposure, one may project the fatality data on pg. xx to be as follows:

	1975	1985
Early Fatality	1	3
Other deaths	16	48
Latent cancer deaths (30 yr. period)	600	1800"

Staff Response - LCFs due to accidents for 1985 are predicted in Tables V-16 and V-17 and EFs for 1985 are predicted in Table V-18. The LCFs due to normal transportation are (as inferred) 3.6 in 1985. The early fatality and LCF predictions from page xx should not be scaled as suggested in the comment. These values are based on a single "worst-case" analysis. The parameters for that analysis are shipment size, population density, material characteristics, and meteorology. None of these parameters will change with the number of shipments, which is the basis for the cited scale factor (3). The aspect of the "worst-case" accident that will change is the annual probability of occurrence, since this is a function of number of shipments. The observation that the alternatives in the DES were not projected to 1985 is correct, but the alternatives in the FES are based on 1985 risk.

DES Chapter V: 49

ERDA - Comment 69D

"Should it not be 0.2 fatalities per year? (Page V-54 of DES)."

State of New York - Dept. of Environmental Conservation - Comment 22

"The last sentence of the first paragraph refers to a number of injuries and fatalities 'per reactor year.' It appears from what is presented previously in the paragraph that it should refer to the number of these events 'per year.'"

Staff Response - The data from WASH-1238 is on a reactor-year basis. Hence the text was correct as written.

DES Chapter V: 50

State of New York - Dept. of Environmental Conservation - Comment 23

"Justification should be given for assuming that the population at risk is 75 million persons."

Staff Response - The selection of 75×10^6 persons at risk has been explained in more detail.

DES Chapter V: 51

State of New York - Skinner/Willen - Comment 48

"Your analyses have considered impacts of transportation accidents in terms of population dose only. Careful consideration must be in the final document of the clean-up costs of all postulated accidents as well as a qualitative description of the inconveniences suffered by residents adjacent to and within accident contamination zones."

State of New York - Skinner/Willen - Comment 49

"Your analyses should contain reviews of typical accidents which have already occurred and the costs and difficulties of clean-up at each. These reviews should include plutonium clean-up operations at Thule, Greenland and Palomares, Spain."

Staff Response - A section on contamination/decontamination has been added to FES Chapter 5. This section includes a discussion of cleanup costs, etc., based on WASH-1400, Appendix VI, data. The authors feel that source is the most current and applicable material on that subject.

DES Chapter V: 52

State of New York - Dept. of Environmental Conservation

"The draft statement should also discuss indemnification for any damages that may result from transportation of radioactive shipments made under Federal regulations including human exposure, contamination limits, etc."

Staff Response - Although the extent of the insurance coverage may have an effect on the way people respond to an environmental impact, insurance does not appear to directly affect the impact itself. An analysis of insurance coverage is therefore not included in this statement. Information on insurance coverage can be obtained from the following reference:

> Joint Committee on Atomic Energy - HR-8631, "NRC Staff Study Concerning Financial Protection Against Potential Hazards Caused by Sabotage or Theft of Nuclear Materials," Appendix D, "To Amend and Extend the Price Anderson Act," Part IIB, "Geographic Limitation on Coverage."

DES Chapter VI: 1

EPA - Comment 18

"The act referred to as the National Environmental Protection Act is correctly cited as the National Environmental Policy Act of 1969."

Staff Response - The error has been corrected.

DES Chapter IV: 2

ERDA - Comment 47

"One section noticeably missing is a detailed history or 'Track Record' of fissile and other radioactive materials during the past 15-20 years and the analysis of that data utilizing the parameters used in this study. This omission is not understood since the first sentence in paragraph 2 on page VI-1 states, 'The environmental impact of an alternative in radioactive materials shipments is meaningful only when compared to the impact of the current shipping practice.' The evaluation of low consequence events of the past could then be compared to projected consequences of future shipments to assess the method used.

"No assessment is made of risks resulting from human error or faulty equipment which could result in dropping or puncturing containers during handling (fork-lifting) operations.

"In addition, no mention is made of specialized training for personnel involved in the various facets of fissile and radioactive materials shipments and the impact it might have in precluding incidents and accidents."

Staff Response - A "track record" section has been added to Chapter 1. The human error problem is addressed in Chapter 4 (in context with Appendix C).

DES Chapter IV: 3

HEW - Comment 14b

"The alternative analysis is based on current shipment impact, pg. VI-1, and does not appear to be projected in terms of conditions which might be expected in 1985. Essentially, the alternatives are compared on a basis of cost benefit versus radiological effect(s), pgs. VI-1 and VI-3. If one accepts the figure of $\$8.22 \times 10^6$ per LCF or any other death, an investment benefit in terms of citizen protection may be calculated."

Staff Response - The alternatives were all discussed relative to the baseline 1975 data in the DES but are based on 1985 data in the Final Environmental Statement. The cost-benefit is assessed by using the value $\$8.22 \times 10^6$ per LCF and comparing the equivalent dollar value for a reduction in LCF with additional costs to provide this reduction.

DES Chapter VI: 4

ERDA - Comment 48

"We suggest that the annual population dose due to accidents be included."

Staff Response - Population dose (in person-rem) has been added to Table VI-1.

DES Chapter VI: 5

State of New York - Dr. Marvin Resnikoff - Comment 40

"How are cancer fatality figures for normal and accident transport situations calculated? (Table VI-1, pg. VI-2)."

State of New York - Dr. Marvin Resnikoff - Comment 41

"What is the basis for figures in Table VI-1 on annual person-rems in normal transport for each type of radionuclide? How are the annual person-rem figures calculated in the alternative section (e.g. Table VI-4, pg. VI-10)?"

State of New York - Dr. Marvin Resnikoff - Comment 38

"There is a major difficulty in determining the areas of sensitivity when the various parameters in the risk equation for accident scenarios, pg. V-8 are changed in alternative situations. We are provided with a set of figures for the baseline and alternative situations, but nowhere are there any intermediate or exemplary calculations which would show what, specifically, contributed to the change between the baseline and alternative figures. For example, in Table VI-3, page 41-7, we are given the set of figures for all air shipments being instead transported by truck. But it is impossible to tell from these new figures alone, just what contributed to the alternative results -- a difference in vehicle miles/year, probability of accidents, accidents of different severity classes, etc. Without the benefit of intermediate calculations, it is impossible to determine why the proposed alternatives result in the changes given in the summaries."

State of New York - Dr. Marvin Resnikoff - Comment 44

"In the summaries of results for each transport mode, how are figures for "probabilities of $\geq$ 1 early fatalities/year" derived, e.g., Table VI-4, page VI-10?"

Staff Response - The calculation methods specified in FES Chapters 4 and 5 and Appendices D and G are used for all baseline and alternative analysis. The alternative section has been expanded to specify the reasons for changes in radiological consequences in more detail.

DES Chapter VI: 6

ERDA - Comment 49

"Table VI-4 and following give baseline and alternative calculated values then a change, usually in percent. Giving this change in percent rather than in absolute value tends to be misleading. This is particularly true when evaluating the sum of LCF for normal and accident. For example, on page VI-22 we find a normal transport LCF increase from 1.166 to 1.195 or 0.029 or 2% while accident LCF decreases 21%. Stopping there it sounds like a substantial overall LCF decrease. But looking farther we see the 21% decrease is from 0.000529 to 0.00044 or 0.000089 decrease off-setting 0.029 increase or a net 0.0289 increase. We recommend showing the change in absolute values throughout this section.

"Furthermore, we feel that the text could be strengthened by the addition of narrative which place the differentials between alternative modes in perspective relative to the probable accuracy of the result (i.e., relative to the confidence limits in the data). For example, what is the confidence in, or significance of, the computed 21 percent decrease in latent cancer fatalities due to accidents?"

City of New York - Comment 6a

"Computed estimates of alleged risk are singularly deficient in statistical confidence limits. For example, the risk assessment relies upon a progression of modelling stages; the cumulative effect of the degree of precision lost at each stage makes the study of little or no value."

Staff Response - The percentage changes in LCF have been deleted; only the absolute values are given. It is very difficult to present confidence limits in a calculation of this type. For example, it is doubtful whether confidence limits could be applied to the package response model because of the paucity of the package test data. However, throughout the calculation, a conservative approach has been taken in those stages of the model where the degree of confidence is unknown. Therefore, the computed values for risk are not statistical averages about which one would place confidence limits but more like a conservative upper bound.

DES Chapter VI: 7

ERDA - Comment 50

"The annual air cost minus truck cost in dollars for plutonium shipments should be 2.8×10^3, not 3.4×10^3, based on the information in this table. Also, the footnote for this table is confusing since it is indicated that the plutonium shipping distance is 1200 miles but the cost is given for a 2000 mile trip."

Staff Response - The two errors in Table VI-6 have been corrected.

DES Chapter VI: 8

State of New York - Dr. Marvin Resnikoff - Comment 42

"How are mileage, exposure time, and population dose figures determined for alternative transportation modes? (e.g., switching from all passenger to all cargo aircraft, paragraphs 1 and 2, pg. VI-16)."

Staff Response - Any changes in parameters used in the baseline 1985 study derived for the alternative calculation were based on data for the mode established earlier and on estimates of increased (or decreased) mileages necessary for performing specific mode shifts or service pattern changes. Wherever possible supporting reference material was cited.

DES Chapter VI: 9

ERDA - Comment 51

"... .States, 'additional secondary mode mileage. . .' This is in conflict with statement on page VI-17, B.1-3 which says, 'shorter distance in secondary mode.'"

Staff Response - There is an error in the assignment of additional secondary mode costs in the shift from cargo air to passenger air, and this error has been corrected. Because of the greater number of airports providing passenger air service, the average secondary mode mileage would be shorter for transport by passenger aircraft.

DES Chapter VI: 10

Friends of the Earth - Comment 15

"In discussing the alternative of shifting all radioactive cargo to passenger aircraft, the report states that although this would increase passenger exposure, it would decrease the exposure (presumably to the public at large) by reducing the total miles travelled in secondary modes. We take issue with the practice of separating passengers - or cargo handlers - or nuclear industry workers - from the public at large, specifically as it relates to the genetic effects of radiation. NRC can hardly take issue with the fact that there is gene flow via reproduction between workers and non-workers, or between passengers and non-passengers. This indefensible distinction becomes particularly odious when one becomes aware of recent studies indicating that ingested plutonium may concentrate in the gonads."

Staff Response - This alternative decreases the total amount of exposure to the public, which is a net positive effect. It is not essential to discuss the exposure to various groups such as cargo handlers in order to assess the risk. As for genetic effects, the discussion in WASH-1400, Appendix VI, indicates that these are negligible compared to somatic effects. The comment about ingested plutonium being concentrated in the gonads is irrelevant to discussions of normal transport.

DES Chapter VI: 11

Transnuclear, Inc. - Comment 2

"In Chapter VI the discussion in Section B.1-6 indicates that seven times as many shipments will be required by truck as compared to rail. However, in Table VI-17, there are 380 shipments per year by truck and none by rail. This value should be 54 + 7(326) = 2336 if all 326 rail shipments are to be transferred to truck. If the radiological impacts as reported in Table VI-18 are based on Table VI-17, there may be significant errors in the results."

Staff Response - The FES includes more accurate treatment of spent fuel shipments, including capacities of truck and rail cars.

DES Chapter VI: 12

ERDA - Comment 52

"The discussion fails to acknowledge the aggravated logistics and increase in facilities and labor required at a reprocessing plant receiving about 5 metric tons of fuel per day by truck relative to rail. This is important also in light of the added potential for operator error, and dosage to plant operating personnel.

"Some mention of the efficient utilization of transport fuels is probaly appropriate A 1000 MWe light water reactor might originate 60 spent fuel cask shipments per year by truck or 10 cask loads by rail. Fuel consumption is typically 670 BTU per ton mile by rail; 2400 BTU per ton mile by truck. Assuming a 1000 mile trip (each way), rail shipments would save over 64,000 gallons of diesel fuel per reactor year."

Staff Response - This information has been incorporated in the FES.

DES Chapter VI: 13

Transnuclear, Inc. - Comment 3

"We also question the economics of spent fuel transport as reported in Section B.1-6.2. A recent study by the Edison Electric Institute on Nuclear Fuels Supply reported in Appendix V:

"'The cost of transporting a normal spent fuel annual discharge for a 1200-1300 MWe reactor over a distance of 1000 miles to a reprocessing plant is about $680,000 using a legal weight truck, $275,000 using an overweight truck, $460,000-$530,000 for a non unit train, and $750,000-$860,000 for a unit train.'

"We suggest that the alternative for spent fuel transport be presented as follows:

	Legal weight truck	Special permit truck	Rail
PWR elements/cask	1	3	7
Trip distance miles	1,000	1,000	1,000
Trips per year (1975)	2,336	780	334
Cost per assembly	11,300	4,600	7,600-14,300

"The radiological impacts should be calculated using the above values."

Staff Response - The EEI information has been incorporated into the discussion of the alternative in the FES.

DES Chapter VI: 14

United Airlines - Comment 2

"To prohibit shipments of radioactive material during adverse weather would be impractical because it changes so quickly in widely separated geographic areas."

Staff Response - A statement concerning the impracticability of this alternative has been incorporated into the FES.

DES Chapter VI: 15

United Airlines - Comment 3

"To restrict movement to daytime flights would eliminate most freighter flights. This would be very undesirable."

Staff Response - Restriction of flights to daytime hours has been eliminated as an alternative.

DES Chapter VI: 16

United Airlines - Comment 4

"It would not be practical to restrict movement by air to airports in low population areas, since service by air is so limited at such locations. A better alternative, if this is a valid concern, would be to prohibit transport by air."

Staff Response - Qualification "a" in Section B.2-2.3 (Qualification 1 in FES Section 6.3.1.2) discusses the limited air cargo service to suburban airports.

DES Chapter VI: 17

City of New York - Comment 3c

"Not only is there a failure to adequately analyze alternative modes of transportation, there is a virtually total lack of discussion of the impact of alternative routing of nuclear transportation shipments. The DES acknowledges the importance of population density in determining the significance of an accident (V48), but nonetheless fails to discuss routing alternatives which would take difference in population density into account."

Staff Response - Routing alternatives for aircraft are discussed in paragraph B.2-2.3 of Chapter VI. Routing alternatives for truck/van are discussed (qualitatively) in paragraph B.2-3.1 of Chapter VI.

DES Chapter VI: 18

EPA - Comment 12

"The discussion on the mitigation of accident consequences which precedes this table [Table VI-25] in this section indicates a decrease in the 'Accident L.C.F.' rather than an increase as given in Table VI-25. The reason for this seeming inconsistency should be explained."

Staff Response - In the discussion preceding the table, it was stated that, by requiring radioactive material flights to avoid zones of high population density, the risk to the population from flight accidents would be lower. However, these restrictions would severely limit the number of available airports, thereby increasing the average secondary mode mileage. The increased number of secondary mode accidents would produce the overall increase in accident LCF.

DES Chapter VI: 19

State of New York - Dr. Marvin Resnikoff - Comment 47

"On page VI-41, Section B.2-3.1, what procedure is used to determine reduction in truck accident rates due to the 3 alternatives given?"

Staff Response - The accident rate reductions for these alternatives are discussed in the cited reference.

DES Chapter VI: 20

ERDA - Comment 53

"States 'Restricting trucks to good weather driving. . .'A restriction of this type would precipitate confusion as to the definition of 'good weather driving' and would prevent the driver from exercising discretion as to whether road conditions are safe or unsafe (he should be in the best position to make that determination)."

ERDA - Comment 54

"This section discusses restriction on truck travel on weekends. Since truck costs are based on miles covered, denial of weekend travel would severely escalate costs of shipments by this restriction. Long-haul operations that are currently on the road for greater than five days would be severely affected."

Staff Response - These observations have been incorporated into the discussion of the alternative in the FES.

DES Chapter VI: 21

State of New York - Dr. Marvin Resnikoff - Comment 45

"Why are certain alternatives evaluated only with regard to cost, while discounting seemingly significant decreases in accident latent cancer fatality figures, e.g., Table VI-28, page VI-44."

Staff Response - A dollar value was assigned to LCF values in an attempt to put accidents, normal transport, and overall cost into perspective.

DES Chapter VI: 22

ERDA - Comment 55

"In view of recent railroad actions, we feel this section deserves more emphasis and perhaps some expansion. Specifically, is there any basis in statistical data to suggest that the addition of special train units (extra's) operating over trackage otherwise scheduled, but at less than normal freight train speed would increase accident frequency or consequences relative to normal freight service?"

Association of American Railroads - Comment 1

"The conclusions on pages VI-44-45 were predicated on regular train service and a number of accidents (most of which were assumed not to be of a serious nature), but should have been predicated upon special train service with no accidents."

Staff Response - The section on special trains has been revised to include safety and economic data from several sources. These sources (notably, an analysis of AEC weapon transportation) indicate that a reduction in accident rate occurs, perhaps by as much as a factor of 7; however, special trains are certainly not immune to accident as suggested.

DES Chapter VI: 23

EPA - Comment 13

"Correction of the term 'ny' is necessary to clarify the sentence's meaning.

Staff Response - The typographical error has been corrected.

DES Chapter VI: 24

Friends of the Earth - Comment 16

"In this table of alternative transportation modes, two modes that could reduce radioactive exposure are inexplicably left out: avoiding cities (by barging materials where possible, as with Brookhaven National Laboratories, and the Shoreham and Jamesport reactors on Long Island); and barges themselves as an alternate or for part of a trip. Cities could be avoided by the use of not only barge but of trucks and railroads; surely the avoidance of populated areas - a general government policy where hazardous materials are involved - could substantially reduce potential effects from accidents or releases. Why is this not considered? Why were barges not considered?"

City of New York - Comment 3a

"There is a failure to make a rigorous and objective evaluation of all reasonably available alternatives. To take but one egregious example, barging is described as creating a "negligible" population exposure (IV-34), and barging has been recognized by USEPA as a desirable alternative to land transportation, yet no assessment of it is made in 'Chapter VI - Alternatives' or in the 'risk assessment section of Chapter IV.'"

Staff Response - The use of barges has been more adequately discussed in the Final Environmental Statement.

DES Chapter VI: 25

State of New York - Dr. Marvin Resnikoff - Comment 39

"The methods of obtaining figures for normal and accident L.C.F. in both baseline and alternative transport situations are quite unclear. There is no derivation given for the equation from which the baseline risk figures are obtained. (The equation itself is very difficult to find, especially in light of its exclusive use in determining the final figures). The variables used in this general equation are also hard to locate and several of them (e.g., vehicle miles/year for each type of shipment, probability/vehicle mile of a specific severity class accident) can only be obtained through a series of separate calculations. Calculations of the alternative results are made by changing a specific parameter in the original equation and following this through; this is obviously done with a computer program, but no program is provided, making it very difficult to reproduce these results. In addition, inconsistencies with the language used to show the changes between baseline and alternative situations make the results confusing and occasionally misleading. While most of the changes are represented in percentages, the very large reductions are not, e.g., a 'factor of 16 decrease', which seems fairly small, actually represents a 94% decrease in the baseline figure, a very significant change. Particularly puzzling are the rankings of truck, rail, and passenger air transport (VI 53-55)."

ERDA - Comment 56

"This table [Table VI-29] shows a factor of 16 increase for one item and 100% decrease for another. We suggest consistency in these tables. Same comment applies to table VI-30, page VI-49."

Staff Response - The calculational scheme is now specified in greater detail in FES Appendices D and G, and the language inconsistencies mentioned have been removed.

DES Chapter VI: 26

ERDA - Comment 45

"Accident LCF reduction in table [Table VI-30] is by a factor of 23, but the text refers to a 23% LCF reduction. This discrepancy should be corrected."

Staff Response - The text has been corrected.

DES Chapter VI: 27

ERDA - Comment 57

"States '. . .Since accidents involving plutonium shipments are expected to produce 98.6% of the total risk. . .' If this statement is true, then the packaging requirements for all quantities of plutonium shipments should be upgraded. Perhaps consideration should be given to require all transuranics to have a super classification of containers to be used for all modes of transport."

Staff Response - NRC is currently evaluating standards for packagings for plutonium.

DES Chapter VII: 1

Friends of the Earth - Comment 1

"The draft environmental statement refers here to air transport as an "effective means of protection" against theft and sabotage of radioactive materials. We strongly disagree. Sabotage of aircraft could lead to a crash and fire and possible dispersal of radioactive materials. Air transport is therefore not an alternative to ground modes of transport since it offers additional potential for such dispersal, in fact triple potential, through aircraft malfunction, pilot error, or sabotage. In our opinion, air transport is the least acceptable and by far the most risky of all transportation modes. Rather than offering an "effective means of protection," it offers instead a wider variety of possible events that could result in dispersal of radioactive materials."

Staff Response - The FES reflects the NRC conclusion that, regardless of the mode of transportation, adequate protection can be provided against theft and acts of sabotage that would result in a significant radiological hazard.

DES Chapter VII: 2

Friends of the Earth - Comment 15

"The report goes to great lengths to assert its desire to protect civil liberties while maximizing safeguards. Yet the Special Safeguards Study has already suggested considering such anti-civil liberties measures as wiretapping, surveillance, and infiltration of groups that the government considers potentially subversive or violent."

Staff Response - The Special Safeguards Study (authored by D. Rosenbaum, et al.) discussed the cited measures in the context of domestic intelligence-gathering activities that are not among the responsibilities of the NRC. Domestic intelligence activities would contribute but marginally to the protective capabilities possessed by NRC licensees. NRC programs for the security of fixed sites and transportation links are designed to benefit from, but not depend upon, any intelligence indicators that may be generated. The NRC attempts to minimize the societal impacts of a nuclear industry by ensuring that each facility and each transportation link is sufficiently secure within itself to minimize the risk of theft or sabotage.

DES Chapter VII: 3

Friends of the Earth - Comment 16

"The footnote referring to an NRC ban against plutonium air shipments is in error. NRC should be reminded that they refused to implement such a ban, and that only a Congressional amendment introduced by Congressman James Scheuer put such a ban into effect. The ban unfortunately does not apply to ERDA shipments."

Staff Response - The NRC ban on air transport of plutonium referred to in this comment implemented legislation passed by Congress. The text of the FES has been revised to reflect this fact.

DES Chapter VII: 4

United Airlines - Comment 5

"Air transport should not be required for the movement of radioactive shipments based on security considerations. The much more important consideration relates to the exposure of people, equipment and facilities to radiation and it is these concerns that should determine whether radioactive shipments can and should be carried by air.

"The transport of radioactive material by air should be limited to only that which is absolutely necessary. In our opinion, this is primarily material related to medical applications including research, diagnosis and treatment."

Staff Response - This comment implies that the DES suggested that air transport should be required on the basis of security considerations. In this regard, it is noted that the FES expresses no such conclusion. It does note, however, that air transport is one of a number of modes for which effective means to protect radioactive material from theft and sabotage have been and can continue to be provided.

DES Chapter VII: 5

City of New York - Comment 1

". . .(The discussion of barging in the Safeguards section (VII 13-14) lists some difficulties with escorting barges carrying nuclear wastes. It is stated that the level of security of escorted trucks is not attainable with barges. We would suggest that the Coast Guard be consulted on this conclusion and would refer the writers of the DES to the Coast Guard's 'procedures for the Movement of LNG/LPG,' Captain of the Port, New York. 1. October 1975, for a discussion of the types of safety measures that can be taken for hazardous marine cargoes.)"

Staff Response - The use of barges under such circumstances would necessitate transfers from one mode of transportation to another thereby making a needless extra step in the transit of the material. Certainly, shipment by barge should not be totally discounted as a viable means of transportation solely because of these limiting factors. The DES discussed the security aspect of such shipments only in terms of escort measures. It is noted that the FES concludes that the level of protection of shipments attainable by barge, if such a mode were utilized, would be comparable to that attainable through other transportation modes.

State of New York - Affidavit of Mason and Leamer, Nov. 30, 1975 - Comment 4

"Each of the following military assisted transportation alternatives for enriched uranium is considered less vulnerable to terrorist action than current commerical practice. The least vulnerable alternative is presented first, the most, last:

(1) long haul military air cargo, leaving from and flying into a military airfield, and connecting with short haul military helicopter service between the airfield and the origin/ultimate destination;

(2) same as (1) but with military surface transport service between the airfield and the origin/ultimate destination;

(3) long haul commercial air cargo, leaving from and flying into a military airfield, and connecting with short haul military helicopter service between the airfield and the origin/ultimate destination;

(4) same as (3) but with military surface transport service between the airfield and the origin/ultimate destination;

(5) long haul commercial air cargo, leaving from and flying into a military airfield, and connecting with commercial surface (truck) service or commercial air (helicopter) service between the airfield and the origin/ultimate destination."

State of New York - Enclosure to Letter of May 17, 1976 - Comment 2 (partial)

"b. indicate that the military has the current safeguard capability to move SNM by surface transport which is significantly less vulnerable to terrorists than commercial air transport and related connecting transport;

c. specifically evaluate the air transport of uranium (as opposed to plutonium) and demonstrate that any one of five (5) military assisted transportation system alternatives is significantly more secure against terrorist action than commercial air transport, because of:

(1) rigorous control of future shipment movement information;
(2) more secure in-transit communications;
(3) reliable and highly motivated personnel with security training and clearances;
(4) appropriate selection of weapons and vehicles;
(5) superior reaction capability;
(6) physical remoteness of airfields and facilities;
(7) psychological deterrent of a U.S. military protection force."

Staff Response - The discussion of assessments and military options in the FES points out that the physical protection affordable through the private sector is adequate to protect against the postulated threat level and the use of military forces is neither legal nor necessary.

DES Chapter VII: 7

State of New York - Affidavit of Mason and Leamer, Jan. 20, 1976 - Comment 19

"Recent Information

19. We note that in a January 12, 1976, p. 11, col. 1 New York Times article by David Burnham, the following was reported:

> 'The commission (NRC), however, is considering recommending the possibility that an existing Defense Department agency such as the Army's special forces be given training to enable it to react to a situation where a terrorist band seizes and holds a nuclear facility for a relatively long period of time.'

"Moreover, it was stated in the New York Times, January 18, 1976, News Of The Week in Review, p. 3, col. 2:

> 'The Federal Nuclear Regulatory Commission is preparing to recommend that Congress consider, instead of creating a special police force to guard nuclear power plants, training Army units to prepare for attacks on the installations by terrorist groups.'

"It is clear that even defendant NRC now considers military safeguards against terrorist attack against nuclear facilities and materials to be necessary and desirable."

Staff Response - The articles incorporated by the comments speculate that the NRC is considering the use of military [Army] personnel for guarding certain nuclear installations or reacting to possible terrorist attacks. While many types of alternatives have been proposed and considered in evaluating what requirements might be appropriate if an increased level of protection were to be found necessary in the future, no conclusion to require an increased level of protection should be inferred at this time. A discussion on the use of military resources to protect SNM is included in the FES.

DES Chapter VII: 8

State of New York - Letter of Aug. 4, 1976

"The NRC is now once again urged to recognize that the continued commercial transport of SNM runs an unacceptable risk of diversion or loss of SNM. More secure modes of transport must be immediately designed and implemented. As this office has previously stated, it is our view that the NRC should require that shipments of plutonium be made by military surface transport and that shipments of uranium** be made by military air transport, using military bases as points of shipment and interim storage for all SNM."

Staff Response - The section of the FES describing the physical protection requirements for SNM in transit has been substantially revised to reflect recent improvements in the physical protection system. Specific note should be taken that features of this system include the use of an armored vehicle or the equivalent as the transporter, escort by a minimum of five armed individuals, a separate escort vehicle (two if at night), redundant means of communications, and several armed guards to protect SNM transfers. These measures have had the effect of significantly increasing the capability of NRC-licensed shipments of SNM to counter possible attempts of theft or sabotage of SNM in transit.

DES Chapter VII: 9

State of New York - Letter of May 17, 1976 - Comments 3 and 4

"3. The only discussion of military assisted air transport alternatives in the DES is limited to approximately one-half of a page (p. VII-12). What little discussion there is emphasizes only the military airfield aspect of these alternatives. It is apparent that the 5 military assisted options for uranium transport detailed in our affidavit of 30 November, 1975 (pp 4-7) were not considered.

"4. The DES does admit that the use of military airfields and/or aircraft 'appears technically feasible.' However, in a footnote, the DES suggests that the use of military airfields and aircraft may be prohibited and cites a law said to provide that: 'Except as otherwise provided by law, sums appropriated for the various branches of expenditure in the public service shall be applied solely to the objects for which they are respectively made.' 31 U.S.C. 628. In light of the obvious danger to the national security inherent to commercial air transport and related connecting transport of SNM, the failure of the DES to demonstrate that there are no sums appropriated which might properly be applied to the use of military airfields and aircraft for transport of uranium is significant."

Staff Response - As pointed out in response to comments on military alternatives elsewhere, the use of military resources is both unnecessary and illegal. The NRC does not agree that commercial air transportation and related connecting transportation of SNM constitute a danger to national security.

DES Chapter VII: 10

State of New York - Enclosure to Letter of May 17, 1976 - Comment 6

"6. Even though the DES makes no specific mention of military helicopters, it does make brief reference to helicopters generally (VII-13). This reference to helicopters, and STOL aircraft, together with their range and payload parameters, is without any qualification and hence without substance. After all this time, only conclusory speculation is offered. It is generally known, however, that a wide range of helicopters is used in the military and in industry with considerable flexibility in range and payload. In fact, a quick check reveals, for example, the following:

Helicopter Manufacturer/Type	Range	Payload (lbs.)
Boeing Vertol model 234	240 nm	20,000
	320 nm	4,000
Bell model 222 (undergoing modification)	425 nm	1350 (Estimated)"

Staff Response - Although no licensee currently utilizes helicopter or STOL modes of transporting SNM, there is no prohibition to do so since the NRC concludes that all modes can be afforded adequate physical protection.

DES Chapter VII: 11

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 (Referring to J. Edlow Affidavit of January 1976) - Comments 5 and 6

"5. In paragraph 3. Edlow's concurrence with his father's recommendation of 'expediting' falls short of accomplishing the task of deterring a determined terrorist from successful seizure of SNM. The statement that '[t]his method and this method only will provide early notice that shipment is astray or diverted' is somewhat after the fact and does not preclude the possibility of diversion by seizure or hijacking. The only reaction to the discovery, or 'early notice,' that a shipment is diverted, is to notify the NRC or 'an appropriate law enforcement authority.' This is not security in the prevention sense and unless a more secure mode of transport is provided at the same time, seizure is not prevented and potential for recovery may be meager.

"6. As we have indicated in our earlier affidavits, one of the weakest links in the current security chain with respect to prevention of successful terrorist action is the wide dissemination of advance shipment information. 'Expediting,' as described by Edlow, is directed toward loss through misrouting or casual theft. However, such programmed pre-scheduling of times, routes, mode of transport, etc., provides precise information on shipment movement and unless access to such information is strictly limited, may add to a successful terrorist act. According to Peter N. Skinner, affidavit of April 20, 1975, a minimum of 124 people had knowledge of the details of the arrival of a specific shipment of plutonium before it arrived at J. F. Kennedy Airport from Brussels on February 25, 1975. As can be seen, the question of knowledge prior to shipment is one of the greatest short-comings of the civilian transport mode and one of the advantages of the military mode. Mr. Edlow at paragraph 15 of his affidavit stated categorically that 'SNM cannot be lost or diverted under current regulations....' Such an unqualified statement raises questions about his expert objectivity. We would not categorize the current system as failsafe."

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 (Referring to Affidavit By Captain Echols (ALPA)) - Comment 11

"Captain James A. Echols, Affidavit of 28 November, 1975

"11. Captain James A. Echols' affidavit of 28 November, 1975 recounts numerous terrorist acts occuring aboard commercial aircraft and/or associated with commercial air facilities and installations. The MITRE report itemizes no less than 26 commercial aviation-related terrorist acts in the last 6 years. These findings are consistent with the view expressed in one earlier affidavit that successful terrorist action against commercial aviation is feasible. We believe that transport SNM in commercial aircraft provides the terrorist with particularly attractive incentive for action."

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comments 12 and 13

"Assessment of 10 CFR 73 through 73.36 and 73.72 as Amended

"12. At paragraph 56 of our affidavit of 16 June 1975 we stated that the regulations as republished on December 28, 1973 were not adequate to prevent or deter a determined group of terrorists from succeeding with their mission. Those regulations were the regulations in effect on March 4, 1974. A review of 10 CFR 73.1 through 73.36 and 73.72 as amended through December 15, 1975, was made to determine whether amendments after March 4, 1974 would substantially alter our assessment of the vulnerability to terrorist action of SNM carried in commercial transport.

"13. Our assessment has not changed. The thrust of these Part 73 regulations remains that of protecting against loss, misrouting and casual commercial theft. Assuming full compliance with the letter and spirit of those sections of Part 73 by all responsible parties (an assumption with which we disagree), the amended regulations do not provide for adequate personnel, equipment or procedures to effectively deter and prevent successful terrorist action or organized theft."

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comments 17 and 18

"17. It is apparent that the conditions in the commercial transportation industry described by Sam Edlow in the 1969 speech attached J. Edlow's affidavit as Exhibit 1 have not substantially improved. Sam Edlow characterized the industry as untrustworthy (Exhibit 1, p. 3) and incompetent (Id. p. 9) and the environment in which the industry operates as one of criminality (Id. p. 6). Indeed he felt that the most that might be accomplished by strengthening requirements within the commercial industry might be early detection and recovery rather than prevention (Id. pp. 6, 10, 11, 12). As pointed out above in paragraphs 5, 6 and 7 current regulations regarding what Sam Edlow called 'expediting' refect (sic) a goal of detection, rather than prevention of diversion.

"18. As to demonstrating that the commercial air system is potentially unsafe from the terrorist threat viewpoint, the recent bombing of LaGuardia Airport is indicative of a level of vulnerability to terrorist activity which far exceeds the vulnerability of military controlled systems, vehicles and installations."

State of New York - Enclosure to Letter of May 17, 1976 - Comments 1a, 5 and 7

"The prior Mason/Leamer affidavits were submitted to:

a. Demonstrate that there is a substantial likelihood a higly motivated group of terrorists could be successful in destroying or seizing for destructive use special nuclear materials (SNM) in the course of commercial air transport, or related connecting transport, notwithstanding existing safeguard regulations and/or actual practice;

"5. The statement that 'adequate protection can be afforded at civilian airfields' (VII-12) is not supported by substantive discussion and misses the point that a military airfield has numerous advantages including inherent security, control of movement information, cleared, motivated and trained personnel, reaction capability, and location outside of highly populated areas.

"<u>Military Assisted Transportation Alternatives for Plutonium</u>

"7. The DES makes no reference whatever to the military surface transport alternatives for shipment of plutonium set forth in our Affidavit of 16 June 1975, pages 20 through 22."

<u>Staff Response</u> - Substantial increases have been made in the level of physical protection afforded to SNM in transit since the time referred to in the foregoing comments. Among other features described in the revised text, the current system of physical protection provides for a higher number of guards and the use of equipment with features of passive resistance to both theft and sabotage. Transfers of SNM from one mode to another now also require an increased complement of guards to be in attendance. (This is in addition to the greater participation of airport guards that is being provided as a result of heightened airport security awareness of the possibilities of hijacking and as required by FAA regulations.) As a consequence of the increased protection afforded to NRC-licensed shipments, the current level of protection for such shipments is considered to be adequate and comparably effective to that afforded to ERDA shipments.

The utilization of military forces and facilities as stated in the revised Chapter VII would be an unnecessary use of such forces.

<u>DES Chapter VII: 12</u>

<u>State of New York - Affidavit of Mason and Leamer of Nov. 30, 1975 - Comment 17</u>

"Although the entire affidavit thus far has addressed itself to enriched uranium transport, one comment regarding plutonium transport is worth making. A recent report by Ensign Dwight L. Gertz, USN, in <u>Terrorist Weapons and the Terrorist Threat</u>, 'U.S. Naval Institute Proceedings,' October, 1975, pp. 113, 114, confirms our conclusion expressed in our 16 June, 1975 affidavit that the terrorist motivation and threat to destroy aircraft is real and the weapons are readily available. In a recent instance, five Arabs rented an apartment in Ostia near Rome, 4 miles from Leonardo da Vinci Airport, directly underneath the North-South runway approach, and were only hours away from initiating a planned attack on a commercial airliner. They were equipped with two Russian made Grail missile launchers and a supply of missiles. In a second recent instance, when authorities were informed that terrorists in the Brussels area had been shipped Grail launchers, hundreds of troops were called out to cordon off airports in Brussels and

London. The Grail is combat proven and available to Soviet supplied nations and some 'neutral' countries. The missile is heat-seeking. The launcher is hand held and simple to use.

"In-transit dispersion of plutonium oxide in many instances would be both a highly effective terrorist act and one of far lesser difficulty than seizure and escape. Hence the threat becomes one of destruction of the aircraft in order to breech (sic) the plutonium oxide containers and disperse their contents."

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 (Referring to J. Edlow Affidivit of January 1976) - Comment 4

"4. In paragraph 6, of his affidavit, J. Edlow's reference to 'strategic' quantities of SNM misses the point. Apparently Edlow is referring to the fact that CFR Sec. 73.30 sets minimum requirements for NRC licensee shipments of certain amounts of SNM computed by formula, which include 5,000 grams or more of plutonium. This regulation fails to cover various significant dangers. For example, any amount of PuO, if used as a dispersant, could cause death and injury. Also, the psychological aspects of SNM seizure are almost equally as real whether the material is low or highly enriched, or in small or large quantities. Any amount of SNM in the hands of a terrorist group would be of great blackmail value and could certainly be used to their advantage. Finally, the factor of multiple thefts must be taken into consideration, with the possible stockpiling of seized SNM."

State of New York - Enclosure to Letter of May 17, 1976 - Comment 9

"9. On page VII-7, the DES admits that plutonium oxide can be used as a dispersant in weapon form or by dispersing plutonium in transit by bursting its container and that such use would have serious consequences. However, in Appendix F, page F-4, the consequences of using plutonium oxide are said to be uncertain and such use is said to be inconsistent with observed behavior of terrorists. Peter Skinner's affidavit of 2 May, 1975 indicates that the consequences of use of plutonium oxide as a dispersant are not uncertain. While it may be true that terrorists have not yet used poisonous agents, that does not mean that they will fail to use them in the future. Moreover, terrorists might find particular appeal in a radioactive poison, not only because of its greater psychological value (over more conventional poisons), but also because of its extermely long life, assured effectiveness and its particular macabre method of destroying human tissue."

Staff Response - As indicated in the expanded section of the FES dealing with plutonium hazards, sabotage of a plutonium shipment of less than a strategic quantity would not result in a catastrophe, and even if plutonium oxide were dispersed in the atmosphere, relatively minor consequences would be expected. Calculations by Cohen indicate that, in a city, a fatality rate of one cancer death per 15 grams of plutonium would be anticipated if dispersal occurred without warning, the cancer death associated with the event resulting 15 to 45 years after the event. A ten-fold reduction in the death rate could probably be effected if warning of the dispersal were given.

DES Chapter VII: 13

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1975 - Comment 16

"16. The Mitre report contains extensive corraboration of numerous points made by us in our current and previous affidavits e.g.:

Terrorists -- 54 pages directed to the history, tactics, capabilities, affiliations, motivations and recent activities of terrorists operating throughout the world. (Mitre Report, pp. 1-55)

Transport Industry -- 10 pages devoted to the extensive role of crime, corruption, employee colusion, and international influences in undermining industry services. (Mitre Report, pp. 55-64)

Weapons -- 6 pages citing types of weapons, their availability and recent employment by terrorists. (Mitre Report, pp. 65-70)

"Conclusions reached include 'terrorism has become commonplace in the Western World and weapons of large caliber and full-automatic fire can be easily procured,' and 'a veritable army of criminals and hoodlums in this country is waiting and willing to undertake any activity, including murder, if the profit justifies it.'"

Staff Response - The conclusions of the MITRE study are among several inputs to the NRC that are being evaluated and weighed in the continuing effort of determining whether to require an increase in the level of protection afforded to strategic quantities of SNM at facilities and in transit. Conclusions reached by firms under contract to the NRC should not be regarded as binding on the NRC.

DES Chapter VII: 14

State of New York - Enclosure to Law Letter of May 17, 1976 - Comments 12 and 13

"12. Plaintiff has demonstrated in three affidavits that the current requirements and practice regarding safeguards are inadequate to cope with the terrorist threat. The DES does not address itself in any meaningful way to the inadequacies previously specified by plaintiff. Indeed, the DES admits (VII-3) that 'present requirements are designed to protect against theft, diversion, or sabotage by one or two employees with access to the plant and material, by a small armed force attacking a plant or vehicle, or by both acting in combination.' '(S)mall force' is not defined in the DES. But, as to nuclear facilities, the Atomic Energy Commission ruled that licensees were only responsible for providing adequate security to repel not more than one or two individuals acting in concert (Nuclear Fuel Services, Inc. - UNC Docket #50-201, Atomic Safety Licensing Decision, November 29, 1974, p. 11). However, it is almost certain terrorists would employ 4, 5 or more persons. Moreover, the AEC ruled that licensees were not required to protect nuclear facilities against a well armed band of saboteurs whatever the size of the band; licensees need only concern themselves with 'an amateur group' (Id. p. 15).

"13. Given the purpose for which the safeguard requirements (10 CFR 73) were designed it is not surprising that the requirements and practice are grossly inadequate to cope with terrorism."

Staff Response - As the revised text of the FES points out, the significant improvements that have been made in the physical protection afforded to SNM in transit provide a system that can handle the postulated threat and that would not fail catastrophically under more violent attacks.

DES Chapter VII: 15

State of New York - Dept. of Environmental Conservation - Letter of Transmittal of Comments Dated June 3, 1976

"Therefore, the State of New York urges the Commission to consider the environmental impacts, and the alternative modes of transporting Plutonium and the security implications thereof separately from all other radioisotopes. Only in this way can the environmental consequences, benefits to society, and costs of alternative modes of transport and packaging requirements be adequately assessed."

Staff Response - The FES includes a discussion of theft and the consequences of sabotage involving shipments of plutonium.

DES Chapter VII: 16

State of New York - Enclosure to Letter of May 17, 1976 - Comment 11

"11. Plaintiff pointed out in the Mason/Leamer Affidavit of 20 January, 1976 that the provisions of 10 CFR 73 apply only to licensees shipping certain amounts of SNM computed by formula, which include 5,000 grams or more of U-235 enriched to 20 percent or more, or 2,000 grams or more of plutonium. Failure to subject smaller quantities to such regulations subjects the public to significant dangers specified in the above-mentioned Mason/Leamer Affidavit. The FES does not respond to this point."

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comment 14 (Partial)

"14. The requirements of Part 73 which may give the appearance of providing good security are grossly inadequate. Among the inadequacies are:

(1) shipments of less than 5,000 grams of SNM are not covered."

Staff Response - As pointed out in the revised text of the FES, the threshold for SNM in transit requiring physical protection measures relates to the prevention of an illegal nuclear explosive device. The quantities of plutonium at and below this threshold, even if dispersed in highly populated areas, would not result in catastrophic consequences.

DES Chapter VII: 17

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comments 7, 8, & 10

"7. In paragraph 11, Edlow's reference to the two principal additions to the regulations which 'prevents the possibility of loss or misrouting of SSNM while being transported,' i.e., 'continuous visual surveillance' and 'frequent communications,' again oversimplifies terrorist and related security problems. Adherence by shippers to these two requirements is intended to provide a degree of protection against misrouting and casual thefts but standing alone, it is inadequate protection against determined terrorist attacks and organized theft.

"8. Further, a report prepared for the NRC, released only in December, 1976 (MITRE Technical Report 7022, September, 1975, The Threat To Licensed Nuclear Facilities ('MITRE Report') para. 3.12.3, page 88) points out the inadequacy of current communications systems, 'One weakness in the operation of these private firms involves the communication system and the difficulties incurred during communication blackouts. Vehicles equipped only with a radio-telephone to handle communications to a base station are subject to periodic blackouts due to terrain and atmospheric conditions. Thus, to comply with a necessary two-hour check with headquarters (10 CFR Sec. 73.31) the driver must on occasion leave his vehicle and use a hand-line telephone. During these blackout periods and during the time the driver leaves his truck to use a telephone, the potential for a hijacking or theft is increased.'

"10. The MITRE Report confirms and augments the observations and conclusions stated in this and our earlier affidavits regarding the inadequacies of the requirements regarding visual surveillance and communications and armed guards, as outlined by NRC's 10 CFR Part 73, of April 1975."

Staff Response - A requirement for an escort vehicle with additional communication capability to accompany all road shipments of SNM was imposed by license condition in May 1976. Subsequent license conditions were issued in February 1977 to formalize security measures currently in use. These included an increase in guard strength and the use of an armored vehicle or equivalent as the transporter vehicle. These increases in physical protection requirements are reflected in the revised section of the FES.

DES Chapter VII: 18

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comments 14 (partial) and 15 (partial)

"(4) Communication requirements in terms of the frequency of communication in transit as well as the number and capability of communication channels is inadequate.

"b. So long as contact is not always possible with vehicles carrying high security material, the present communication system will contain weaknesses. Response capability suffers accordingly."

Staff Response - The May 1976 licensing actions by NRC have required additional radio communications capabilities to be provided for all SNM shipments. The February 1977 license conditions restricted road travel to major highways during daylight hours unless an additional (second) escort vehicle is also provided (Section 7.4.2).

DES Chapter VII: 19

State of New York - Enclosure to Letter of May 17, 1976 - Comment 17

"17. Plaintiff has previously demonstrated the wide dissemination of information regarding future SNM shipments (Affidavit of Peter Skinner, 2 May 1975) and emphasized the danger which this presents. The DES makes no response. Plaintiff has also pointed out the inadequacy of current communication systems used in commercial SNM transport. Again, the DES fails to respond."

Staff Response - The NRC does not believe the dissemination of SNM shipping information that is required by regulation represents danger to the transport of SNM. Response to the second point of the comment has been made elsewhere, and the text of the FES has been revised to reflect the current physical protection systems.

DES Chapter VII: 20

State of New York - Enclosure to Letter of May 17, 1976 - Comment 18

"18. The DES (VII-10) asserts that local law enforcement agencies located along a truck route would supply a secondary response. This is all well and good but for the fact that the regulations do not require communication equipment or frequency of contact which assures that such persons would be alerted when required. In connection with truck transport from airports to facilities, the DES (VII-11) states that convoys will have the additional protection of the facility's security force to act as a response capability, but fails to deal with the practical aspects involving distance, transport, communications, and on site responsibilities. The DES statement (VII-11) that 'airplane security personnel' would be present during airport SNM transfers in addition to the guards accompanying the truck is not supported by the regulations. The regulations do not provide for armed airplane security personnel."

Staff Response - The measures currently required for physical protection of SNM have been described in the FES and are referred to in response to several other comments. The NRC believes that these measures adequately protect against the postulated threat and ensure delay until local law agencies can respond in case of possible larger threats.

DES Chapter VII: 21

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comment 9

"9. Regarding Edlow's statements (Aff. paras, 12-14) concerning delivery by armored truck with armed guards, one should note that the MITRE Report, para. 3.12.4, page 69, points out:

'It should be noted that armed guards of an interstate shipment have no statutory authority to carry weapons in states other than the one in which they are licensed or across state lines, yet regulations require that they carry weapons in exercising their primary duty of protecting SNM in their custody. These guards are probably often in violation of both state and federal laws.'

"In other words, the fact that a guard is armed, and in an armored truck, is not necessarily a strong deterrent to terrorist or organized attack; the guard probably knows that he may be in violation of a state or federal statute or law, and, when faced with an armed attack situation, may simply not use the weaponry available for fear of legal, as well as physical, consequences to himself."

State of New York - Enclosure to Letter of May 17, 1976 - Comment 16

"16. Nevertheless, the DES (VII-6) makes the bold assertion:

'Licensee guards are expected at all times to (1) interpose themselves between SNM and any adversary attempting entry and (2) intercept anyone exiting with such material. A sufficient degree of force should be applied to counter that degree of force directed at them, including the use of deadly force. . . .' Considering the number of personnel and the weapons selection likely on both sides in a confrontation with terrorists, it would be tantamount to suicide for licensee guards to act in the manner suggested by defendant."

Staff Response - License conditions have made clear to licensees that guards are to be instructed to take appropriate action to thwart theft or sabotage of SNM. Guards are expected to "interpose themselves...and use force including deadly force if they have a reasonable belief their lives or that of another is threatened." The NRC expects guards to be trained in accordance with commitments contained in approved plans and expects the licensee to meet all requirements for the protection of SNM including the possession and use of weapons.

DES Chapter VII: 22

State of New York - Affidavit of Mason and Leamer of Jan. 20, 1976 - Comment 14 (partial) and 15 (partial)

"(2) Though plans for selecting, qualifying and training guards as well as for specially-designed trucks are called for, neither minimum standards or implementation dates are specified:

"(3) The number of guards provided for and their arming is minimal:

"15. The Mitre report states: (para. 3.12.5, pp. 89-90)

'a. A wide dispartiy (sic) presently exists in the various screening techniques used in selecting guard personnel and in the training they receive.'"

State of New York - Enclosure to Letter of May 17, 1976 - Comments 14 and 15

"14. The DES fails to respond to plaintiff's previously specified criticisms of various aspects associated with the use of private guards: inadequate training, lack of security clearances, low pay, and lack of military type motivation. When the DES discusses the number of guards employed it is misleading. At one point (VII-10), it states that in truck transport 'the number of guards would be varied to suit the particular shipment and preceived (sic) threat,' the regulations do not require this. At another point (VII-4), the DES states that when cargo aircraft are used, enroute transfers must be observed by more than one armed person; the regulations do not necessarily so require.

"15. Plaintiff has previously pointed out that the weapons and vehicles employed by private guards are inadequate for coping with the terrorist threat. The DES offers no meaningful response."

Staff Response - Regulatory Guide 5.20 was published in April 1974 to provide guidance to the industry on selection and training of guards. This guide is also used by the NRC staff in evaluating the adequacy of guards. Specific additional training requirements for guards escorting shipments of SNM were added in May of 1976. License conditions were issued in February 1977 to formalize security measures currently being employed. These included an increase in the minimum number of guards required and the use of armored vehicles or equivalent as transporters."

DES Chapter VII: 23

State of New York - Affidavit of Captain James A. Echols (ALPA) of November 28, 1975 - Comment 3

"3. Critical to the safety of commercial air transport of SNM is the severely inadequate security within the air cargo industry. Presently, regardless of cargo, multi-million dollar aircraft and pilots are subject to selection at any time as a 'target of opportunity' by sky-jackers, extortionists, terrorists or saboteurs. We received a clear lesson as to the very real terrorist threat as 3 Boeing 747's burned to ashes on a patch of Jordanian desert while crew and passengers were held hostage under the muzzles of terrorist sub-machine guns. We have seen as well:

-mid air sabotage
-grenade attacks on land
-attacks on terminals
-abductions
-diversions
-over 370 global acts of terror
-endangering 16,000 people.

"As I have stated, the lesson is clear, SNM must be removed from commercial air transport."

Staff Response - The commenter's affidavit reflects concerns predating the increased airport security measures required by FAA that have reduced hoaxes, threats, attempts, and diversions of passenger aircraft within the USA. It also does not take account of security measures required by NRC for SNM shipments that have been instituted in the interim and are reflected in the FES.

DES Chapter VII: 24

State of New York Letter of May 17, 1976 - Comment 4

"The DES safeguards discussion bases portions of its analysis on the as yet incomplete and unreleased analysis of safeguards in the Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in LWR's. WASH 1327 ('GESMO'). General references to uncompleted studies in other proceedings render the DES legally inadequate.

Staff Response - The safeguards discussion in the FES Chapter 7 is based on current efforts related to the overall level and quality of protection accorded the nuclear industry as a whole. The analysis and subsequent conclusions presented therein are not dependent in any way on the outcome of any uncompleted studies or decisions stemming from the NRC review of safeguards related to the wide-scale use of plutonium mixed oxide fuels (GESMO deliberations).

DES Chapter VII: 25

ERDA - Comment 58

"Page VII-1, Third Paragraph

"This paragraph indicates, according to the text, that nuclear material is subject to security procedures and safeguards intended to preclude the diversion or theft of nuclear material or sabotage of the nuclear facilities in which it is handled.

"This statement in regard to the safeguarding of strategic quantities and types of special nuclear material is misleading and should be revised. There is no option to safeguard special nuclear material in this category. NRC regulations prescribe the safeguarding both at fixed facilities and in transit. Additionally, safeguards and security procedures are not limited to "strategic quantities" but to all special nuclear material.

"That part of the paragraph which speaks to radioisotopes, such as cobalt-60 should be eliminated. There are no security and safeguards features in the context within which they are discussed, i.e., to preclude diversion or theft or sabotage, applicable to the handling of radioisotopes by NRC. Mentioning cobalt-60 raises numerous related questions regarding other hazardous radioactive materials not subject to NRC safeguards and security type control (e.g., radium)."

Staff Response - This section of the FES has been substantially revised to more clearly state the potentials of misuse of the various categories of radioactive materials. The revision describes those measures currently in effect that limit the hazards from misuse of cobalt-60. It also more clearly describes the basis for providing physical protection to special nuclear material.

DES Chapter VII: 26

ERDA - Comments 59-61

"59. Page VII-2 B(2) and (3)

"Meaning of 'Contractors' unclear. Contractors to NRC, U.S. Government, nuclear industry or what?

"60. Page VII-5, Second Paragraph

"The meaning of "supporting safeguards security systems" requires clarification.

"61. Page VII-8, Third Paragraph

"We see no reason to specify 'escort guards' but would refer to 'guards' without the qualification since it is unlikely that guards would be used solely for escort purposes. The same sentence apparently intends to refer to 'the transportation mode' rather than 'the transporation model.'"

Staff Response - The ambiguities and typing errors cited in the above comments have been resolved in the FES.

DES Chapter VII: 27

State of New York - Enclosure to Letter of May 17, 1976 - Comment 8

"8. In our Affidavit of 16 June 1975, pages 14-16, we cite a number of authorities in support of the following propositions:

a. That the information necessary for the design of a nuclear device is publicly available; and

b. That a technically competent group of terrorists could fabricate an effective, even if crude, nuclear device notwithstanding the fact that it had no prior experience in fabricating such a device.

"Notwithstanding some discussion regarding the benefits of prior experience in the fabrication of such a device, the DES admits that persons without such experience could produce a device with a low tonnage yield, apparently a yield of one kiloton or less, or even a device with a substantial yield (F 1-3). Moreover, the DES admits that 'the potential consequences arising from any nuclear explosive are so serious as to warrant the utmost vigilance, however low the probabilities may be.' (F-2). The DES places great emphasis on the supposed difficulty of 'emplacement' of a nuclear device because law enforcement agencies would be watchful (p. F-4). However, this is not very comforting when one considers the almost infinite opportunities for emplacement in a large city."

Staff Response - Primary reliance against the possibility of a terrorist group acquiring a nuclear explosive device is placed on denying the acquisition of SNM not on any technical difficulties in fabricating such a device. (Appendix F of the DES has been deleted.)

DES Chapter VII: 28

Enclosure to New York State Department of Law Letter dated May 17, 1976 - Comment 10

"10. The DES makes a significant admission regarding the NRC's overall policy on safeguards. The DES states (VII-2) that while safeguards must be capable of preventing acts which could result in a 'major civil disaster,' safeguards need only provide a 'high degree of protection' against acts that could result in 'serious civil damage.' No justification or analysis is presented to support such a policy and no definitions are provided for any of the salient concepts employed. One would think that, given the immense danger posed to the public by terrorist use of SNM, safeguards should be capable of preventing any such use."

Staff Response - This section of the FES has been revised to accurately describe the NRC responsibilities.

DES Chapter VII: 29

State of New York - Enclosure to Letter of May 17, 1976 - Comment 20

"20. The statement in the DES that hardware and techniques are currently available to allow an effective recovery effort is inexplicable in light of the admission that recovery cannot be relied upon as the strong link in the security system (VII-9)."

Staff Response - The recovery aspect of the national capability, which relies to a considerable extent on the expertise and organization structure developed to protect ERDA/DOD weapons programs, involves coordinated action by many Government agencies. Should nuclear materials be stolen or diverted, the national system would use the collective resources of the various departments and agencies involved in nuclear safeguards, including the FBI, ERDA, DOD, USCG, the intelligence community, and local law enforcement agencies (LLEA).

DES Chapter VII: 30

State of New York - Enclosure to Letter of May 17, 1976 - Comment 21

"21. With regard to monitoring and inspection of safeguard systems, the statements in the DES (VII-5) appear to be wishful thinking. Not even the DES claims this monitoring and inspection of SNM transport actually occurs."

Staff Response - The NRC inspects for compliance with physical security requirements all imports and exports of SNM shipped under the provisions of 10 CFR Part 73. These currently comprise approximately 90% of all such SNM shipments. Domestic road shipments are periodically inspected while in route.

DES Chapter VII: 31

State of New York - Enclosure to Letter of May 17, 1976 - Comment 22

"22. The fact that the DES fails to respond to the plaintiff's previous affidavits is not surprising when one notes that the DES admits that an 'in depth analysis of safeguards' is currently being undertaken (VII-9) and that studies are being completed to determine 'the cost and effectiveness of alternative systems' to safeguard SNM (VII-15). Thus, at this late date, NRC admits that it has not yet analyzed and studied the safeguards issue involved in the air related connecting transport."

Staff Response - Chapter 7 of the FES has been substantially revised. The analysis of safeguards for transporting SNM indicates to the NRC staff that the current measures for control of radioactive material in transit (including physical protection for certain quantities of SNM) are adequate. (See response to DES Chapter VII: 24.)

DES Chapter VII: 32

City of New York - Comment 8

"Scenarios involving sabatage (sic) or diversion of spent fuel or fissionable materials by terrorists or criminal elements are mentioned tangentially but are incompletely evaluated."

Staff Response - The section of the FES dealing with the potential for misuse for the various classes of radioactive materials has been expanded.

Dr. K. Z. Morgan - Comment 4

"There seem to be large discrepancies between this table and the values given in the GESMO report, WASH-1327, which I reviewed earlier. These discrepancies are shown below:

Radionuclide	% by weight in Table B-1	% by weight in WASH-1327	Ci calculated WASH-1327	g in WASH-1327
Pu-238	1.9	3.49	3.47×10^5	0.20×10^5
Pu-239	63.0	43.63	5.30×10^3	2.50×10^5
Pu-240	19.0	26.00	3.37×10^4	1.49×10^5
Pu-241	12.0	15.65	1.00×10^7	0.90×10^5
Pu-242	3.8	11.21	239	0.64×10^5
Am-241	0.6		2.52×10^4	7.78×10^3
Am-243			6.78×10^3	3.66×10^4
Cm-244			1.70×10^6	2.04×10^4

"When each new NRC report uses a new set of assumptions about the SGR-GESMO-120 day spent fuel inventories, how can we be expected to believe any of the numbers or evaluate the data? Which NRC report are we to believe?

"I have added also my calculations of Curies using the WASH-1327 data. Here we note that most of the risk is not from ^{239}Pu but from ^{238}Pu, ^{241}Pu, ^{244}Cm and ^{241}Am. Also, I have shown (HPJ 10, 151, 1964) that ^{238}Pu is 150 times more hazardous (Curie-for-Curie) than ^{239}Pu, ^{241}Pu is 3 times more hazardous, ^{244}Cm is 32 times more hazardous, and ^{241}Am is 16 times more hazardous. In addition, this 2.04×10^4 g of ^{244}Cm comprises 2.2 Ci of neutrons for which extra precautions must be taken."

Staff Response - The percent-by-weight values were taken from column 1, Table IV D-4, of Volume III of WASH-1327 (GESMO). Values closely approximating those suggested by Dr. Morgan also appear in that table in column 3. In using the values from that column, Dr. Morgan has made the tacit assumption of equilibrium plutonium recycle. Since the DES evaluated 1975 and 1985 only, the assumption of high-burnup LWR fuel is far more accurate and certainly doesn't represent a "new set of assumptions."

The risk comparison cited by Dr. Morgan (HPJ 10, 151, 1964) is a relative risk comparison ostensibly discussing the risk to laboratory or engineering process line personnel exposed to releases of material. It defines hazard by H = specific activity/MPC. This is an occupational analysis and is not suitable for application to an atmospheric release of material. The relative hazard of all isotopes shown to be present in plutonium obtained from high burnup versus LWR fuel was taken into account in the DES. However, note that Table IV D-10 of GESMO does not show any curium isotopes although Dr. Morgan lists a significant amount.

DES Appendix B: 2

ERDA - Comment 69a

"Clearance half-time of 150-200 on page B-7 omitted units."

EPA - Comment 19

"The clearance time for soluble plutonium needs to have units added to it."

Staff Response - Units have been added.

DES Appendix B: 3

EPA - Comment 146

"The movement of particles captured in the mucoid lining is properly termed transported not sloughed."

Staff Response - The phraseology has been changed.

DES Appendix B: 4

ERDA - Comment 62

"A portion of material deposited in the tracheobronchial region may also pass directly to blood, depending on initial solubility. The term 'reticuloendothelial cells of the alveoli' is ambiguous; it is not clear whether this refers to fixed or mobile pulmonary macrophages."

Staff Response - The suggested addition has been made. Both types of pulmonary macrophages are involved in the phagocytosis process. The sentence will be changed to read "...in the alveolar region." to attempt to clarify this distinction.

DES Appendix B: 5

ERDA - Comment 63

"'Soluble plutonium' is a thoroughly non-specific term. Translocation half-times and fractions can vary several-fold depending on inhaled particle size, specific chemical form, and isotopes of plutonium. Use of the narrow range '150-200' is misleading and may be dangerous in risk estimates; the unit of time is not even given."

Staff Response - The discussion concerns plutonium in soluble chemical form that has already reached the pulmonary region. Material of this sort does translocate with the stated half-time.

DES Appendix B: 6

ERDA - Comment 64

"This figure is taken directly from publications by J. F. Park and W. J. Bair at Battelle Pacific Northwest Laboratories; reference and credit should be given.

Staff Response - The reference cited (Reference 7) was the source for the figure.

DES Appendix B: 7

ERDA - Comment 65

"This discussion is not complete; the lethal biological effect of progressive pulmonary fibrosis leading to death by respiratory insufficiency is not even mentioned. We suggest that this section be expanded."

Staff Response - This paragraph is not intended to deal with biological effects to specific organs. The discussion of effects of acute pulmonary exposure is given in Section E.3 of Appendix B (FES Appendix C, Section C.5.4).

DES Appendix B: 8

State of New York - Dr. John Gofman - Comment 4

"On page B-10, the DES states, 'Cancers have been induced in laboratory animals, although no cancers attributable to plutonium have been observed in humans.' This statement is not only meaningless, it is dangerous. What the DES should state is, 'No meaningful study has been undertaken to determine how many lung cancer fatalities have been caused by plutonium handling.' For the population-at-large, the best estimate currently available is that plutonium fallout has condemned 1 million persons in the Northern Hemisphere to lung cancer deaths. (Gofman, (3).)"

EPA - Comment 14d

"In the cited case of the Los Alamos personnel, the draft statement indicates that '. . . none of these people has shown any evidence of radiation injury.' It seems this statement is probably too broad and could be optimistic. We doubt that all possible indicators have been checked and even if they have it is quite unlikely that there has been no radiation damage. This statement, if taken literally, would indicate that the NRC has adopted a threshold model for radiation effects. If this is true, the decision should be documented."

Staff Response - Dr. Gofman's implication that the continuing studies of Manhattan Project workers, Rocky Flats workers, etc., are meaningless is questionable. These studies include chest counts, urinalysis, and autopsy information and have been carried out by LASL, PNL, and other respected scientific organizations. The "best estimate of 1 million condemned people" is based on Dr. Gofman's own unconfirmed analysis. Healy et al. (Ref. C-28, Appendix C) have examined Dr. Gofman's plutonium lung cancer estimates in detail and concluded that "Gofman's speculations require the arbitrary acceptance of too many numerical parameters and unconfirmed mechanisms to be acceptable as even an approximate numerical estimate of potential lung carcinogenesis by plutonium." Several other reputable studies have also rejected Dr. Gofman's analysis (see Appendix C, Section C.6).

The assertion that the statement in paragraph 3 represents a threshold model is invalid. The statement is made that no one has shown any evidence of radiation injury, not that radiation injury at those body burdens is impossible. The conclusion drawn is that current data does not support some of the claims of excessive plutonium toxicity.

DES Appendix B: 9

EPA - Comment 14c

"On page B-10, to prevent confusion, a beta particle is not an ion and it is confusing to describe its nature as ionic, its nature is more properly termed that of a charged particle; also, beta particles can travel much further than a few microns in body tissue, in fact into the centimeter range."

Staff Response - The nature and range of beta particles has been clarified.

DES Appendix B: 10

ERDA - Comment 66

"Terms 'high,' 'low,' 'lower,' and 'relatively' should be given values or ranges; 'relatively high body burdens (.00007 to .09 microcuries)' spans 3 orders of magnitude. We suggest that '.00007 to .09 microcuries' be changed to '0.005 to 0.420 microcuries.' (Reference - WASH-1320, page 25)."

Staff Response - The suggested change has been made.

DES Appendix B: 11

EPA - Comment 14e

"In section E.3, first, there are no references cited for the information given; second, there are apparently symbols missing from the amounts of plutonium cited, 0.5 curies Pu-239/gram of lung is the same as 8.2 grams Pu-239/gram of lung."

Staff Response - The references are now cited and the curie values have been corrected to read microcuries.

DES Appendix B: 12

Dr. K. Z. Morgan - Comment 12

"Although the dose to the pulmonary lymph nodes is 100 or more times that to other lung tissue, this dose is ignored in the risk evaluations. I realize the ICRP has depreciated this risk because the ERDA studies of Thompson et al at BNW have failed to produce cancers in this part of the reticulo endothelial system in animal studies. However, I am uneasy in applying these data to man who lives 70 years instead of 20 years (dog's life span) and Thompson has in fact observed some malignancies in tissues adjacent to the lymphatic tissue which may suggest that blood vessels leading into these organs or tissue just beyond the α-particle complete kill within the lymph nodes may be the tissue at greatest risk in the case of man."

Staff Response - The question of lymphatic cancer is addressed in DES Appendix B (FES Appendix C). A qualifying statement has been added to indicate that dog and rodent experiments are not completely conclusive with regard to lymphatic cancers. As Dr. Morgan points out, however, the ICRP does not consider the lymph system to be a potential cancer site.

DES Appendix B: 13

ERDA - Comment 67

"It should be pointed out that 'increases in urinary excretion in some cases by orders of magnitude' may represent only a decrease of a few percent in long-term lung burden of insoluble plutonium."

Staff Response - This paragraph has been modified to specify that DTPA therapy is only effective in mitigation of exposure to soluble plutonium.

DES Appendix B: 14

EPA - Comment 14f

"The discussion in section F on chelating agents does not mention any side-effects on their use; e.g., possible deposition in other organs, rather than excretion, which could create worse problems."

Staff Response - "Advances in Radiation Biology" (Vol. 4) suggests that DTPA is very effective at reducing the overall body burden of systemic soluble plutonium. It states that the use of that material appears to reduce the concentration in liver and bone by causing the plutonium complexes to mobilize to extracellular fluid from which urinary excretion is likely. This does not appear to imply that redeposition in other organs is likely.

DES Appendix B: 15

EPA - Comment 14g

"And, finally, the comparisons given on p. B-12 are too simplistic. Nowhere is it stated that the effect of these materials depend on innumerable factors, e.g., exposure time, time between intake and effect, condition of the victim, and how the material acts in a biologic system. This should be corrected in the final statement."

FEA - Comment 2

"On page B-12, the median lethal dose of plutonium is compared with the lethal dose of other toxic materials. We suggest that this paragraph also point out that the projected death from the referenced dose of plutonium would result from cancer at some undetermined time after a latent period of approximately 15 years, but that death from the other toxins would occur within a short period of time."

ERDA - Comment 68

"We suggest that NRC staff may wish to reference Dr. J. N. Stannard's paper 'Plutonium Toxicology and Other Toxicology' in The Health Effects of Plutonium and Radium (Jee, W. S. S., ed.). J. W. Press, Salt Lake City, Utah (1976) pp. 363-372 rather than the B. L. Cohen reference. ERDA staff feels the suggested reference to be more current."

Staff Response - The toxicity section has been rewritten using Stannard's information. Both acute effects and carcinogenesis are included. The factors mentioned in the EPA comment have also been included.

DES Appendix B: 16

State of New York - Dr. John Gofman - Comment 3

"In Appendix B, page B-12 the DES refers to '...the median lethal dose of plutonium as 260 micrograms.' This statement is not only meaningless, it is grossly erroneous. The dose that guarantees a lung cancer fatality is 0.058 micrograms of Pu^{239} for cigarette smokers and it is 7.3 micrograms for non-smokers. Thus, for cigarette smokers, a dose 4483 times smaller than the DES will kill all humans, whereas the DES estimates their dose will kill 1/2 those exposed. Thus the DES is much more than 4483 times too low on plutonium toxicity. For non-smokers the amount required to guarantee fatality is 35.6 times lower than the dose DES calculates will only kill one half the exposed. Unless the Nuclear Regulatory Commission learns something of the true toxicity of plutonium, it is likely to continue to make such absurd statements as that on page B-12 that 'Although plutonium is certainly a potentially dangerous material, it is not orders of magnitude more potent than numerous other existing materials.'"

Staff Response - The values of 0.058 and 7.3 micrograms are based on Dr. Gofman's own unconfirmed analysis. Healy et al. (Ref. C-28, Appendix C) have examined Dr. Gofman's plutonium lung cancer estimates in detail and concluded that "Gofman's speculations require the arbitrary acceptance of too many numerical parameters and unconfirmed mechanisms to be acceptable as even an approximate numerical estimate of potential lung carcinogenesis by plutonium." Several other reputable studies have also rejected Dr. Gofman's analysis (see Appendix C, Section C.6).

DES Appendix B: 17

EPA - Comment 14a

"The list of references should be more specific where appropriate when only one part of a book or one article in a collection is used. Other references need to give more information to be complete, such as numbers 5 and 12."

Staff Response - The list of references has been corrected.

DES Appendix C: 1

ERDA - Comment 29a

"Appendix C does not provide a deciphering code."

EPA - Comment 15

"The listing of incidents as presented is hard to follow since there are neither dates indicating when incidents occurred nor meanings of the abbreviations used. Such data needs to be included in the final statement."

City of New York - Comment 7

"The discussion of reported incidents involving transportation of nuclear materials is grossly inadequate. Appendix C, does not even contain an explanation of its codes. Nor is there any discussion of possible unreported incidents. Based on the DES's own figures, incidents in 1975 may well have doubled those reported in the four-year period 1971-1974 (IV-38), yet the risk assessment, which used the number of shipments projected for 1985 apparently relied on 1974 accident data."

Staff Response - The use of the information in Appendix C has apparently been misinterpreted: (1) No effort was made to project the effect of abnormal transport occurrences to 1975. (2) The listing of incidents in Appendix C includes incidents from the first 3-1/2 months of 1975. (3) It would be speculative at best to attempt to assess unreported incidents. The FES includes an explanatory section to accompany the data in Appendix C (FES Appendix F).

DES Appendix G: 1

State of New York - Dr. Marvin Resnikoff - Comment 24

"The sensitivity analysis presented in Appendix G of the DES covers a number of factors which can be varied for an examination of the range of effects on calculated impact. The 'theoretical basis' for this analysis is in equation (2). $\Delta I = dI/dX \Delta X$. This is an elaborate way of saying that, if the dependent variable (X) is changed by a certain amount (ΔX), ΔI will change on the basis of dI/dX. For the few variables analysed in this manner, none of the dI/dX components are presented and the methods and assumptions utilized to get them are missing as well."

Staff Response - The ΔI values are shown for a fixed variation of 10 percent in all X parameters that were analyzed. The text has been revised to clarify the computational method.

DES Appendix G: 2

State of New York - Dr. Marvin Resnikoff - Comment 26

"Assuming a linear dI/dX term, the 5.1% increase in baseline value (Figure G-2) would be increased by a factor of some 204%. Therefore LCF numbers would be doubled due to the four times greater density of population in the region at risk. The sensitivity of this parameter in the DES is contradicted by an uncontested affidavit filed by the State in its case against the NRC (Skinner and Wang, sworn to June 13, 1975). The affidavit shows that a 400% increase in population density would occasion a 400% increase in lung cancer fatalities (see Tables 1-9). The analysis of Annual Early Fatality Probability increases (DES Figure G-3) does not consider population density in such a way as to be meaningful in terms of figure V-13."

Staff Response - As discussed earlier, New York City is not a "representative" urban area because of its abnormally high population density. A 400 percent change in any parameter is not appropriate to a sensitivity analysis. Consideration of much higher population densities is included in the Final Environmental Statement.

DES Appendix G: 3

State of New York - Dr. Marvin Resnikoff - Comment 27

"This section in the DES on sensitivity analysis is totally inadequate, having failed to analyze those variables we have discussed herein and having further failed to consider other variables essential to a valid final impact assessment (e.g., shipments by barge, putting plutonium in 'bulk' form)."

Staff Response - Barge shipments are now discussed in FES Chapter 6, and "form" restrictions for plutonium were considered even in the DES, but not in the sensitivity analysis section. The number of parameters covered by the sensitivity analysis has been expanded in the FES.

8.5 DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT FINAL ENVIRONMENTAL STATEMENT DATED FEBRUARY 1977

Dr. Karl Z. Morgan, ACRS Consultant

Comment 1

"My general impression of NUREG-0170 is that it is not an attempt to assess the effects on health and the risks of surreptitious diversion of fissile or radioactive materials during shipping, but rather an attempt to prove the effects on health and the risk of surreptitious diversion are completely negligible. Sometimes there is only a shade of difference in these two styles of writing, but the effect of one is concurrence and acceptance of the public and the result of the other is a challenge to the public to show the NRC is wrong. The job of the NRC would be easier if the public were made to believe NRC was simply stating the true facts and explaining their meaning. Nuclear energy could sell itself better sometimes without the aid of a salesman."

Staff Response - The assessments made on NUREG-0170 were performed in an objective manner. There was neither prejudging of the situation nor influencing of the results toward any particular conclusions.

Comment 2

"I do not believe this report treats adequately the long term problems of wide spread contamination of a city by plutonium and transplutonium following a major shipping accident. In Rocky Flats, Colorado, we have many square miles contaminated with plutonium above the 2.2 dpm level and this contaminated desert land is resulting in serious immediate and long-term problems. Not many persons would care to live in a building or make their home in a city that is badly contaminated with plutonium."

Staff Response - Decontamination costs attributable to transportation accidents are covered in Section 5.5 of NUREG-0170. Long-term effects on cities will be examined in the "Generic Environmental Impact Statement on Transportation of Radionuclides in Urban Environs" now being prepared by the NRC staff.

Comment 3

"I think a poor case is made for shipping plutonium and transplutonium material by air."

Staff Response - This Environmental Statement makes no attempt to promote any type or mode of shipping radioactive material. It presents facts about the current situation as it already exists.

Comment 4

"The cost comparisons for shipment via air, truck, train and barge are biased because of transhipments at each end. What would be the cost (in man-rem) were barge or train terminals located at all nuclear facilities? In a proper comparison, I believe the man-rem cost by rail would be about 1/10 that by truck and the cost by barge would be about 1/100 that by truck."

Staff Response - The person-rem costs of rail, truck, and barge shipments are already quite small. A detailed analysis of alternative transportation modes is not justified by the small total dose.

Comment 5

"I would like to see the estimated saving in costs (in man-rem) were we to completely change our future nuclear power program and do the following:

a. Discontinue the LMFBR program for the present.
b. Establish large reactor parks over suitable bedded salt formations such that:
   1) High level waste would not have to be shipped
   2) Build converter (Pu ^{232}Th + ^{233}U) reactors at the parks
   3) Denature the ^{233}U with ^{238}U when it is shipped outside the park to reduce the risk of hijacking and diversion.
   4) Have proper isolation of these parks
   5) Several studies at Georgia Tech suggest Th-breeders are possible which would have a negative void coefficient in the coolant, and would have a doubling time much less than that of the LMFBR.
   6) Pu and trans-Pu elements would not be produced
   7) The problems of ^{232}U and ^{234}U production in the Th cycle are minor compared with the Pu problems.
   8) Of course, the parks would have fuel reprocessing and fabrication plants as well as power reactors (convertors and breeders)."

Staff Response - The suggested alternatives listed go far beyond the intended scope of this Environmental Statement. It is not possible to evaluate them within the constraints of the Statement.

Comment 6

"I think NUREG-0170 should have given more attention to the recommendation of the Special Panel to Study Transportation of Nuclear Materials and its report to the JCAE of Congress (December 17, 1974)."

Staff Response - All recommendations have been given the attention considered appropriate to the intent and scope of NUREG-0170.

Comment 7

"It was indicated by Mr. Hoppins (sic) in answer to my question that some of the shipping containers that were improperly designed and approved by the AEC (now NRC) are still in use under the grandfather clause. This presumably includes the C-10 industrial source shipping container which occasioned the serious accident into Atlanta in which I became involved a few years ago. It was indicated that NRC places reliance on administrative control rather than upon safe design in these cases. I think this is a very serious situation because unless the operator is careful about what he is doing, the source will be pushed outside the C-10 shipping container where no shielding protection is provided. I think NRC must share responsibility for any accidents that result during the term of the grandfather clause because it (or the AEC) is responsible for this ridiculous design in the first place."

Staff Response - In the case of the container mentioned (C-10 container), the NRC has required it to be redesigned. The new design makes it impossible to misplace the source in the shield. In general, the Department of Transportation is phasing out the "grandfather clause" authority for using existing shipping packages.

H. M. Parker, ACRS Consultant

Comment 1

"I understand that it [the Environmental Statement] started in support of proposed rule-making concerning air transportation of radioactive materials (Federal Register June 2, 1975). Such a study would have considered alternatives to air transport but only for such packages as a reasonable person would have contemplated sending by air as one option. That vital distinction has not been observed so that one immediately becomes involved with the whole gamut of transportation scenarios."

Staff Response - The scope of this study as originally presented in the Federal Register (June 2, 1975) dealt only with air transportation. Subsequently the scope was expanded to include all modes of transport, referencing those environmental studies that had already been carried out. These studies include the "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, WASH-1238," and the "Assessment of the Environmental Impact of the FAA Proposed Rulemaking Affecting the Conditions of Transport of Radioactive Materials on Aircraft (Draft)" sponsored by the Federal Aviation Administration. The scope was broadened in response to public interest in the entire area of transporting radioactive material. This study does investigate alternatives to air transportation of radioactive material. Using data from a survey of shippers, it looks at the effect of shipping by land or sea those packages actually shipped by air. These alternatives are discussed in Sections 6.2.1, 6.2.2, and 6.2.3.

Comment 2

"They [shipment models] are so different from the earlier NUREG-0034 versions in number and activity that one wonders whether a third look would bear any resemblance to either -0034 or -0170 tallies."

Staff Response - The standard shipment model used in NUREG-0034 was based on limited data from interviews with the shipping industry, while the NUREG-0170 model is based on a comprehensive shippers survey conducted for the NRC.

Comment 3

"They [shipment models] contain packages whose 'hazard properties' are polar extremes."

Staff Response - Packages with very different hazards have been included in the analyses because they are the packages actually shipped. Differences in the degree of hazard have been considered in the analyses.

Comment 4

"In NUREG-0170 the so-called alternatives group all these classes together so that real differences between modes tend to cancel each other out."

Staff Response - Some of the differences do tend to cancel each other, but the study shows that the contribution from individual nuclides to the overall risk is too small to justify an individual analysis for each.

Comment 5

"The quoted differences in health effects for the various scenarios, are in my opinion below the uncertainty level of any of the calculations of risk and cost-effectiveness."

Staff Response - It is true that the health effects for the various scenarios differ by amounts less than the total uncertainty. However, other factors taken into account in assessing cost-effectiveness (shipping costs, for example) in some cases differ enough to establish whether or not the alternative is cost effective.

Comment 6

"I, for one, believe that air shipments should be limited to cases where speed is of the essence*--in practice, to the radiopharmaceutical case, where the public does accept a compensating social benefit. If that analysis had been made separately it would at once have been clear that innovative alternatives have not been included... one should make the alternatives for each generic type of shipment--not for all taken together."

Staff Response - Section 6.2.4 examines the effect of transporting all high-hazard dispersible material by land. All the remaining radionuclides shipped by air would then be less hazardous materials, mostly radiopharmaceuticals. Further detailed examination did not appear to be justified by the level of impact. In addition, the restrictions on shipments by air imposed by the Congress in the Transportation Safety Act of 1974 limited the available alternatives.

Comment 7

"Table IV-19 (p. IV-55) displays an annual individual dose to an airline passenger of 108 mrem... In view of the NRC's efforts to get reactor fencepost doses down to the range of 10 mrem/yr, casual acceptance of 108 mrem/yr for an unsuspecting passenger is incredible Surely the ALARA principle calls for reduction by about one order of magnitude."

Staff Response - This 108 mrem/yr figure, about the same as the natural background dose, was calculated as the maximum credible dose to any individual. It is not an expected dose to any real group of passengers. A more realistic figure is the 0.34 mrem calculated as the average annual dose to airline passengers from radioactive material shipments. An average dose of this size does not justify relocating radiopharmaceutical facilities, adding shielding, or radically changing the distribution system. Implementing the ALARA principle requires detailed consideration of such factors as economic and social impacts. We do not feel such a detailed study is justified by the small average exposure or by the estimated maximum dose.

Comment 8

"As examples, let it be assumed that estimated doses from air shipments are too high. Then, at the source of the transportation web, one must analyze the merits of radiopharmaceutical preparation at more and better chosen locations. Upon loading on planes, one must consider packaging with one thick shielding face under the passengers instead of conventional equal shielding on all sides.

"At the natural terminals, usually large cities with clustered hospitals, one must examine the possibility of underground tube delivery, and so on."

Staff Response - The small impact from transporting radiopharmaceuticals does not justify the effort necessary to investigate redesigning the distribution system.

Comment 9

"Genetic effects are excluded on the grounds of scarcity of information. Curiously, this is one area in which there is essential agreement on a dose and dose-rate effect. There is no real way to add genetic effects and cancer fatalities on a common scale, but some arbitrary allowance has to be shown."

Staff Response - Genetic effects are now quantitatively considered in NUREG-0170.

Comment 10

"There is much more scarcity of information on the somatic side than is reflected by an LCF Index of 121.6 per 10^6 person-rem. The implied precision for a number that may be 12 (or even zero) on the one side or perhaps 600 on the other side is entirely out of place."

Staff Response - The 121.6 figure, although perhaps overly precise, is the value implied by the "Reactor Safety Study" (WASH-1400).

Comment 11

"The best efforts of NRC to set dollar indices such as $1000 per person rem, or $8 million per LCF simply cannot be accepted."

Staff Response - The $1000 per person-rem figure is one established by United States Government agencies and reflects the best available data. The figure of $8 million per LCF is derived from the $1000 per person-rem figure and the 121.6 LCFs per 10^6 rem figure discussed in FES Section 3.7.

Comment 12

"Some of the basic dosimetry equations need better support. Even the point source formulation

$$\frac{Ke^{-\mu D}B(D)}{D^2}$$

where μ is some formal absorption coefficient and B(d) is a Berger build-up factor is arbitrary. The relevant absorption factor is rarely well known and the build-up factor is both empirical and terrain-variable. What is known is the total energy emitted from any well described source. Then, the integration of energy absorption over all space would demonstrate the appropriateness of the combinations of μ and B(d) used.

"In the integration of dose at a point from a source moving uniformly in a straight line, we have mathematically the same issue as dose at a point from a uniform line source, the familiar Sievert equations published in Acta Radiologica in 1928. Formal demonstration of this equivalence would have improved confidence in the result.

"In the second stage of double integration as in Fig. D-2 of p. D-4, the same result should be obtained by integrating the dose from an infinite disc of radioactive material (also a familiar Sievert equation) as the receptor moves uniformly across a diameter."

Staff Response - Although we did not recalculate the dosage results using the Sievert equations or energy considerations, we have established that the methods suggested by this comment do support the results of this study. A summary of the NRC staff calculations is available in the NRC Public Document Room in Washington, D.C.

Environmentalists, Inc

Comment 1

"The impact of transporting radioactive nuclear materials associated with nuclear weapons is excluded."

Staff Response - The relation of benefits to impacts for transporting nuclear weapons is evaluated on a different basis than that for transporting other radioactive material. The Atomic Energy Act of 1954, as amended, exempts nuclear weapons from licensing and other regulatory controls. Thus their transportation is not within the scope of this study.

Comment 2

"Accidental releases are not among the factors included in the models used to calculate radiation dose predictions. The long-term detrimental environmental impact from a major transportation accident, such as an unplanned release of radioactive materials, is not included in the models used to calculate radiation dose predictions. The pathways by which such radioactive releases might continue to increase the public's exposure to radiation are not considered."

Staff Response - Accident releases are included in the dose predictions of Chapter 5.

Comment 4

"The increase of radiation exposure to the public and to workers at those points where delays in shipment occur are not included as part of the model calculations, i.e., on highways, in rail, air, and barge transport, during switch operations in freight yards, and at transfer points."

Staff Response - The average transit times for all modes include allowances for reasonable delays. Specific cases have been analyzed for some modes.

Comment 5

"The failure to calculate radiation exposures with consideration for the converging of transportation routes to one central point is conspicuous."

Staff Response - Specific routing was not included in this Generic Environmental Study but will be included in the Urban Study now being prepared. Nevertheless, estimates of the total cumulative dose to the population have been made, and the risk from that exposure has been assessed. Thus the overall environmental impact of the convergence of routes has been evaluated.

Comment 6

"The study fails to include an estimate for the releases that might result during hijacking, theft, and other terrorist activities."

Staff Response - Consequences of terrorist activities are qualitatively treated in Chapter 7, which covers Safeguards.

Comment 7

"There is an absence of any evaluation of genetic damage resulting directly from transportation activities or indirect damage to the gene pool from such activities."

Staff Response - Genetic effects are now quantitatively treated in Section 3.7 of NUREG-0170.

Comment 8

"The study fails to reveal whether or not the 'No Threshold/Linear Hypothesis' is utilized in assessing the impact on public health. Any amount of man-made radiation is damaging and is an added harm over and above the harm done by natural radiation."

Staff Response - Use of the "Linear Hypothesis" in the Study is clearly stated in Chapter 5, which says:

> "...we do not intend to give the impression that we believe thresholds exist for the onset of radiation effects. Both for the accident case and under normal operational conditions, it is presumed that radiation damage varies linearly with exposure."

Comment 9

"The study fails to prepare a number of models which would be relevant to special areas. Many vicinities will be receiving radiation exposure from a number of sources: nuclear power plants, waste handling facilities, weapons operations, etc."

Staff Response - Environmental impacts from radioactive material in any particular location are the sum of those from this study and those from specific facilities in the vicinity. Although the risk from exposure to persons living in specific areas has not been evaluated, the total cumulative dose to persons from all transportation activities has been evaluated.

Comment 10

"The study fails to take into account the varying qualities of rail points in existence on the various routes proposed."

Staff Response - This Generic Study looks at the average impacts of rail transports. It does not aim at evaluating specific routes.

Comment 11

"The defects in calculating and assessing the effects of radiation exposure due to the transport of radioactive materials make the existing report practically useless. Environmentalists, Inc., is most concerned about transportation activities associated with the various

Barnwell facilities. The Barnwell area will be the terminal of many transportation routes. The population will be exposed to radiation not only from numerous shipments, but will be exposed to accidental and normal releases from the Savannah River Plant, BNFP, converging transportation routes, Chem Nuclear waste handling, nuclear submarine base, nuclear power plants --- including leaks to the drinking water. NUREG-0170 will be of small value in assessing the environmental impact of the Barnwell operations."

Staff Response - Environmental impacts from transportation associated with particular facilities are covered in the Environmental Statements associated with those facilities.

Comment 12

"We question the use of taxpayers' money for a report which appears to have little if any use. The report does not follow the provisions of NEPA. The alternative section does not include discussion of the possibility of not transporting nuclear materials nor the alternative of halting the use of nuclear energy. The cost-benefit analysis fails to quantify many of the transportation costs and some are not even listed."

Staff Response - This environmental impact assessment and statement was prepared to be a basis for deciding on the adequacy of existing regulations governing the transportation of radioactive materials. In this country there are medical, industrial, and commercial activities involving the transportation of radioactive materials. The statement treats alternative modes for such shipments but does not consider the alternative of stopping the shipment of radioactive materials entirely. That alternative could only be considered in the far broader context of evaluating whether any medical, industrial, or commercial use of radioactive material should be permitted. That vastly broader consideration is completely outside the scope and purpose of this statement and beyond the NRC's expressed intent to review its regulations to determine what changes, if any, should be made.

Comment 13

"Environmentalists, Inc., regrets not having had the opportunity to make initial comments on NUREG-0034. However, since NUREG-0170 appears to have such little merit, we anticipate a redundant study for the purposes of licensing the Barnwell facilities."

Staff Response - The licensing of the Barnwell facilities requires a separate Environmental Statement. This study was not intended to replace or remove the need for such a specific statement.

Georgia Public Interest Research Group

Comment 1

"G-Pirg's chief concern with the Final Draft Environmental Statement is with the adequacy of treatment accorded coordination between State and Federal Authorities. There are twenty

Federal and State agencies that could be called upon to act in the event of an incident. The instant document does not adequately deal with this problem."

Staff Response - NUREG-0170 assumes that authorities respond to transportation incidents involving radioactive material in the same way they respond to other transport incidents. No special response to radiological incidents was included in the model. There is a totally independent Federal interagency program as well as several State studies on responding to radiological incidents.

Comment 2

"The New York Department of Law asked similar questions in a letter to NRC dated May 17, 1976. The NRC failed to sufficiently address the issue. For example, there are no regulations or plans for communications equipment or frequent contact between local law enforcement agencies along truck routes (see VII-10). Nor does NRC's answer deal with distances, transportation, or communications between airports (see VII-11) or with regulations concerning 'airport security personal' (sic) as stated in VII-11, or airplane security personal (sic)."

Staff Response - The May 17, 1976, letter from the New York State Department of Law has been answered in Chapter 8 of NUREG-0170. Communications requirements for safeguarded shipments are described in Section 8.4 of NUREG-0170, as well as in 10 CFR Part 73.

Comment 3

"G-PIRG also feels that the FES should have focused more attention on the issue of financial responsibility in the event of an incident. Will the costs be borne by the agencies involved or by the carrier? If by the former, how would the liabilities be apportioned?"

Staff Response - Costs that may be involved in accidents have been estimated as environmental costs. Although the apportionment of financial responsibility may have an effect on the way people respond to an environmental impact, the source of the funds is not pertinent to this study. An analysis of financial responsibility is therefore not included in this Statement.

Comment 4

"G-PIRG also feels compelled to ask who is responsible for the planning and approving of routes and times of travel and for the notification of checkpoints. These activities are vital in the effort to reduce the risk of incidents. Again, these questions are not sufficiently dealt with in the FES."

Staff Response - The regulations of neither DOT nor NRC specify routing, times of travel, or (except for safeguards purposes) notification of checkpoints. Although some local restrictions may be imposed on routing and time of travel, these have little overall effect on transportation. Therefore, no discussion of responsibilities for them was considered necessary. Alternatives to current practices are analyzed in Section 6.3, "Alternatives Introducing Operational Constraints on Transport."

Comment 5

"Finally, G-PIRG cites the NRC for not confronting the potential problem of non-compliance. It is naive to assume that the regulations will be followed merely because they exist. We are mindful of the Brown's Ferry incident. G-PIRG also submits that it is extremely unwise to accept 'industry practices' as assurances of compliance."

Staff Response - An analysis of incidents from 1971 to 1975 is included in Section 4.6. This includes incidents caused by defective or improper packaging.

Comment 6

"In conclusion, we feel that the potential dangers of transport of radioactive materials are great enough to warrant an unhurried and careful consideration of all the issues and ramifications. These risks are particularly acute to Atlanta and to Georgia because of their location at the crossroads of America's transport links and because of their proximity to the Barnwell Nuclear Reprocessing Plant. In light of this, G-PIRG urges more thorough attention to the issues addressed in this paper and to the convening of another public meeting in Atlanta concerning NUREG-0170 with proper advance notice to all interested parties."

Staff Response - NUREG-0170 is the most comprehensive analysis of the environmental impacts of transporting radioactive material thus far produced. The public will be invited to participate directly in any decisions on conclusions drawn from this study. A more detailed study of transporting radioactive material in cities is now being prepared by the NRC Staff.

The Georgia Conservancy (Letter of February 1977)

Comment 1

"It is self evident that a generic statement such as this is inadequate to meet the needs of specific areas of the Nation where a concentration of nuclear facilities or a convergence of transportation routes to such facilities create circumstances demanding independent and detailed treatment. This is particularly true of Georgia, where the presence of the Savannah River Plant, Chem-Nuclear low level waste storage facility, Barnwell Nuclear Fuel Reprocessing Plant, together with the proposed Posiedon Base at Kings Bay, nuclear reactors, weapons systems and weapon components within the State, medical radio-pharamaceutical, industry, etc., will funnel a disproportionate shore of hazardous nuclear materials through Georgia's rails, highways, waterways, and airways. A separate Environmental Impact Statement incorporating the aggregate and cumulative effect of such activities is a minimal requirement of the understanding and protection of those asked to accept and support their existence. We need a comprehensive study of precisely what is moving through and to our State now, and a projection for 1985 and beyond."

Staff Response - It was not the intention of this study to investigate impacts to specific areas. NUREG-0170 assesses environmental impacts on the nation as a whole. Each licensed facility is required to evaluate in a separate NEPA statement the specific environmental impacts it causes.

Comment 2

"The cost for land reclamation of a radiation accident site is stated to "exceed $200 million" in the Summary and Conclusions. However, Table V-14 shows the cost of decontamination being as high as $8.21 billion which is 40 times as much cost. We therefore find it materially misleading to include only the lower figure in the summary statement."

Staff Response - The Summary and Conclusions section has been revised to more accurately reflect the data from the body of the report.

Comment 3

"...the possible costs resulting from a radiation transport accident are enormous. It appears that insufficient attention has been given to the question of who will be responsible for absorbing these costs and their financial ability to pay. It is questionable that the shipper would be able to cover such costs and the State of Georgia should certainly not be required to bear the responsibility for reclamation and decontamination. What provisions have been made for assurances that these costs are paid? Will the Federal Government be prepared to cover such costs? Through what mechanism?"

Staff Response - Although financial indemnity and insurance coverage may affect the way people respond to an environmental impact, they do not directly affect the impact itself. Analyses of these factors is therefore not included in this statement. Information on insurance coverage can be obtained from the following:

> Joint Committee on Atomic Energy-HR-8631, "NRC Staff Study Concerning Financial Protection Against Potential Hazards Caused by Sabotage or Theft of Nuclear Materials," Appendix D, "To Amend and Extend the Price Anderson Act," Part IIB, "Geographic Limitation on Coverage."

Comment 4

"It's apparent that the accident risks and health effects due to a given accident are directly tied to the frequency of shipments and routes of transport. The full impact of radioactive transport on the State of Georgia or communities in the State cannot be fully assessed without adequate information on these factors.

"Is information on the projected frequency and routes of shipments available to the State of Georgia and concerned citizens?

"It is imperative that the State be provided with advance notice of radioactive shipments and that the State be given the option of prescribing acceptable routes and times of transport.

"It is our understanding that the State of Florida is already pursuing this option.

"Is there provision for Georgia to exercise this right?"

Staff Response - This Generic Study analyzes no specific cases. Frequency and routing information about radioactive material shipments is not available from this report. An ongoing study of transportation in urban areas is developing methods to model this information. Under contracts with NRC and DOT, several states have been inspecting the transportation activities within their borders. Also, legislation on preemption of regulations "inconsistent" with DOT regulations has recently been put into effect. Specific questions on the States' role in regulating radioactive material transportation should be addressed to the United States Nuclear Regulatory Commission, Office of State Programs, Washington, D.C. 20555.

Comment 5

"The magnitude of health effects following a radioactive transport accident will obviously depend to a large degree on what immediate action is taken at the accident site to minimize these effects.

"Has an established procedure been developed for handling such an event and have responsibilities for specific activities been fully defined?

"For example, who will be responsible for radioactive monitoring, for evacuation of adjacent areas, for retaining contaminated people at the site, for decontamination of the accident site?

"We question whether there are even adequate medical and personnel decontamination facilities in Georgia to handle victims of such incidents.

Staff Response - This Study considers the average response to incidents, not specific cases. The question of responsibility for accident response is partially answered in NUREG-0179, "Regulatory and Other Responsibilities as Related to Transportation Accidents," June 1977. Specific response actions are the subject of an ongoing NRC study of emergency response to transportation incidents. Also, both the Western Interstate Nuclear Board (WINB) and the Southern Interstate Nuclear Board (SINB) have carried out study programs and developed proposed plans on accident response.

Comment 6

"We question whether all reasonable alternatives have been considered to reduce the environmental effects of radioactive transport. For example, the alternative of limiting the amount of radioactive material transported should be addressed. This would include limiting the number of nuclear power plants in the country to those now in operation or under construction. This would significantly reduce the risk of adverse environmental effects due to transport, and particularly in Georgia, it would help to minimize the amount of nuclear materials transported across the State to and from the Barnwell, South Carolina Reprocessing Plant."

Staff Response - We have examined a cross section of reasonable alternatives in the transportation system. Questions of altering the types or quantities of radioactive materials transported are beyond the scope of this study, which analyzes the impacts of transporting the present types and amounts of material.

Comment 7

"Spent fuel shipments are specifically exempted from physical protection requirements of 10 CFR Part 73. No discussion of special precaution or less rigorous methods of protection proportionate to the risk are discussed. The rupture of a cask is a stated possibility, resulting in a total of 244 predicted deaths (page VII-2). A consequence of this magnitude (or worse, should the cask fall in a water supply for example) merits more serious consideration of escorts or other appropriate types of safety precautions."

Staff Response - The type of rupture referred to in this comment is a hypothetical result of an act of sabotage. Actually, far fewer fatalities would be expected, and they would be delayed and spread over a period of decades. We believe the absence of immediate fatalities make spent fuel shipments a relatively unattractive target for sabotage.

Comment 8

"The final conclusion of Section VII dealing with special nuclear materials, states that 'alternative means of protection --- are neither necessary nor desirable for the protection of privately owned materials.' Apart from the highly debatable merit of this conclusion, a more profound question which should be addressed is 'What are materials such as these (which have the potential for cataclysmic harm to society in a variety of ways) doing in private ownership to begin with?'

"It seems to us that there is a substantial question as to whether bomb grade material should be introduced into the general stream of commercial traffic."

Staff Response - Private ownership of special nuclear material has been authorized by Congress. Weapons grade material is not in the general stream of commercial traffic. Virtually all of it is transported by the U.S. Government. All such material is transported with special safeguards beyond those used in normal commercial transport.

Comment 9

"Table VI - 2 sets forth the economics of rail and truck shipments of spent fuel. Do the 'costs' include the costs to the State for road damage and maintenance (particularly for overweight shipment), bridge strengthening where needed, increased police coverage and special equipment, if necessary? Who bears these costs? Sec. 168 of the AEC Act of 1954, as amended, and Sec. 91 of the Atomic Energy Community Act, of 1955, as amended, provide a specific statutory mechanism for the evaluation and determination of the need for financial assistance to local entities which may be affected by ERDA activities.

"Would these or similar costs imposed by any of the various modes of transport comtemplated by this statement qualify for relief under these provisions?"

Staff Response - Cost-per-shipment data in NUREG-0170 include State and local licensing fees, which go to support maintenance and road repairs. Provisions for reimbursement of costs as described are not within the purview of this study.

Comment 10

"On Page XXV of the Detailed Summary as one of the long term positive results from the shipment of radioactive materials the assertion is made that the use of nuclear fuels in reactors allows production of electricity for society with lower costs than is possible by more conventional methods of generating electricity.

"Statements like the above have for far too long accompanied cost benefit assessments. To state it now, without qualification or supporting data, in the light of increasing numbers of critical analyses which arrive at contrary conclusions, is simply inexcusable.

"This is particularly true when it is characterized as a 'long term' benefit, implying either (1) an adequate supply of uranium for the indefinite future, (2) the acceptability of plutonium recycle, (3) and/or the economic and environmental viability of a breeder reactor, none of which has or can be demonstrated at the present time."

Staff Response - This statement is based on the best available information.

The Georgia Conservancy (Letter of March 4, 1977)

Comment 1

"Among the final matters dealt with by the Committee was the question of what consequences might reasonably be expected as a result of a successful 'diversion of special nuclear materials,' a question wholly omitted in the Statement itself.

"The ultimate consequence of a successful theft of bomb grade materials, or any major credible catastrophe which might occur anywhere in the commercial fuel cycle [is not covered]. Such an assessment should address not just the immediate economic or biological effects of such an occurence as this statement does, but the predictable events which are likely to ensue, including the possible shutdown of the industry and the attendant disruption in our economy and other major effects (on our foreign policy for example). Alternatively, if the plants are not closed, what effect on public and worker morale? And to production costs if more stringent safety features were demanded?"

Staff Response - NRC efforts are directed at preventing the success of any attempted diversion of special nuclear material, rather than at controlling the consequences of the act. Therefore, an evaluation of the consequences of a diversion is felt to be unnecessary. A brief description of the potential impacts was included in the Draft Statement, NUREG-0034, as Appendix F.

Comment 2

"A clarification of language using plain english rather than terminology which tends to obscure fact or meaning.

"First we would suggest that euphemistic terms like 'special nuclear materials' and 'diversion' be deleted entirely from any communication which is intended to enlighten or edify. 'Special nuclear material' means bomb grade material and 'diversion' means theft. It does not change the nature of a substance or an act to call it something else. The literature of this industry and the agencies governing it is replete with similar efforts to obscure reality. Please stop it. Learn to tell the truth in a fashion that can be understood and dealt with."

Staff Response - Congress originated the term "special nuclear material" in the Atomic Energy Act of 1954, including not only weapons grade material, but also nonfissionable plutonium, enriched uranium, and other materials enriched in plutonium or certain uranium isotopes. Most special nuclear material is not weapons grade material; to label it as such would be incorrect and misleading. The term "diversion" is used rather than "theft" because "diversion" is a more general term that more accurately covers the possible occurrences. Theft connotes an unauthorized removal of another's property, while diversion can be any unauthorized use of the material. Thus the two terms are not quite synonymous.

Comment 3

"In the NRC spokesman's formal presentation on the threat of 'diversion,' in the following sequence we understood him to say first that 'it is impossible to quantify the threat' and later on to state that 'any mode of transportation can be protected against any level of threat.' Those two statements are totally inconsistent. More importantly, they reveal an attitude, a 'way of thinking' as the Chairman expressed it, which in our opinion has characterized the Government's role in the nuclear industry from its inception, and accounts in large part for the growing mistrust and resistance on the part of the public to continued or increased reliance on nuclear power as the sine qua non of our economic existence."

Staff Response - We believe sufficient resources can be assembled to protect a shipment against any level of threat. Quantification of the threat in terms of expected attacks per year, or assigning probabilities to shipment attacks is not necessary for preventing their success. A review of the transcript of the February 1977 ACRS briefing on NUREG-0170 did not reveal the statement "...it is impossible to quantify the threat." However, a qualitative assessment of the safeguards necessary to protect a shipment does not require assigning a numerical value to the threat.

Comment 4

"The specific question addressed briefly in this proceeding were the probabilities and consequences of theft of bomb grade material. We suggest for your consideration that history supports the view that any human endeavor whose success depends upon achieving 'zero defects' is doomed to failure. Recent examples in the realm of technology are the Apollo and SNAPS programs. A similar failure in the field of 'anthropology' is exemplified by the actions of Mr. Nixon's staff."

Staff Response - Security in the transportation of radioactive materials is not dependent on "zero defects." Protection lies in the small chance of success in an attempted diversion and in the very small probability of an attempt.

Comment 5

"We further suggest that any serious effort to achieve zero probability of failure, whether technological or anthropological, will, in itself, incur unprecedented costs to our society. Financially, power companies are already chafing under the escalating capital costs of nuclear facilities which knowledgeable critics proclaim to be still not safe enough. Societally, you gentlemen calmly discussed the introduction of guards armed with automatic weapons to traverse Amercia's expressways - a profound 'environmental impact' upon our society, we should say. We urge you to reflect upon it.

"The price already paid or incurred to generate electricity in this way is far greater than that which appears in any cost-benefit analysis. The more we seek to attain zero defects the more the price will rise.

"And we have no choice but to seek it, for the consequences of a major failure, whether it be a transportation accident, a successful theft, or any other mode, though not infinite would surely be intolerable. With costs in the billions, and fear of repetition rampant, regardless of who pays what to whom, what do you think would happen? Do you think it would end there? Would a new Rasmussen study placate the public?

"And suppose it happens when 20% - 40% of the electrical power of the United States is generated by nuclear fission and you are the President? What do you do?

"It seems to us, as it has for a long time now, that, in dealing with the nuclear questions we will remain torn between intolerable risk and intolerable cost."

Staff Response - We agree that to achieve a zero probability of failure would be very difficult. But the target is achieving a very high probability that there will be no successful diversion of special nuclear material. The safeguards program exists because of the chance of an attempted diversion and the magnitude of the possible consequences. Questions on probable U.S. policy in the event of an accident are beyond the scope of this Study.

Comment 6

"Nuclear power generation has already distorted our judicial system in a variety of ways. Most notably, the ancient doctrine of tort law creating liability to innocent third parties for harm done them by a negligent act has been laid aside to accommodate the growth of this particular industry and for none other.

"Less obviously, but perhaps even more importantly, scientific dissent is quelled, not encouraged, as it properly should be in the search for truth. William Rowe, a ranking official of the Environmental Protection Agency, recently responded to a question on this topic by stating that no effort was made to discourage dissent 'except, of course, when it is contrary to departmental policy.'

"This EIS is inadequate in failing to consider the above questions. They are being discussed in other forums. As a presidential candidate addressing the Washington Press Club, Mr. Carter predicted that a major reactor accident would mean the end of the nuclear power industry. Dr. Lynn Weaver head of Georgia Tech's Nuclear Engineering Department has expressed the same opinion. Countless others share this view. Clearly, it is a credible consequence of any major nuclear disaster, including theft or transportation accident, and should be included in any responsible overall assessment of acceptablility. Adequate notice and availability of subject matter to all interested parties in timely fashion."

Staff Response - Neither the effect of nuclear power on our judicial system nor the quelling of scientific dissent are within the scope of this statement. Demise of the nuclear power industry is not considered to be a credible consequence of an attempted theft of special nuclear material or a transportation accident.

Comment 7

"Civilian guards armed with automatic weapons. What effects, subtle or overt, on travelers sharing the expressways and the general public? What specific instruction to the guards as to their response in a wide range of potential encounters, both real, or as they may be perceived by the guards in a sudden and unexpected confrontation: What quality of individual is contemplated to be recruited and trusted to bear these weapons? What program of indemnification and financial responsibility on whose part for error in selection, training, supervision or performance?"

Staff Response - NUREG-0170 neither assumes nor advocates automatic weapons for civilian guards. For many years ERDA shipments of special nuclear material have been made on public highways with armed escorts, with no discernible effect on the general public. Thus the civilian safeguards program, based on this ERDA experience, is expected to have no significant effect on the public. Specific responses and indemnity questions are not among the topics analyzed by this Study.

Comment 8

"What surveillance systems are specified and in place to identify and monitor potential threats to transportation of nuclear materials? The statement was made that there are no known groups who have the motivation and capability to successfully divert bomb grade materials. Who made that determination? The FBI? The CIA? The NRC? Is the dollar cost of acquiring and maintaining such information charged to the public generally, or is it internalized and accounted for in the cost-benefit analysis? Apart from financial cost, what loss of freedoms is likely to occur to individual citizens? Will there be increased numbers of phone taps and similar encroachments on privacy deemed necessary to adequately protect these materials? Will the need to protect them result in the successful passage of legislation such as that proposed in the State of Virginia to grant to the Virginia Electric and Power Co. a variety of police powers?"

Staff Response - Information about possible threats to special nuclear material shipments is furnished to the NRC by all U.S. intelligence agencies that gather such information. Among the agencies that have worked with the NRC on the safeguards program are ERDA, the FBI, the CIA, the Department of Defense, and the Department of State. Financial and social impacts of intelligence gathering are not within the purview of the Environmental Study.

Comment 9

"What additional effects can be expected in our judicial and political systems to protect and encourage nuclear power generation? We have identified the abandonment of tort liability, the repression of dissenting opinion, and the extension of police powers to private firms. Will the states be preempted by the Federal Government from a voice in nuclear plant siting and the regulation of nuclear materials transported within their borders? Is that good or bad? Who decides? These are not frivolous questions and they are not adequately considered (if addressed at all) in the Final Environmental Impact Statement. We think they should be."

Staff Response - These topics are beyond the scope of this Study.

State of New York - Department of Law

Comment 1

"Pursuant to the Notice of Availability of the above-referenced Draft Environmental Impact Statement ('DES') published at 41 Fed. Reg. 12937 and the solicitation of comments on that DES as contained in the Notice of Availability, the New York State Attorney General submitted a series of comments on the DES. It was noted in the Attorney General's filing of May 17, 1976 that the DES did not address the issues set forth in the materials previously submitted by the office to the NRC in the course of this administrative proceeding on transportation of nuclear materials as originally noticed in the Federal Register. 40 Fed. Reg. 23768 (June 2, 1975). More specifically the DES did not address the materials submitted by way of this office's letter, dated July 2, 1975, which letter and materials are apparently on file in the Commission's public docket room.

"It has been brought to our attention that, as with the DES, the unreleased final environmental impact statement ('FES') ignores the above described materials and, in part, subsequent filings."

Staff Response - The comments in this and previous letters concerning the June 2, 1975, "Advance Notice of Rule Making Proceeding" will be considered in the course of that proceeding. Neither the DES (NUREG-0034) nor the FES (NUREG-0170) treats those topics.

Comments received on the DES were considered in the preparation of the FES.

Comment 2

"In addition, we have been informed that certain comments are dismissed as being based on 'unconfirmed analysis.' Such a response to the comments, calculations and estimates of this office is meaningless and displays a failure by staff to resolve factual disputes. All the comments and supporting materials filed by this office must be responded to in a thorough manner in order for the Commission to comply with the Guidelines of the Council on Environmental Quality under the National Environmental Policy Act, 42 U.S.C. K 4321 et seq. It is particularly appropriate for the Commission to attend to this matter now in view of its recent decision to have the FES redrafted."

Staff Response - The dismissal of comments about the "hot particle" and "enhanced risk to smokers" models for plutonium health effects is based on their lack of acceptance by the medical and health physics communities and on the conclusions of an extensive NRC staff study.

APPENDIX J

COMMENTS ON THE DRAFT ENVIRONMENTAL STATEMENT

DOCKET NUMBER PROPOSED RULE PR-71,73 (40 FR 23768) (72)
Transportation of Radioactive Mtl by Air (Revised)

STATE OF NEW MEXICO

HEALTH SAFETY WELLBEING COMFORT

Environmental Improvement Agency

P.O. Box 2348 - Room 215
Santa Fe, New Mexico 87503

Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Arlotto:

We have reviewed the Draft Environmental Statement on the transportation of radioactive material by air and other modes, and we see no conflict in the conclusions.

Thank you for the opportunity to comment.

Yours truly,

Charles A. Marquez

Charles A. Marquez
Environmental Planner

DOCKETED USNRC
MAY 10 1976
Office of the Secretary Docketing & Service Section

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40 FR 23768)
Transportation of Radioactive Mtl by Air (Revised)

STATE OF NEW MEXICO

Environmental Improvement Agency

PERA Building - Rm. #215
P.O. Box 2348
Santa Fe, New Mexico 87503

SPECIAL PROJECTS SECTION

April 21, 1976

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Arlotto:

We have reviewed the Draft Environmental Statement on transportation of radioactive material by air and other modes. We have no additional comments to offer.

In our opinion this draft complies with the spirit and intent of the National Environmental Policy Act of 1969.

Sincerely yours,

Dick Burgard
Environmental Program Manager

DB/mtm

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40 FR 23768) (14)
Transportation of Radioactive Mtl by Air (Revised)

FEDERAL ENERGY ADMINISTRATION
WASHINGTON, D.C. 20461

APR 30 1976

OFFICE OF THE ASSISTANT ADMINISTRATOR

FEA 76-86

DOCKETED USNRC
MAY 10 1976
Office of the Secretary Docketing & Service Section

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Arlotto:

In response to your request for review of the draft environmental impact statement (EIS) on the Transportation of Radioactive Material by Air and Other Modes (NUREG-0034), we are providing the following comments.

The "Standard Shipments" used in assessing potential environmental impacts include plutonium, but do not include enriched uranium. Although the concern expressed during the past year by public officials and others about the air shipment of special nuclear material has emphasized plutonium, uranium has not been excluded. If the NRC is able to certify to the Joint Committee on Atomic Energy (JCAE) that a safe container for plutonium has been developed and tested which will withstand the crash of a high-flying aircraft, the public concern over air shipments could shift to enriched uranium. Accordingly, we suggest that low enriched uranium typically used in light water power reactors be included in the "Standard Shipments" analyzed in NUREG-0034.

On page B-12, the median lethal dose of plutonium is compared with the lethal dose of other toxic materials. We suggest that this paragraph also point out that the projected death from the referenced dose of plutonium would result from cancer at some undetermined time after a latent period of approximately 15 years, but that death from the other toxins would occur within a short period of time.

We hope that these comments are useful to you in preparation of the final EIS.

Sincerely,

Roger W. Sant
Assistant Administrator
Energy Conservation and Environment

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40 FR 23768)
Transportation of Radioactive Mtl by Air (Revised)

FRIENDS OF THE EARTH 72 Jane Street • New York, New York 10014 • (212) 675-5911

Friends of the Earth would like to submit the following comments on the Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (NUREG-0034, U.S. Nuclear Regulatory Commission Office of Standards Development, March 1976)

- - -

Summary & Conclusions, p.v, para.3

The draft environmental statement refers here to air transport as an "effective means of protection" against theft and sabotage of radioactive materials. We strongly disagree. Sabotage of aircraft could lead to a crash and fire and possible dispersal of radioactive materials. Air transport is therefore not an alternative to ground modes of transport since it offers additional potential for such dispersal, in fact triple potential, through aircraft malfunction, pilot error, or sabotage. In our opinion, air transport is the least acceptable and by far the most risky of all transportation modes. Rather than offering an "effective means of protection", it offers instead a wider variety of possible events that could result in dispersal of radioactive materials.

Detailed Summary, p. xix, para.2

We take issue here, as elsewhere, with the reprehensible practice of averaging radiation exposure over large populations and thus submerging individual health effects. This averaging is misleading in that it infers lower radiation releases than actually occur; it also ignores the very real health effects, short- and long-term, on the individual who is unfortunate enough to contract cancer or leukemia, suffer genetic mutations, or give birth to a deformed infant. For this individual the risk is one, e.g. certainty.

One could compare this habit of averaging to the argument used by nuclear proponents in trying to refute public concern over plutonium toxicity. These individuals denigrate public concern by saying that perfectly uniform dispersal and ingestion of plutonium oxide is highly unlikely and therefore we should not worry about plutonium releases. Here, however, it is the NRC that is guilty of assuming - for their own purposes of underplaying the seriousness of radiation releases - that radiation resulting from an accident will be uniformly dispersed and uniformly received by vast populations numbering in the hundreds of thousands, even millions. Nuclear opponents and critics have never assumed such perfect dispersal, and we therefore insist that the NRC not make a similar assumption, and discontinue its use of the term man-rem.

p.xx, para. 2

We refer the NRC to the affidavits of Drs. John Gofman, Marvin Resnikoff and Karl Z. Morgan, prepared for the New York State Attorney General in his lawsuit against the U.S. government to halt air shipments of plutonium. The above are leading scientists with expertise in plutonium toxicity and dosimetry; the NRC figures of one fatality and dixteen latent fatalities are unsubstantiated by any expert studies or data and therefore indefensible.

(more)

FRIENDS OF THE EARTH 72 Jane Street • New York, New York 10014 • (212) 675-5911

p.xxiv

We take strong exception to the statement in paragraph d that nuclear fuels produce lower levels of gaseous and solid pollutants - not because the statement is false but because it compares apples and oranges, .eg. fails to note that nuclear fuels do in fact produce pollutants that are qualitatively different and much more lethal, namely radioactive fission products; in normal operation, through waste accumulation, activation products, and in unplanned releases. Furthermore, the potential for large radiation releases is always present in all parts of the nuclear fuel cycle, normal operational releases aside.

Chapter I, p. I-15

Paragraph 1 has an unfortunate error: the substitution of the word safeguards for the word security. Or is the NRC implying that highly radioactive spent fuel will never be the object of attempted diversion or sabotage because of its innate hazards? Or does the NRC mean that irradiated fuel needs no safeguards, period?

Chapter I, pp.I-22,24,28

If the subject of possible accidents in transport of radioactive materials were not so serious, one could be amused by the NRC's use of the geometric mean of the extremes in curies per package for shipments. The statement "The geometric mean was chosen to avoid attaching undue significance to the relatively few large quantity shipments" could be re-phrased to read:..."to avoid undue attention to the potential hazards from radioactive releases of those shipments exceeding the geometric mean".

One hardly needs to point out that accidents do not space themselves out for our convenience so as to select only small-quantity shipments. An accident is as likely to occur to a large package as to a small one. Does the NRC mean to infer that the health effects from dispersal of a 100-kilogram plutonium shipment (such as those that took place at Kennedy Airport up until last year) are negligible? That the likelihood of large quantities being dispersed is smaller than that for small quantities? In this particular stochastic game, the NRC has fallen flat on its face. One hopes that we do not need an accident involving plutonium to pull them to their feet.

Chapter III, para. H, p. III-15

We question the reliance on the WASH-1400 health effects model. The Union of Concerned Scientists-Sierra Club critique of the Rasmussen reactor safety study has criticized the assumptions of low numbers of health effects posited by WASH-1400 on the grounds that the study assumed near-perfect evacuation of the metropolitan New York area within several hours, while simultaneously assuming that most of the population would be indoors or underground and therefore shielded from radiation. More recently, Dr. J. Martin Brown, Assistant Professor of Radiology at Stanford University School of Medicine has criticized WASH-1400 for neglecting to assess long-term cancer deaths from a reactor core meltdown (Rasmussen uses only immediate deaths of people in the immediate vicinity). Nor does Rasmussen calculate genetic disorders, thyroid disease, etc.

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Chapter V, pp.V-2,3

We dissent from the statement that "The most severe accidents are generally the least likely to occur" as yet another departure from logic and from knowledge of stochastic events. If the NRC wishes to persist in this type of argument, they should provide us with the mathematical model supporting this position. Similarly, they refer to "The complete logic model" of accident sequences leading to an environmental impact. A complete logic model is by definition impossible, since if all accident causes and sequences could be articulated, in theory all accidents could be foreseen and avoided. What disturbs us are those sequences that will be left out of the logic model and therefore are unknown.

p. V-13

Paragraph one states that "only 10% of the land area of the United States could be considered as 'unyielding surfaces' such as rock, concrete, or rock covered by soil. However, it should be pointed out that if air transportation is utilized to any great degree in the future (something we strongly oppose), this will mean a larger number of shipments departing from and arriving by air over concrete air strips. Thus, a larger per cent of shipments would be at risk.

p. V-14

Paragraph three states that accidents of severity VII or VIII are expected to occur randomly. If so, then how does the NRC justify its statement (see above, Chapter V, pp.V-2,3) that the most severe accidents are the least likely to occur? And how does the NRC justify non-random dispersal of radioactive materials?

p. V-24

NRC states that present shipping containers exceed required standards, apparently in reference to the Sandia Laboratories tests comparing severity of the thirty-foot drop onto an unyielding surface to a 2,000-foot drop onto hard prairie. The parameter excluded here is the 2,000-foot drop onto a hard surface, e.g. the surface of airports, which by the NRC's own standards, would therefore exceed both of the aforementioned tests.

p. V-29

We disagree with the statement that "Consequences to the aquatic environment are less well understood than for the land". At least one thing is known about living organisms in aquatic environments, namely that they concentrate radionuclides in their flesh(and bones, if they are bony fish), and that these concentrations can easily end up in the food chain that terminates with man. It is also quite obvious that radioactive spills in water are irreversible and cannot be cleaned up, unlike contamination of buildings, solid materials, etc. Consequently, radioactive contamination of bodies of water and of aquatic organisms is likely to be highly detrimental to non-human species of plants and animals, whereas radioactivity released into air can be more injurious to human beings through ingestion or high whole-body doses from gamma radiation.

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Chapter V, p.V-30

In paragraph three, the NRC states certain population densities as their method of calculating person-rems from accidents involving radioactive materials, and then states that 78% of the U.S. area has a population density lower than any of these densities. However, they have overlooked the fact that insofar as air transportation is involved, most airports are located in metropolitan areas, particularly those of the heavily populated northeast where a good proportion of existing nuclear facilities are now located. Since only 25 states have no commercial nuclear reactors, it hardly matters what their population densities are. It is the population density in the areas near nuclear facilities that count.

p.V-51

NRC inexplicably says that the risk of plutonium accidents goes down in the 1985 projections. We would like to inquire: why? How can this statement be justified, in view of the government's determination to proceed with experimental, and later commercial, plutonium recycle and the fast breeder plutonium economy? It is not unreasonable to assume that greater use and transport of plutonium increases the risk of accidents due to plutonium release (or diversion).

Chapter VI, p.VI-19

In discussing the alternative of shifting all radioactive cargo to passenger aircraft, the report states that although this would increase passenger exposure, it would decrease the exposure (presumably to the public at large) by reducing the total miles travelled in secondary modes. We take issue with the practice of separating passengers - or cargo handlers - or nuclear industry workers - from the public at large, specifically as it relates to the genetic effects of radiation. NRC can hardly take issue with the fact that there is gene flow via reproduction between workers and non-workers, or between passengers and non-passengers. This indefensible distinction becomes particularly odious when one becomes aware of recent studies indicating that ingested plutonium may concentrate in the gonads.

Table VI-31, p. VI-53

In this table of alternative transportation modes, two modes that could reduce radioactive exposure are inexplicably left out: avoiding cities (by barging materials where possible, as with Brookhaven National Laboratories, and the Shoreham and Jamesport reactors on Long Island); and barges themselves as an alternate or for part of a trip. Cities could be avoided by the use of not only barge but of trucks and railroads; surely the avoidance of populated areas - a general government policy where hazardous materials are involved - could substantially reduce potential effects from accidents or releases. Why is this not considered? Why were barges not considered?

Chapter VII, p. VII-2

The report goes to great lengths to assert its desire to protect civil liberties while maximising safeguards. Yet the Special Safeguards Study has

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already suggested considering such anti-civil liberties measures as wiretapping, surveillance, and infiltration of groups that the government considers potentially subversive or violent.

p. VII-4

The footnote referring to an NRC ban against plutonium air shipments is in error. NRC should be reminded that they refused to implement such a ban, and that only a Congressional amendment introduced by Congressman James Scheuer put such a ban into effect. The ban unfortunately does not apply to ERDA shipments.

-Lorna Salzman
Mid-Atlantic Representative
Friends of the Earth
May 11. 1976

DOCKET NUMBER PROPOSED RULE PR-71,73 (40 FR 23768)
Transportation of Radioactive Mtl by Air

Babcock & Wilcox

Nuclear Materials Division

609 North Warren Avenue, Apollo, Pa 15613
Telephone. (412) 842 0111

May 12, 1976

U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Attention: Director, Office of Standards Development

Dear Sir:

On March 29, 1976, the NRC announced the publishing of NUREG-0034, "Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes". Enclosed herein is one comment.

The DES assumed that dose rates were proportional to the transport index. While this is true for non-fissile material, it is not so in the case of plutonium, where the transport index is derived from criticality considerations. It is felt that the exposure rate is the correct number to use, and it is not clear that this number was used in the DES. (See Page IV-42, for example). Experience has shown the exposure to be about 1 mr/hr at one meter from a container of PuO_2. Thus, the transport index of 5 that was applied to shipments of PuO_2 in the DES is too large by a factor of five.

In closing, I would like to express appreciation at the opportunity to comment.

Sincerely,

J. C. DelSignore (raa)

J. C. DelSignore,
Regulatory Projects Manager

JCD/raa

DOCKETED USNRC MAY 18 1976 Office of the Secretary Docketing & Service Section

The City of New York

LAW DEPARTMENT
MUNICIPAL BUILDING
NEW YORK, N. Y. 10007

W. BERNARD RICHLAND,
Corporation Counsel

DOCKET NUMBER PROPOSED RULE PR-71,73 (40 FR 23768)
Transportation of Radioactive Mtl by Air

May 14, 1976

Secretary
Nuclear Regulatory Commission
Washington, D.C. 20545

Dear Sir:

The City of New York will be mailing out its comments on the Draft Environmental Impact Statement on the Transportation of Radioactive Material by Air and other Modes on May 17, 1976.

The Commission should receive its copy on Tuesday, May 18, 1976.

Very truly yours,

William R. Coleman

WILLIAM R, COLEMAN
Assistant Corporation Counsel

DOCKETED USNRC MAY 18 1976

DOCKET NUMBER
PROPOSED RULE PR-71, 73 (40 FR 27368)
Trans. of Radioactive Mtl. by Air

The City of New York
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W. BERNARD RICHLAND,
Corporation Counsel

USNRC
MAY 1 1976

May 17, 1976

Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20545

Dear Sir:

Enclosed please find an original and 20 copies of the Comments of the City of New York on the Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes. If additional copies are required, please contact the undersigned and they will be provided.

Very truly yours,

William R. Coleman

Enc.

WILLIAM R. COLEMAN
Assistant Corporation Counsel
N.Y.C. Law Department
1625 Municipal Building
New York, New York 10007

UNITED STATE OF AMERICA
NUCLEAR REGULATORY COMMISSION

The Transportation of Radioactive Materials by Air and Other Modes	Docket No. PR-71,73 (40 FR 23768)

COMMENTS OF THE CITY OF NEW YORK

The City of New York here submits its comments on the Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, Docket No. PR-71,73 (40 FR 23768). It is our view that the DES is fatally inadequate and thus cannot serve as a basis for determining the effectiveness of NRC's present rules governing the air transportation of radioactive materials and of possible alternatives to those rules.

I

The rule-making proceeding to which this DES is addressed arises from a nationwide expansion of the nuclear material transportation program. However, even if the DES at issue were adequate (as it is not) as a generic environmental statement, if the rules purport to apply to transportation within and through New York City, there must be an additional DES prepared for shipments in and through New York City. See Sierra Club v. Morton, 514 F. 2d 856, 872 (D.C. Cir. 1975); Scientists' Institute for Public Information v. AEC, 481 F.2d 1079, 1086-87 (D.C. Cir. 1973); Nelson v. Butz, 377 F. Supp. 819 (D. Minn. 1974). To an even increasing extent New York City has been sought as a conduit for the transportation of nuclear materials. The DES upon which we are commenting utterly fails to deal with New York City's unique problems, which include its density of population, the exceptionally high number of nuclear shipments which shippers have sought to make in and through the City, and the combined impact of these two factors. See Nelson v. Butz, supra.

II

The DES is made virtually worthless by its unexplained exclusion, as "outside the scope of this document" (I-19), of all government shipments. The degree of such shipments is unstated, but they are undoubtedly substantial in number and in degree of ratioactivity. The cumulative impact on the environment of all shipments to and from an area must be assessed in a proper ES. Scientists' Institute for Public Information v. AEC, 481 F. 2d 1079, 1086 - 1087 (D.C. Cir. 1973); Jones v. Lynn, 477 F. 2d 885, 891 (1st Cir. 1973). Clearly, no meaningful assessment of cumulative impact, either nationwide or in a given area, can be made if a substantial portion of the shipments are arbitrarily excluded and treated, in effect, as if they make no adverse contribution to the environment. There is thus a failure to make the required comprehensive and integrated assessment of the environmental risks associated with the transportation of nuclear materials. In addition, exclusion of any discussion of government shipments contravenes one of the main purposes of the EIS requirement, namely, the coordination of different federal agencies in environmental policy matters. Portland Cement Association v. Ruckelshaus, 486 F. 2d 375 (D.C. Cir. 1973), cert. den. 417 U.S. 921, 94 S. Ct. 2628, upp. after remand 513 F. 2d 506, cert. den __ U.S. __. 96 S. Ct. 469 (1975). Henry v. F.P.C., 513 F. 2d 395, 406 (D.C. Cir. 1975).

III

There is a failure to make a rigorous and objective evaluation of all reasonably available alternatives. To take but one egregious example, barging is described as creating a "negligible" population exposure (IV-34), and barging has been recognized by USEPA as a desirable alternative to land transportation, yet no assessment of it is made in "Chapter VI - Alternatives" or in the "risk assessment section of Chapter IV." Thus, the DES fails to "...set forth those alternatives 'sufficient to permit a reasoned choice,'" Life of the Land v. Brinegar, 485 F. 2d 460, 472 (9th Cir. 1973); NRDC v. Callaway, 524 F. 2d 79, 92-93 (2nd Cir., 1975); NRDC v. Morton, 458 F. 2d 827, 836 (D.C.Cir. 1972); Sierra Club v. Froehlke, 359 F. Supp. 1289, 1343-44 (S.D. Tex 1973) mod. on other grounds, 499 F. 2d

982 (5th Cir. 1974); EDF v. Corps of Engineers, 348 F. Supp. 916, 931 (ND.Miss. 1972) (The discussion of barging in the Safeguards section (VII 13-14) lists some difficulties with escorting barges carrying nuclear wastes. It is stated that the level of security of escorted trucks is not attainable with barges. We would suggest that the Coast Guard be consulted on this conclusion and would refer the writers of the DES to the Coast Guard's "procedures for the Movement of LNG/LPG", Captain of the Port, New York. 1. October 1975, for a discussion of the types of safety measures that can be taken for hazardous marine cargoes.)

Not only is there a failure to adequately analyze alternative modes of transportation, there is a virtually total lack of discussion of the impact of alternative routing of nuclear transportation shipments. The DES acknowledges the importance of population density in determining the significance of an accident (V-48), but nonetheless fails to discuss routing alternatives which would take difference in population density into account. (It may also be noted that the population assumptions used in the DES risk assessment section (V-14,30) bear no relationship to the City of New York, which has a density of population grossly in excess of that assumed by the DES for a high population area.)

IV

The DES purports to review a 30 year program but fails to include increases in nuclear shipments beyond 1985. Nor is there adequate basis for the DES's forecast of a 250% increase of shipments. For example, in New York State in 1974 the only nuclear plants in operation were Indian Point I and II (990 mw) and Nine Mile Point I (610 mw). By the end of 1985, eight additional plants or upgrading of existing plants for a total of 8552 mw, may be in operation. Six more plants are projected by 19991 with a total additional capacity of 7640 mw.

V

While the DES purports to be evaluating certain existing regulations, there is no attempt to deal with the critical issue of compliance with, and enforcement of those regulations. The NRC, in the course of its purportedly close supervision over shipments of nuclear materials, appears to have no accurate idea of how many shipments are made per year, where they go, by what route they go and to what extent their transport is in accord with applicable law. We submit that no proper assessment of the environmental impact of the nuclear transportation program can be made in the absence of both accurate data and an evaluation of the extent to which existing rules and regulations in fact achieve their purpose.

In addition, in order for the public and Congress to be able to evaluate a DES, it is essential for the DES to explain the assumptions made therein. The DES at issue is replete with unexplained assumptions and references to what unspecified "expermental work" or "private communication" has shown (See, for example, pp. II-9, II-10, V-14, V-24). It is also replete with reliance on undocumented and apparently unrequired and unenforced industry "practice" (See, for example, pp. II-8 and II-30). Such reliance hardly provides assurance to the public that the NRC has adequately evaluated the environmental impact of the nuclear transportation program.

VI

Chapter V of the DES, "Effect of Transport under Accident Conditions" is fatally defective. We will briefly note only a few errors which, in themselves, totally undermine the validity of the DES's conclusions.

1. Computed estimates of alleged risk are singularly deficient in statistical confidence limits. For example, the risk assessment relies upon a progression of modelling stages; the cummulative effect of the degree of precision lost at each stage makes the study of little or no value.

2. At pages V-8 through V-15, there, the probability of spillage model which purports to calculate accident statistics, takes accident data not from actual aircraft accidents but from Clark's model, based upon laboratory simulations of crashes on unyielding surfaces. Clark's results are then modified by an unexplained process of "engineering judgment" (at page V-13 an explanation is included which provides no proofs nor any basis for the assumptions made). No attempt is made in this analysis to use actual aircraft collision data in a study similar to that performed by Bovet, "Preliminary Analysis of Tanker Collisions" D.H. Bovet. Reported by U.S. Coast Guard Office of Research and Development, November 30, 1970, or Monorsky, "An Analysis of Ship Collisions with Reference to Protection of Nuclear Power Plants, " Journal of Ship Research, October 1959.

3. The accident classification scheme improperly relates severit of an accident to fire duration and speed of impact. It fails to evaluate crush and puncture damage.

And it fails to consider population density as a contributing factor to accident severity.

VII

The discussion of reported incidents involving transportation of nuclear materials is grossly inadequate. Appendix C, does not even contain an explanation of its codes. Nor is there any discussion of possible unreported incidents. Based on the DES's own figures, incidents in 1975 may well have doubled those reported in the four-year period 1971-1974 (IV-38), yet the risk assessment, which used the number of shipments projected for 1985 apparently relied on 1974 accident data.

VIII

Scenarios involving sabatage or diversion of spent fuel or fissionable materials by terrorists or criminal elements are mentioned tangentially but are incompletely evaluated.

Respectfully submitted,

W. BERNARD RICHLAND
Corporation Counsel of the
City of New York

By Nina Gershon Goldstein
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Assistant Corporation Counsel
New York City Law Department
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William R. Coleman
Of Counsel

May 17, 1976

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One First National Plaza, Chicago, Illinois
Address Reply to Post Office Box 767
Chicago, Illinois 60690

DOCKET NUMBER PR-71,73 (40FR23768) (78)
PROPOSED RULE
Transportation of Radioactive Mat'l by Air

May 17, 1976

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Comments on The Draft Environmental Statement on The Transportation of Radioactive Material by Air and Other Modes

Dear Mr. Arlotto:

Thank you for the opportunity to provide comments on the subject statement.

We have reviewed the Draft Environmental Statement and have no comments. However, we would appreciate reviewing future documents as they become available.

Very truly yours,

R. L. Bolger
Assistant Vice President

Acknowledged by card 5/26/76

USNRC
MAY 25 1976
Office of the Secretary
Docketing & Service
Section

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

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U S COAST GUARD
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PROPOSED RULE PR 71,73 (40 FR 23768)
Trans. of Radioactive Mtl by Air

15 MAY 1976

Mr. Guy A. Arlotto
Director
Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Arlotto:

This is in response to your letter of 24 March 1976 addressed to Mrs. Judith Conner concerning a draft environmental statement dealing with the transportation of radioactive material by air and other modes.

The concerned operating administrations and staff of the Department of Transportation have reviewed the material submitted. We have no comments to offer nor do we have any objection to this project.

The opportunity to review this draft statement is appreciated.

Sincerely,

Chief, Office of Marine Environment and Systems

USNRC
MAY 25 1976
Office of the Secretary
Docketing & Service
Section

Acknowledged by card 5/26/76

-717 (40FR23760)

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA GEORGIA 30332

SCHOOL OF NUCLEAR ENGINEERING

May 17, 1976

MAY 25 1976

Mr. Guy A. Arlotto
Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Arlotto:

This communication is being sent on May 17, 1976, the date on which comments "must be received by your office"--thus I cannot meet your deadline.

First I would like to emphasize that I am sending a few hurried comments, not as a paid consultant but as a private citizen or university professor interested in these matters. Perhaps on this basis alone I am disqualified. In any case, the short time I have had a copy of NUREG-0034 for review (since May 10, 1976) assures I can only make a rather cursory examination of its contents and check a few of its assumptions. Needless to say, since I am oing this entirely on my own time, other things associated with my employment at Georgia Tech must take precedence. However, I cannot restrain my desire to make a few observations about report NUREG-0034 since I am a member of the Special Panel to Study Transport of Nuclear Materials reporting to the Joint Committee on Atomic Energy of Congress and I am passing on to you some evaluations which are in line with comments and opinions I volunteered earlier in reference to what I considered a bad practice of permitting plutonium and other actinide elements to be transported into and out of densely populated areas.

A quick perusal of the report fails to indicate you have made an adequate comparison of all possible modes of transportation. Some studies have indicated the population exposure (man·rem) from the shipment of radioactive materials decreases in the order of shipments by truck, rail and barge. I realize nuclear power plants, reprocessing plants, fuel fabrication plants, etc, have not in most cases been located where direct barge shipment is possible, but I regret to say I can only conclude this has been by design and refusal of the AEC and now NRC to take this mode of transportation into proper account in the environmental impact statements and in the lisencing of new nuclear operations. For example, discussion of radioactive shipments by barge was not permitted at the Barnwell hearings or the St. Lucie hearings in which I took part.

In general, I am disappointed with the report because of so many half truths and unsubstantiated statements. It presumes to take a conservative stance and to treat the "worst case" but in many cases just the opposite seems to be the case. I am <u>for</u> nuclear energy and for 34 years I have tried to show

Acknowledged by card 5/26/76

we can make and keep this one of the safest of all modern industries, but I fear reports like this may shake the confidence of some of us in those we hold responsible for making and keeping this industry acceptably safe.

In order to be as brief as possible and because of my growing concern about the shipment of Pu and the other actinide elements, I will limit this discussion mostly to the treatment of the risks of shipping plutonium. In what follows I give a few random examples of why I am concerned about this report.

1. Page V-39 Here I read "The Contribution to the Total Dose from Cloudshine, Groundshine, and Resuspension can be obtained by the application of established factors to the results shown in Fig. V-11. For ^{239}Pu and other isotopes of interest, these radiation effects are negligible...."

I believe one has to be a bit naive to assume resuspension makes a negligible contribution to the human Pu dose. For example, several papers at the IAEA San Francisco meeting (November 1975) indicated the importance of resuspension. Here Romney (University of California) indicated that small particles of Pu are rapidly blown away from the source, and when resuspended they are deposited on plants that are eaten by animals and man. Most of the Pu found in vegetation got there by resuspension of dust. Jakublick (of Germany) indicated this PuO_2 on the soil migrates 100 times faster than soluble Pu (e.g. nitrate). Bondietti (of ORNL) indicated the Pu in soil forms complexes that are much more available for uptake by plants and animals. Becker (of EPA) suggested that the action of microorganisms in the soil may render this Pu available for uptake. McLendon (Savannah R. Plant) found a high concentration of Pu in plants (~1/10 that of core camples). This all suggests we cannot disregard the Pu in the soil where, in time, it may be transformed such that its fractional uptake by the human body may increase from 10^{-6} to 10^{-2}.

2. Tables V-7, V-12 and V-13 are good examples of an attempt to give the impression of a very conservative consideration of the problem and an evaluation of the "worst case accident" and yet your worst case assumes a shipment of only 20 kg of Pu when it is an established fact that larger Pu shipments have passed through some of our airports. When the reader notes such tactics used to depreciate the risks, he is inclined to question the credibility of the rest of report.

3. Table III-8 is given without explanation and I have reason to question its reliability. I was chairman from the beginning until 1972 of the Internal Dose Committee of ICRR that made such calculations and set the standards for all these radionuclides (and I was chairman of the NCRP internal dose committee for 20 years). Since 1972, I have been busy with research and teaching at Georgia Tech, so I am not completely up-to-date with the latest ICRP calculations. However, the following Table shows discrepancies I found in your table for Pu radionuclides in comparison with ICRP Committee 2 values as of 1974, and I doubt there have been substantial changes since then.

Values of Rem/Ci Given by NUREG-0034 and by ICRP

Plutonium Radionuclide	Table III-8 Values			Values Given by ICRP (1974)				
	Lung	Bone	Marrow	Lung	Bone*	Marrow	Liver	Ovaries
Pu-238	$3.1x10^8$	$7.6x10^8$	$1.3x10^6$	$3.1x10^8$	$4.0x10^9$	$6.7x10^3$	$3.6x10^8$	$1.7x10^8$
Pu-239	$2.0x10^8$	$8.7x10^8$	$1.5x10^6$	$2.9x10^8$	$4.6x10^9$	$4.4x10^3$	$4.1x10^8$	$2.0x10^8$
Pu-240	$2.0x10^8$	$8.7x10^8$	$1.5x10^6$	$3.0x10^8$	$4.7x10^9$	$7.6x10^3$	$4.1x10^8$	$2.0x10^8$
Pu-241	$5.6x10^5$	$1.7x10^7$	$3.2x10^4$	$5.5x10^5$	$9.8x10^7$	$1.3x10^3$	$8.3x10^6$	$4.4x10^6$

*This value is for trabecular bone. I do not know for what type of bone the Table III-8 is representative.

From the above it is seen there are some significant discrepancies. For example, the bone risk (where most of the malignancies develop from Pu) is underestimated by a factor of 5. The risk to the liver and ovaries may be as great as that to the lungs, but they are not even considered. Surely some consideration should be given to the genetic risk!

Table B-1 There seem to be large discrepancies between this table and the ..lues given in the GESMO report, WASH-1327, which I reviewed earlier. These discrepancies are shown below:

Radionuclide	% by weight in Table B-1	% by weight in WASH-1327	Ci calculated WASH-1327	g in WASH-1327
Pu-238	1.9	3.49	$3.47x10^5$	$0.20x10^5$
Pu-239	63.0	43.63	$5.30x10^3$	$2.50x10^5$
Pu-240	19.0	26.00	$3.37x10^4$	$1.49x10^5$
Pu-241	12.0	15.65	$1.00x10^7$	$0.90x10^5$
Pu-242	3.8	11.21	239	$0.64x10^5$
Am-241	0.6		$2.52x10^4$	$7.78x10^3$
Am-243			$6.78x10^3$	$3.66x10^4$
Cm-244			$1.70x10^6$	$2.04x10^4$

When each new NRC report uses a new set of assumptions about the SGR-GESMO-120 day spent fuel inventories, how can we be expected to believe any of the numbers or evaluate the data? Which NRC report are we to believe?

I have added also my calculations of Curies using the WASH-1327 data. Here we note that most of the risk is not from ^{239}Pu but from ^{238}Pu, ^{241}Pu, ^{244}Cm and ^{241}Am. Also, I have shown (HPJ 10, 151, 1964) that ^{238}Pu is 150 times more hazardous (Curie-for-Curie) than ^{239}Pu, ^{241}Pu is 3 times more hazardous, ^{244}Cm is 32 times more hazardous, and ^{241}Am is 16 times more hazardous. In addition, this 2.04×10^4 g of ^{244}Cm comprises 2.2 Ci of neutrons for which extra precautions must be taken.

5. Pages XIX and I-24 I am forced to conclude that this Draft Environmental Statement (NUREG-0034) like other NRC Draft Reports (e.g. WASH-1327) was hurriedly and perhaps carelessly written. I believe there are acceptable ways of shipping radioactive materials (as there are acceptable ways of recycling Pu), but I am convinced that more carefully prepared and properly reviewed draft reports, before they are issued for almost instantaneous review and comment by members of the public, would go a long way toward easing the tasks of some of us who are trying to develop a reasonably safe nuclear power industry that is worthy of strong support of the public.

On page XIX we find the statement, "It is estimated that the total annual population exposure resulting from normal transport is about 9600 person·rem." Such a statement is completely meaningless and valueless because the year is not indicated and there is no indication of whether this man·rem is to the total body, thyroid, trabecular bone, deep lung compartment, etc.

On page I-24 we have another useless statement because of insufficient qualifications. I refer to, "The total amount of Pu shipped annually is estimated to be 2000 kg." Presumably, this was for 1974? From WASH-1327 we find that for a BWR-1.15 SGR fuel discharge after 120 days decay we have 574 kg of Pu. Thus the 2000 kg corresponds to only 2000/574 = 3.5 reactor discharges per year assuming 1000 MWe per reactor.

I could go on and on pointing out weaknesses in this report, but in order to mail this on your deadline date I will close with a few general comments as follows:

a. I believe the severity of aircrash accidents assumed in this report comes far short of the worst case.
b. There are too many rather arbitrary and unsubstantiated assumptions.
c. There are serious inconsistencies between this and previous NRC reports and statements of NRC officials.
d. Average cases and the standard or reference man data are used in estimating cancer risk. Don't the children, the persons with respiratory diseases, etc, count? It seems we should protect them as well as the healthy adult worker to whom the standard man data apply.
e. The ICRP lung model is used improperly. If the 750 ml lung tidal volume curve had been used (for the child) instead of the 2150 ml curve, it would be noted that about 28% and not 14% of the particles of 3 microns mean size distribution are retained in the lower pulminary compartment of the lungs, and in either case (for the child or the adult) the larger Pu dust particles should not be neglected in the calculations of risk.

r. Guy Arlotto
ay 17, 1976
Page 5

f. The man-rem dose for normal and accident c... tions should be integrated over the entire population f... all age g... and for all dose rates. Arbitrary cut-offs, and boundary assumpti... lead to serious underestimates of the risk.

g. Although the dose to the pulmonary lymph n... is 100 or more times that to other lung tissue, this dose is ignored in the risk evaluations. I realize the ICRP has depreciated this ris... because the ERDA studies of Thompson et al at BNW have failed to produ... cancers in this part of the reticulo endothelial system in animal studies. However, I am uneasy in applying these data to man wh... lives 70 ... instead of 20 years (dog's life span) and Thompson has in fact obs... some malignancies in tissues adjacent to the lymphatic tissue which ... suggest that blood vessels leading into these organs or tissue just beyond ... α-particle complete kill within the lymph nodes may be the tissue at greatest risk in the case of man.

I hope you will find these hurried comments helpful and constructive in the redraft of report NUREG-0034.

Sincerely,

Karl Z. Morgan
Neely Professor

KZM:tm

UNITED AIRLINES

May 17, 1976

JUN 7 1976

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Arlotto:

Further to your letter of April 26, the following are our brief comments on the Draft Environmental Statement prepared by your department in support of the Nuclear Regulatory Commission's advance notice of rule-making action:

Chapter I - Page 1

This reference page states that the purpose of the publication is to assess the impact upon the environment from the transportation of radioactive materials, primarily by aircraft, etc.

This would appear to indicate that an effort has been made to justify an increase in the allowable limits for air movement. We will need to be extra careful in reviewing future rule making actions.

Capter VI - Page 36 - Paragraph B. 2-2.1

To prohibit shipments of radioactive material during adverse weather would be impractical because it changes so quickly in widely separated geographic areas.

Chapter VI - Page 38 - Paragraph B. 2-2.2

To restrict movement to daytime flights would eliminate most freighter flights. This would be very undesirable.

Chapter VI - Page 39 - Paragraph B. 2-2.3

It would not be practical to restrict movement by air to airports in low population areas, since service by air is so limited at such locations. A better alternative, if this is a valid concern, would be to prohibit transport by air.

Chapter VII - Page 15

Air transport should not be required for the movement of radioactive shipments based on security considerations. The much more important consideration relates to the exposure of people, equipment and facilities to radiation and it is these concerns that should determine whether radioactive shipments can and should be carried by air.

The transport of radioactive material by air should be limited to only that which is absolutely necessary. In our opinion, this is primarily material related to medical applications including research, diagnosis and treatment.

We trust this information may be of some assistance.

Sincerely,

E. Stohr

Edmund Stohr
Vice President
Industry Affairs

DOCKET NUMBER PROPOSED RULE PR-71,73 (FR...)

TRANSNUCLEAR, INC.

May 24, 1976

JUN 7 1976

Mr. Donald R. Hopkins
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20545

Subject: Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes Docket No PR-71,73; NUREG-0034

Dear Mr. Hopkins:

Transnuclear, Inc. is a fuel cycle services company specializing in all aspects of the transportation of radioactive materials. We are responsible for arranging transportation of much of the nuclear fuel cycle materials which move etween the U.S. and Europe each year. Modes of shipment used include air, ocean, road and rail.

We own and utilize several different types of packagings for unirradiated nuclear fuel material. We will also have licensed spent fuel casks available for service in mid-1977. These casks are suitable for transport by rail or road and will hold 3 PWR assemblies or 7 BWR assemblies and are currently being used in Europe on a routine basis.

The purpose of this letter is to comment on the DES and request that the final statement include the use of these intermediate size casks as another alternative to the rail casks and small truck casks.

There appear to be some typographical and/or mathematical errors in the tables and discussion relating to spent fuel transportation.

Table I-2 on page I-20 shows a total of 370 spent fuel packages per year in 1975 with a truck/rail split of 14.2/85.8 percent. However, the Baseline Shipment Information as shown on Table IV-1, page IV-11, shows 54 shipments by truck and 326 by rail for a total of 380. The percentage split in Table I-2 is compatible with the number of shipments in Table IV-1, so perhaps the 370 total packages per year is incorrect.

Acknowledged by card 7/2/76

ONE NORTH BROADWAY • WHITE PLAINS, NEW YORK 10601

In Chapter VI the discussion in Section B.1-6 indicates that seven times as many shipments will be required by truck as compared to rail. However, in Table VI-17, there are 380 shipments per year by truck and none by rail. This value should be 54 + 7(326) = 2336 if all 326 rail shipments are to be transferred to truck. If the radiological impacts as reported in Table VI-18 are based on Table VI-17, there may be significant errors in the results.

We also question the economics of spent fuel transport as reported in Section B.1-6.2. A recent study by the Edison Electic Institute on Nuclear Fuels Supply reported in Appendix V:

" The cost of transporting a normal spent fuel annual discharge for a 1200-1300 MWe reactor over a distance of 1000 miles to a reprocessing plant is about $680,000 using a legal weight truck, $275,000 using an overweight truck, $460,000-$530,000 for a non unit train, and $750,000-$860,000 or a unit train."

We suggest that the alternative for spent fuel transport be presented as follows:

Mode	Legal weight truck	Special permit truck	Rail
PWR elements/cask	1	3	7
Trip distance miles	1,000	1,000	1,000
Trips per year (1975)[1]	2,336	780	334
Cost per assembly[2]	11,300	4,600	7,600-14,300

1 Assumes only one mode used

2 Based on costs in EEI report and 60 assemblies per year for an 1100 MWe PWR

The radiological impacts should be calculated using the above values.

We would appreciate an opportunity to discuss this with you at your convenience. We will be glad to review the results to be published in the FES prior to publication. Please contact us if you have any questions.

Very truly yours,

Bill R. Teer
Vice President

Ne 'ork State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Peter A.A. Berle
Commissioner

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40 FR 23768)
Trans. Radioactive Mtl. by Air

June 3, 1976

Mr. Robert B. Minogue, Director
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Minogue:

The State of New York has completed its review of the U.S. Nuclear Regulatory Commission "Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes", issued in March, 1976. In preparing the enclosed comments, we have taken into consideration the views of interested State Agencies including those represented on the NYS Atomic Energy Council.

The draft statement (NUREG-0034) indicates that consequences of an accident involving shipments of plutonium vastly outweigh the consequences of transporting all other radionuclides.

Therefore, the State of New York urges the Commission to consider the environmental impacts, and the alternative modes of transporting Plutonium and the security implications thereof separately from all other radioisotopes. Only in this way can the environmental consequences, benefits to society, and costs of alternative modes of transport and packaging requirements be adequately assessed.

The draft statement should also discuss idemnification for any damages that may result from transportation of radioactive shipments made under Federal regulations including human exposure, contamination limits, etc.

Thank you for providing the State the opportunity to comment on this environmental statement.

Sincerely yours,

Theodore L. Hullar

Theodore L. Hullar, Ph.D.
Deputy Commissioner for
Programs and Research

Enclosure

Comments of the

STATE OF NEW YORK

ON THE

U.S. NUCLEAR REGULATORY COMMISSION

"DRAFT ENVIRONMENTAL STATEMENT ON

THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY

AIR AND OTHER MODES" (NUREG-0034) ISSUED

MARCH 1976

NRC DOCKET NO. PR-71,73

May 28, 1976

1. General Comment

The Draft Environmental Statement indicates that radiation exposure from no 1 transportation averaged over the number of people exposed is small. It would result in a statistical increase of one latent cancer fatality in the U.S. per year.

While the use of average exposure is reasonable to predict the effects resulting from normal transportation, the use of the estimated average accident risks can be misleading. The low average accident risk results from taking the very low accident risks associated with the large number (some 70% of total shipment) of radiopharmaceutical shipments and distorts the risks associated with the transportation of plutonium.

Table V-14 notes that the plutonium oxide accident risk analysis results for 1975 shipments indicate a risk total of 6.5 latent cancer fatalities. This same table notes that accidents involving the release of plutonium oxide would account for 99.8% of the total accident risks.

Tables VI-31 and VI-32 - these tables list alternative actions ranked in order of the impact in decreasing transportation risks. The first two alternatives, i.e., developing more stringent packaging standards for plutonium and establishing a 1% respirable plutonium criteria for shipment, should be given high priority and established as regulatory criteria. In addition, the third most significant alternative in reducing transportation risks, shipment of plutonium by rail, should by fully evaluated (including security implications) prior to authorizing resumption of shipment of plutonium by air.

The Draft Environmental Statement notes that the accident risks of latent cancer fatalities and early fatalities arise principally as a result of a very unlikely event of a major release of plutonium associated with the nuclear fuel cycle. The statement acknowledges that the consequences of such an accident, a ough very unlikely, could be severe for a few individuals. Accidents in a densely populated area were estimated to produce one fatality within 365 days and approximately 16 exposures sufficient to produce death from cardiopulmonary insufficiency in some cases. In addition, the Draft Environmental Statement notes th 'atent cancer fatalities associated with this major release are estimated at twenty per year over a 30-year period, or 600 cancer fatalities. The Draft Environmental Statement then indicates the probability of such an occurrence is estimated to be 10^{-9} per year in 1974.

In spite of the low probability of a major release of plutonium the severe consequences of the accident merits attention to the further analysis of the alternative transportation and packaging modes and security implications thereof in order to further reduce the probability of plutonium release in an accident. Therefore, New York State suggests that the alternative modes of transporting plutonium be considered separately from other radionuclides. In such a separate review, the need for developing an "air-safe" container for plutonium shipment must be considered as part of the requisite overall analysis of the environmental consequences (in normal and accident situations) of alternative modes of plutonium tr...sportation and packaging and the security requirements associated therewith.

2. General Comment

The concern for the severe consequences of the release of plutonium should not be used to require a major modification of packaging and shipping requirements of small quantities of radiopharmaceuticals, for example. However, the Draft Environmental Statement notes that packages being used for transportation of radioactive materials perform significantly better than the present packaging standards and that the present shipping procedures result in shipments well below the packaging and transportation index standards. It is, therefore, recommended that the present standards for packaging and shipping be made more stringent to reflect present practices. The report notes that this can be done without changing shipping practices and with no change in present overall risks. This would, however, prevent the in ease in exposure that would result from increased use of packages and shipping practices that would just meet the existing standards.

3. General Comment

The various modes of Transportation including options within each mode should be subjected to systematic analysis wherein all of the risks, (i.e., normal transportation; accidents and security consideration), are interrelated so that both the impact and a Transportation strategy could be developed. The Draft Environmental Statement fails to perform this function and, therefore, does not provide a meaningful comparison of the benefits and risks of alternative transportation modes.

4. General Comment

The draft statement should reference and thoroughly discuss the safety analyses performed for the development of spent fuel shipping containers and the accident parameters used to develop safety analyses.

5. General Comment

It is noted by the NYS Dept. of Commerce that the suggestions offered by the New York State Atomic Energy Council to the NRC on August 1, 1975 were generally addressed in the subject document. Although specific assumptions and input data may be subject to question, the methodology used in the DES is technically sound. The DES recognizes that the transportation of radioactive materials is a necessary and beneficial action, and that the associated risk is extremely small - several orders of magnitude less than other commonly accepted societal risks.

6. PI-24 Section I.D. · The last sentence of the middle paragraph states:

> "The annual numbers of spent fuel shipments for 1975 and for 1985 are estimated to be 370 and 3600 respectively."

The NYS Department of Transportation notes that the number of 370 shipments for 1975 appears to be too low for the following reasons.

a. NYS Department of Transportation has conducted a survey by mail of the nuclear power plants and government reactors that could be shipping spent fuel across New York State and to date have determined that 199 shipments of spent fuel were made from just two nuclear power plants and two federal reactors in 1975 across New York State.

b. Supplement 1 to WASH-1238 (NUREG 75/038) - "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants" includes on Pages 4, 5 and 6, a Table S-1, entitled Summary of Transportation Data for Nuclear Power Reactors. Table S-1 is the result of individual analyses by the Commission during the period January 1972 through March 1973 of the environmental impact of such transportation for 84 individual nuclear power reactors at 53 different sites.

Using the data for irradiated fuel shipments from Table S-1 and excluding movement by rail where optional methods of transportation were shown New York State Department of Transportation arrived at the following totals.

Irradiated Fuel	
Number of Truck Shipments	2516
Number of Rail Shipments	283
Total Shipments	2799

7. General Comment

The New York State Department of Health notes that the annual population dose during normal transportation is low and that shipments of radiopharmaceuticals, Mo-99 and radioiodines, represent a greater source of exposure than the shipment of spent nuclear fuel and plutonium oxide.

8. General Comment

Information should be added to the Draft Statement that clearly establishes the level of enforcement action being undertaken by the U.S. Department of Transportation, the Nuclear Regulatory Commission and various states in connection with the transportation of radioactive materials. This information should include tabular material about the number of inspections relating to radioactive materials that have been undertaken and the type and number of enforcement actions that have been taken in connection with radioactive materials during the last five years. There should also be an indication of the number of inspections that are scheduled during the coming year.

9. Pi-Summary and Conclusions - In the event that NRC proposes a significant change in the regulations for Transportation of radioactive material, an environmental impact statement must be prepared pursuant to NEPA for such a proposed federal action. NUREG-0034 will obviously be an excellent reference for such a study.

10. Piv, No. 7 - The Draft Statement indicates (P. iv) that a few individual transport workers whose radiation exposures exceed the limits established for members of the general public should be, and in most cases are monitored and otherwise treated as radiation workers. There does not seem to be clear indication of when such transportation workers are to be treated as radiation workers. It is necessary that workers required by their job to work with radioactive materials and radiation, whether in a laboratory or on a loading platform, are dealt with in a consistent manner. Therefore, it is important that the class of transportation workers and work situations involving significant shipments of radioactive materials should be identified so appropriate radiation protection measures can be taken. The regulations should be amended so that transportation workers likely to receive a dose in any calendar quarter in excess of 25 percent of the applicable value in paragraph (a) of 10 FER 20.101 are provided with appropriate personnel monitoring equipment

11. PI - 3 Section A - The Draft Statement indicates (P. I-3) that updated shipment information will be available in time for use in the fina version of the Statement. We urge that such shipping data be incorporated fully into the final Statement. The newer data, in other words, should be used not only to revise Tables I-2 and I-3 but also to recompute transport impacts and to reevaluate alternative transport modes in the event that the newer data warrents such effort. If this information significantly alters the results of the draft environmental statement, than NRC should issue another draft statement for comment prior to the issuance of a Final Environmental Statement.

12. PI 4 Section I.B. This section should present quantitatively the various applications for which radioactive materials are used and the benefits to society from these applications.

13. Pages I-4 and I -19

The DES uses a figure of 600,000 packages of radioactive material shipped annually. This differs from other estimates previously used, including an estimate of 800,000 packaged cited by the U.S. Atomic Energy Commission on page 61 of WASH-1238, dated December 1972. The reason for using the 600,000 figure should be indicated.

14. Page I-20

Table I-2 indicates that 85.8% of the estimated 370 spent fuel shipments transported in 1975 were shipped by rail and that the other 14.2% were moved by truck. This information does not agree with information provided to "The State" regarding 186 motor truck shipments of spent fuel to the West Valley, New York reprocessing plant in 1975. These shipments, which came from only two nuclear power stations would alone account for over 50% of the estimated 370 shipments.

15. Page I-25:

The first sentence of the second paragraph refers to "Figure I-2". It appears that it should refer to "Figure I-3".

16. Section V.B.

The basis is not provided for the distribution of accidents among the various population densities for each of the transportation modes considered. Although some description of the basis for the fractions used for aircraft accidents is provided, almost no basis is provided for expecting the low severity truck accidents to occur mainly in urban areas. If these assumptions are based on a statistical analysis, that analysis should be identified.

17. Section V.B. 2

This section indicates that in the case of accidents involving motor carriers the dominant factors in the determination of accident severity are crush and fire. Currently, packaging standards do not include crush specifications. It is recommended that the responsible regulatory agencies consider implementation of a crush standard.

18. Tables V-12 and V-13

These tables should include the consequences of accidents involving spent fuel.

19. Table V-13

For the 20 kg Pu Case, the number of persons receiving doses greater than 15 rem, 10^4 rem, and 10^5 rem are listed.

Since the number of persons receiving a dose greater than 15 rem is several orders of magnitude greater than those receiving a dose greater than 10^4 rem, the number of persons receiving doeses at intermediate levels should be provided.

20. Pages V-24:

The first sentence of the last paragraph refers to "Table V-2". It appears that it should refer to "Table V-6".

21. Page V-44:

Table V-11 does not identify the first radionuclide on the list. It appears that it should specify Plutonium.

22. Page V-54:

The last sentence of the first paragraph refers to a number of injuries and fatalities "per reactor year". It appears from what is presented previously in the paragraph that it should refer to the number of these events "per year".

23. Pg. V-57:

Justification should be given for assuming that the population at risk is 75 million persons.

24. General Comment

It is recommended that the environmental statement be expanded to include

24. General Comment - (continued)

Federal monies expended, (1) in the development of regulations and (2) in the enforcement of regulations followed by a discussion as to the optimal amount of money that should be expended to effectively minimize the hazard to the Public from the transportation radioactive materials.

DOCKET NUMBER
PROPOSED RULE [illegible]

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
OFFICE OF THE SECRETARY
WASHINGTON D.C. 20201

MAY 2 6 1976

JUN 7 1976

Mr. Guy A. Arlotto
Director, Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Arlotto:

We have reviewed the draft Environmental Impact Statement concerning the transportation of radioactive material by air and other modes. On the basis of our review, we offer the following comments:

1. We note that the June 1975 public comments on the proposed rulemaking concerning air transportation of radioactive materials are not included in the draft document.

2. Detailed Summary: As presently contained in the document, the detailed summary does not present the reader with a thorough examination of the probable effects expected to occur from a shipping accident involving radioactive materials. Information should be included in the final document on the individual effects of each of the various types of accidents that could happen, modes of shipment, and the identity and quantity of materials involved. These should be described with and without ameliorating actions and/or safeguards. Comparing the overall exposure to populations from accidents involving radioactive material to the overall exposure from other sources does not address the consequences of a shipment accident in absolute terms.

3. Page I-15: It is noted that the shipments listed and their modes of transport are representative of the radioisotope industry (Table I-1). There are no estimates for postal shipments, which probably use any and all modes of transportation. Although these are of small individual quantity, they may be large in volume.

4. Page I-19: Weapons shipments and all shipments in government-owned vehicles are not considered. These omissions may have seriously affected the calculations presented in the statement.

5. Page III-8: It is stated that the Biological Effects Ionizing Radiations (BEIR) report was used in the Health Effects Model. Actually, the Health Effects Model used is that found in Appendix VI of the Reactor Safety Study (WASH-1400). WASH-1400 significantly modified the risk estimates contained in the BEIR report by introducing "Dose Effectiveness Factors" (Table VI, 9-70, Appendix VI, WASH-1400). These factors do not access a straight linear extrapolation, (as does the BEIR report), making these risk estimates of low doses and dose rates used in the draft statement lower by a factor of five than those found in the BEIR report. It is erroneous to give the impression that the health effects calculated in this draft document would be equivalent to those that would be arrived at by using the BEIR report.

Also, references are made to studies which seem to indicate that rodents exposed to radiation have longer life spans. It has been theorized that radiation creates a more sterile environment, thus reducing the probability of respiratory infection in rodents, increasing their life span in a radiation environment. We are of the opinion that the draft statement should clearly state the reasons for an increased life-span among the rodents, as well as mention the above cited hypothesis.

6. Page III-9: The source should be cited for the statement that declares that EPA has adopted the dose limits proposed by the National Council on Radiation Protection (NCRP). We are of the impression that EPA is in the process of reviewing these radiation standards but has not agreed to the limits proposed by NCRP.

7. Page III-13: We suggest that line 12 in paragraph 2 read as follows: "Technetium -99 can be given in rather large quantities with little radiation dose." As presently used in the draft document, the word "dose" refers to pharmaceutical dose (which in this instance is not the case). Also a discussion of the short half-life of Technetium-99 should be included in the final document as a means to support the above statement.

8. Page III-13/14: It should be noted that the use of pertechnetate for brain scanning is relatively low, amounting to 1.5 million administrations during 1972. The impact of other technetium compounds and kits as well as ^{67}Ga, ^{75}Se, and ^{133}Xe should also be considered.

9. <u>Page III-15</u>: It is important that the basis for simplifying assumptions be documented, even if only briefly, since they can significantly influence the risk estimates.

10. <u>Page III-17</u>: We do not agree with the statement made in paragraph one. Soluble Plutonium is listed in Table III-7 and represents a material that can enter the food chain. Since I_{131} constitutes an inhalation hazard, it also represents a potential health threat to the food chain in the event that a dairy or truck farming area were to become contaminated.

11. <u>Page IV. Item 7</u> indicates that a few individual transportation workers might possibly be exposed to radiation limits which exceed those established for the public. The draft document devotes little attention to the problems of identifying, monitoring, and controlling the exposure to "truckers", "handlers" and others.

12. <u>Page IV-49, Statement 6</u>: The average individual dose from transportation is stated as 0.5 mrem/year. This is a factor of 2, not 20 less than the average per capita dose from radiopharmaceuticals (Table III-3).

13. <u>Page V-29, line (1)</u>: This represents two cycles incorporated into one and is usually referred to as "grass-cow-milk-man" and "grass-cow-man" cycles.

14. The statement does not project the latent cancer fatalities (LCF) or early fatalities (EF) to the year 1985. Although exposure is projected to increase by a factor of approximately 3 from 9589 (1975) to 28,590 (1985), this suggests the LCF could increase from 1.2 in 1975 to 3.6 in 1985 as a result of normal transport only. Assuming the increase of a factor of 3 and an essentially equivalent population exposure, one may project the fatality date on pg. xx to be as follows:

	1975	1985
Early Fatality	1	3
Other deaths	16	48
Latent cancer deaths (30 yr. period)	600	1800

The alternative analysis is based on current shipment impact, pg. VI-1, and does not appear to be projected in terms of conditions which might be expected in 1985. Essentially, the alternatives are compared on a basis of cost benefit vs. radiological effects(s), pgs. VI-1 and VI-3. If one accepts the figure of 8.22×10^6 per LCF or any other death, an investment benefit in terms of citizen protection may be calculated.

It is therefore suggested that as a minimum alternative B.3-1, Restriction of Physical and/or Chemical Form, of B.4-1, Revision of Packaging Standards, be required for radioactive material shipments.

Thank you for the opportunity to review the document.

Sincerely,

Charles Custard
Director
Office of Environmental Affairs

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

ER-76/290 DOCKET NUMBER PROPOSED RULE PR-71, 73 (40FR23768) JUN 8 1976
Trans. Radioactive Mtl. by Air

USNRC JUN 15 1976 Office of the Secretary Docketing & Service Section

Dear Mr. Arlotto:

Thank you for your letter of March 24, 1976, requesting our comments on the draft environmental statement on the Transportation of Radioactive Material by Air and Other Modes (Docket No. PR-71, 73, dated March, 1976).

Our comments are submitted according to the format of the statement or by subject.

Detailed Summary

It would be helpful to summarize the proposed action more clearly at the outset of the environmental statement. We conclude that it is proposed to continue regulating the transport of radioactive materials under present Federal regulations, pending completion of further studies of the costs and effectiveness of alternate transportation systems. While these studies are referred to generally (i.e., page v, paragraph 3), we find no summary of the specific studies in progress or of their expected date of completion.

The non-radiological consequences of accidents involving vehicles used solely for transport of radioactive materials are variously given as "two injuries and less than one fatality each four years" (for example, page iii, page xx, page xxiii). It would be advisable to use the same terminology throughout. In addition, some indication should be given of what percentage of transport is by vehicles used solely for transport of radioactive materials; otherwise, the figures on non-radiological consequences of accidents have little or no meaning or relevance to an evaluation of overall risk to individuals.

Acknowledged by card 6/16/76

CONSERVE AMERICA'S ENERGY

Save Energy and You Serve America!

Since hydropower is a significant conventional energy source, we suggest revision of the ninth line of page xxiv, by adding the words "such as by fossil-fuel plants" at the end of the sentence.

Introduction

Throughout the statement there is little information on the adequacy of regulations as applied to the transport of large-curie radiation sources that are stated to contain as much as hundreds of thousands of curies, for use in large-scale sterilization operations (page I-9). These are described as consisting chiefly of the radioisotopes cobalt-60 and cesium-137. Large curie sources of up to 10,000 curies are also said to be shipped to cancer treatment centers both in the United States and abroad, with overseas transport by ship and domestic transport by truck or rail (page I-9, paragraph 2). However, we found little or no information on the size or weight of the casks, or particularly on the adequacy of protection afforded the transport of the large-curie radiation sources under existing regulations.

Tabular data in Chapter I, that appears to provide comprehensive information for most classes of radioactive materials shipments, provides little or no information on the large-curie radiation sources, which appear to be among the potentially most hazardous materials shipped. For example, Table I-2 (page I-20) shows no shipment class having an average of more than 5,000 curies per package. We feel that comparable information, including the number of packages shipped annually in 1975 and 1985, should be provided for the teletherapy sources containing up to 10,000 curies of radioactivity and for the radiation sources that contain as much as hundreds of thousands of curies of activity, particularly in view of the fact that some of these large-curie sources are said to be shipped to locations abroad and by means of truck, rail, and ship. These shipments appear particularly important for inclusion in this evaluation because it is noted that 6,600 industrial 100-curie sources were estimated to be shipped in 1975 (Table I-2), but a single shipment of a radiation source containing hundreds of thousands of curies of radioactivity appears to be potentially as hazardous as thousands of the 100-curie-source shipments.

Transport Impacts Under Normal Conditions
Several statements suggest that the study is based on surprisingly incomplete information in some important areas pertinent to transport of radioactive materials. For example, it is stated: "While no specific information is at hand to suggest that radioactive materials are not shipped on passenger trains, no evidence of such use was discovered in an informal survey of the industry" (page IV-31, paragraph 1). This suggests that the facts now available to the staff provide no information on whether or not radioactive materials are shipped on passenger trains. It is also stated that "it is suspected that barge may be a method for transport of new and spent fuel to reactors and reprocessors located on appropriate waterways" (page IV-34, paragraph D.4-1). This lack of certainty on the part of the Nuclear Regulatory Commission regarding even the basic mode of transport in use for such materials does not provide reassurance that transport of radioactive materials is being carefully regulated in all cases.

Security and Safeguards
Chapter VII, concerning security and safeguards, raises further concerns relative to the transport of the large-curie radiation sources discussed previously. It is noted that one of the two groups of nuclear material that may require safeguarding consists of "a few radioisotopes such as cobalt-60," the other group being Special Nuclear Materials (SNM), and it is stated further that "isotopes such as cobalt-60 could be used by a terrorist in the form of a dispersal weapon" (page VIII-1, last paragraph). However, only the safeguarding of the SNM appears to have been considered in depth. Specific mention of the adequacy of present regulations to assure the safety and security of the large-curie sources containing cobalt-60, particularly when shipped overseas, should be presented in the final statement.

It has been stated that "other materials, such as cobalt-60, which are in special form, might be stolen and then dispersed in a highly populated area" (page VIII-7, paragraph 3). In spite of acknowledgment of the hazard, there is no specific discussion of risks in shipment of the high-curie sources or of adequacy of safeguards provided by existing regulations, even though these could contain several hundred thousand curies, evidently largely of cobalt-60. It is stated that "adequate safeguard measures are available if it is determined that some isotopes need added protection" (page VII-12, paragraph 1), but the need has evidently not yet been fully evaluated with respect to shipments of large quantities of cobalt-60.

The report does not specifically analyze consequences of accidents resulting in significant quantities of radioactive materials entering surface waters. While the probability of such occurrences would no doubt be very low, such an analysis might still be desirable to determine if conditions could arise requiring emergency measures to protect public water supplies.

Sincerely yours,

Stanley D. Doremus

Deputy Assistant Secretary of the Interior

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D. C. 20555

DOCKET NUMBER PROPOSED RULE PR-71,73 (FR23768) Trans. Radioactive Mtl. by Air

STATE OF NEW YORK
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LOUIS J. LEFKOWITZ
ATTORNEY GENERAL

PHILIP WEINBERG
ASSISTANT ATTORNEY GENERAL
IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

May 17, 1976

JUN 16 1976

Director
Office of Standards Development
United States Nuclear Regulatory
Commission
Washington, D.C. 20555

Re: Comments on the Nuclear Regulatory Commission's Draft Environmental Impact Statement on the Transportation of Radioactive Materials (NUREG-0034)

Dear Sir:

Pursuant to Notice of Availability of the above-referenced Draft Environmental Impact Statement ("DES") published at 41 Fed. Reg. 12937 and the solicitation of comments on that DES as contained in the Notice of Availability, the New York State Attorney General submits herewith comments on certain portions of the Draft Environmental Impact ("DES") from this office. Comments on other portions of the DES are in final preparation and will be submitted shortly hereafter. These additional comments will, in part, relate to the analysis in the DES of toxicity of materials, containerization, and overall risk analysis.

The DES if adopted as a Final Environmental Impact Statement ("FES") without major revision by the NRC will constitute a legally inadequate EIS under the National Environmental Policy Act, ("NEPA") 42 U.S.C. § 4321 et seq. The DES does not address many of those issues set forth in materials previously submitted by this office to the NRC in the course of this administrative proceeding as originally noticed in the Federal Register. 40 Fed. Reg. 23768. Moreover, the DES does not address those issues discussed in the affidavits of Theodore T. Mason and Robert R. Leamer dated November 30, 1975 and January 20, 1976 previously submitted to the United States District Court for the Southern District of New York in the case of the State of New York v. The Nuclear Regulatory Commission (75 Civ 2121 [WCC]), copies of which are enclosed. These affidavits should be treated as sealed documents. Similarly the NRC should address those problems cited by John F. Shea, III, in the affidavits submitted in that court action, dated December 11, 1975 and January 20, 1976 and Captain James A. Eckols, dated November 28, 1975. Copies of all of these affidavits are enclosed.

In addition to the comments previously and now submitted to the NRC on this transportation issue and apart from those soon to be filed by this office with the NRC, several other more general comments are pertinent to a discussion of the DES and ultimate impact statement adequacy:

1) The DES fails to discuss in any way shipments of special nuclear materials ("SNM") and other radioactive substances by the Energy Research and Development Administration ("ERDA"). These shipments should be described in detail as to substance, quantity, and number. Of course a risk analysis of these shipments should be made.

2) More detailed discussion of the substance, quantities and numbers of shipments by NRC licensees should be included in the DES.

3) One of the most glaring inadequacies of the DES is the failure to give a meaningful assessment of the hazards of shipments by the water mode. Two pages of cursory discussion in the DES is given to this major alternative (pp. IV-34-35).

4) The DES safeguards discussion bases portions of its analysis on the as yet incomplete and unreleased analysis of safeguards in the Generic Environmental Statement on the Use of Recycle Plutonium in Mixed Oxide Fuel in LWR's. WASH 1327 ("GESMO"). General references to uncompleted studies in other proceedings render the DES legally inadequate.

The NRC must recognize, of course, that the execution of a generic review of this transportation issue and the drafting of a generic environmental impact statement will not satisfy the NRC's full obligation under NEPA. In this regard see the points raised in the affidavit of John F. Shea, III, dated January 20, 1976, as to the scope of the NEPA review process necessitated by this transportation issue.

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
By

John F. Shea III

JOHN F. SHEA, III
Assistant Attorney General

JFS:rab
Enc.

JUN 1 6 1976

USNRC JUN 1 6 1976

Mr. Louis J. Lefkowitz, Attorney General
State of New York Department of Law
Two World Trade Center
New York, New York 10047

Dear Mr. Lefkowitz:

Thank you for your letter dated May 17, 1976 commenting on the Nuclear Regulatory Commission's Draft Environmental Statement on the Transportation of Radioactive Materials (NUREG-0034)

Your letter requested that two of its enclosures be treated as "sealed documents". We have considered this to be a request for withholding those two enclosures from public disclosure, a request subject to the provisions of Part 2, "Rules of Practice", and Part 9, "Public Records", of Title 10, Code of Federal Regulations, copies of which are enclosed. Since your request contained no reasons recognized in those regulations for nondisclosure of the two documents, your request is denied without prejudice to your future resubmittal. The two enclosures to your letter dated May 17, 1976, identified as affidavits of Theodore T. Mason and Robert R. Leamer dated November 30, 1975 and January 20, 1976 are hereby returned to you, and will not be considered as comments on the Commission's Draft Environmental Statement NUREG-0034

Sincerely,

ORIGINAL SIGNED BY [illegible]

Robert B. Minogue, Director
Office of Standards Development

Enclosures (original only):
1. 10 CFR Part 2, "Rules of Practice"
2. 10 CFR Part 9, "Public Records"
3. Affidavit dated November 30, 1975
4. Affidavit dated January 20, 1976

TP513-1

bcc: Public Document Room (PR 71, 73 40 FR 23768)

COMMENTS OF THE NEW YORK STATE ATTORNEY GENERAL ON THE DISCUSSION OF SAFEGUARDS IN THE NUCLEAR REGULATORY COMMISSION'S DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY AIR AND OTHER MODES
NUREG 0034

By

THEODORE T. MASON

ROBERT R. LEAMER

Introduction

1. Three affidavits were submitted by Robert R. Leamer and Theodore T. Mason, dated 16 June, 1975, 30 November, 1975 and 20 January, 1976 to the United States District Court for the Southern District of New York in the case of the State of New York v. The Nuclear Regulatory Commission, et al. Copies of these affidavits have been provided to the Nuclear Regulatory Commission ("NRC") in the course of this proceeding dealing with the transportation of radioactive materials as originally noticed in the Federal Register. 40 Fed. Reg. 23768. References to the "plaintiff" in these comments on the Draft Environmental Impact Statement ("DES") are, of course, to the State of New York. Occasionally references are made to the "defendants" and "defendants' affidavits"; these references are to the NRC and its sister agencies which are involved with the transportation of radioactive materials and the affidavits which this agency and its sister agenices have filed in the litigation initiated by the State of New York.

The prior Mason/Leamer affidavits were submitted to:

a. demonstrate that there is a substantial likelihood a highly motivated group of terrorists could be successful in destroying or seizing for destructive use special nuclear materials (SNM) in the course of commercial air transport, or related connecting transport, notwithstanding existing safeguard regulations and/or actual practice;

b. indicate that the military has the current safeguard capability to move SNM by surface transport which is significantly less vulnerable to terrorists than commercial air transport and related connecting transport;

c. specifically evaluate the air transport of uranium (as opposed to plutonium) and demonstrate that any one of five (5) military assisted transportation system alternatives is significantly more secure against terrorist action than commercial air transport, because of:

(1) rigorous control of future shipment movement information;
(2) more secure in-transit communications;
(3) reliable and highly motivated personnel with security training and clearances;
(4) appropriate selection of weapons and vehicles;
(5) superior reaction capability;
(6) physical remoteness of airfields and facilities;
(7) psychological deterrent of a U.S. military protection force.

d. indicate that points contained in J. Edlow's affidavit submitted by defendants and in the MITRE Report prepared for the Nuclear Regulatory Commission (MITRE Technical Report 7022, September, 1975, The Threat to Nuclear Facilities), corroborate the findings of Mr. Leamer and myself regarding the vulnerability of commercial air and related connecting transport systems, including the following points:

(1) "Expediting" as practiced under current Part 73 Regulations and described by Mr. Edlow may provide notice after a shipment of SNM has been misrouted or diverted and may help prevent casual theft. However, it will not prevent determined terrorist attacks or organized theft. Shipment preplanning integral to "expediting," without stringent information control, could substantially aid a terrorist in seizing or destroying SNM in transit.

(2) There have been no less than 26 commercial aviation-related terrorist acts in the last 6 years; carriage of SNM in commercial aircraft provides terrorists with an additional incentive; the MITRE Report observed that terrorism has become commonplace in the Western World and weapons of large caliber and full-automatic fire can be easily procured;

(3) The transportation industry is heavily infiltrated with criminals, corruption, employee collusion, and has been characterized by Sam Edlow as untrustworthy, incompetent, and operating in an environment of criminality; the MITRE Report has observed that a veritable army of criminals and hoodlums in this country is waiting and willing to undertake any activity, including murder, if profit justifies it.

Purpose of this Affidavit

2. The purpose of this affidavit is to evaluate, as well as possible within the brief time available, the Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, March, 1976 ("DES"), as a response to the previous affidavits of Mr. Leamer and myself.

Military Assisted Transportation Alternatives For Uranium

3. The only discussion of military assisted air transport alternatives in the DES is limited to approximately one-half of a page (p. VII-12). What little discussion there is emphasizes only the military airfield aspect of these alternatives. It is apparent that the 5 military assisted options for uranium transport detailed in our affidavit of 30 November, 1975 (pp. 4-7) were not considered.

4. The DES does admit that the use of military airfields and/or aircraft "appears technically feasible." However, in a footnote, the DES suggests that the use of military airfields and aircraft may be prohibited and cites a law said to provide that: "Except as otherwise provided by law, sums appropriated for the various branches of expenditure in the public service shall be applied solely to the objects for which they are respectively made." 31 U.S.C. 628. In light of the obvious danger to the national security inherent in commercial air transport and related connecting transport of SNM, the failure of the DES to demonstrate that there are no sums appropriated which might properly be applied to the use of military airfields and aircraft for transport of uranium is significant.

5. The statement that "adequate protection can be afforded at civilian airfields" (VII-12) is not supported by substantive discussion and misses the point that a military airfield has numerous advantages including inherent security, control of movement information, cleared, motivated and trained personnel, reaction capability, and location outside of highly populated areas.

6. Even though the DES makes no specific mention of military helicopters, it does make brief reference to helicopters generally (VII-13). This reference to helicopters, and STOL aircraft, together with their range and payload parameters, is without any quantification and hence without substance. After all this time, only conclusory speculation is offered. It is generally

known, however, that a wide range of helicopters is used in the military and in industry with considerable flexibility in range and payload. In fact, a quick check reveals, for example, the following:

Helicopter Manufacturer/Type	Range	Payload (lbs.)
Boeing Vertol model 234	240 nm. 320 nm.	20,000 4,000
Bell model 222 (undergoing certification)	425 nm.	1350 (Estimated)

Military Assisted Transportation Alternatives for Plutonium

7. The DES makes no reference whatever to the military surface transport alternatives for shipment of plutonium set forth in our Affidavit of 16 June 1975, pages 20 through 22.

Terrorist Use of SNM

8. In our Affidavit of 16 June 1975, pages 14-16, we cite a number of authorities in support of the following propositions:

a. that the information necessary for the design of a nuclear device is publicly available; and

b. that a technically competent group of terrorists could fabricate an effective, even if crude, nuclear device notwithstanding the fact that it had no prior experience in fabricating such a device.

Notwithstanding some discussion regarding the benefits of prior experience in the fabrication of such a device, the DES admits that persons without such experience could produce a device with a low tonnage yield, apparently a yield of one kiloton or less, or even a device with a substantial yield (F 1-3). Moreover, the DES admits that "the potential consequences arising from any nuclear explosive are so serious as to warrant the utmost vigilance, however low the probabilities may be." (F-2). The DES places great emphasis on the supposed difficulty of "emplacement" of a nuclear device because law enforcement agencies would be watchful (p. F-4). However, this is not very comforting when one considers the almost infinite opportunities for emplacement in a large city.

9. On page VII-7, 8 the DES admits that plutonium oxide can be used as a dispersant in weapon form or by dispersing plutonium in transit by bursting its container and that such use would have serious consequences. However, in Appendix F, page F-4, the consequences of using plutonium oxide are said to be uncertain and such use is said to be inconsistent with observed behavior of terrorists. Peter Skinner's Affidavit of 2 May, 1975 indicates that the consequences of use of plutonium oxide as a dispersant are not uncertain. While it may true that terrorists have not yet used poisonous agents, that does not mean that they will fail to use them in the future. Moreover, terrorists might find particular appeal in a radioactive poison, not only because of its greater psychological value (over more conventional poisons), but also because of its extremely long life, assured effectiveness and its particular macabre method of destroying human tissue.

DES Discussion of Current Policy, Regulation and Practice

10. The DES makes a significant admission regarding the NRC's overall policy on safeguards. The DES states (VII-2) that, while safeguards must be capable of preventing acts which could result in a "major civil disaster," safeguards need only provide a "high degree of protection" against acts that could result in "serious civil damage." No justification or analysis is presented to support such a policy and no definitions are provided for any of the salient concepts employed. One would think that, given the immense danger posed to the public by terrorist use of SNM, safeguards should be capable of preventing any such use.

11. Plaintiff pointed out in the Mason/Leamer Affidavit of 20 January, 1976 that the provisions of 10 CFR 73 apply only to licensees shipping certain amounts of SNM computed by formula, which include 5,000 grams or more of U235 enriched to 20 per cent or more, or 2,000 grams or more of plutonium. Failure to subject smaller quantities to such regulations subjects the public to significant dangers specified in the above-mentioned Mason/Leamer

Affidavit. The DES does not respond to this point.

12. Plaintiff has demonstrated in three affidavits that the current requirements and practice regarding safeguards are inadequate to cope with the terrorist threat. The DES does not address itself in any meaningful way to the inadequacies previously specified by plaintiff. Indeed, the DES admits (VII-3) that "present requirements are designed to protect against theft, diversion, or sabotage by one or two employees with access to the plant and material, by a small armed force attacking a plant or vehicle, or by both acting in combination." "[S]mall force" is not defined in the DES. But, as to nuclear facilities, the Atomic Energy Commission ruled that licensees were only responsible for providing adequate security to repel not more than one or two individuals acting in concert (Nuclear Fuel Services Inc. - NRC Docket #50-201, Atomic Safety Licensing Board Decision, November 29, 1974, p. 11). However, it is almost certain terrorists would employ 4, 5 or more persons. Moreover, the AEC ruled that licensees were not required to protect nuclear facilities against a well armed band of saboteurs whatever the size of the band; licensees need only concern themselves with "an amateur group" (Id. p. 15).

13. Given the purpose for which the safeguard requirements (10 CFR 73) were designed it is not surprising that the requirements and practice are grossly inadequate to cope with terrorism.

14. The DES fails to respond to plaintiff's previously specified criticisms of various aspects associated with the use private guards: inadequate training, lack of security clearances, low pay, and lack of military type motivation. When the DES discusses the number of guards employed it is misleading. At one point (VII-10), it states that in truck transport "the number of guards would be varied to suit the particular shipment and preceived [sic] threat;" the regulations do not require this. At another point (VII-4), the DES states that, when cargo aircraft are used, enroute transfers must be observed by more than one armed person; the regulations do not necessarily so require.

15. Plaintiff has previously pointed out that the weapons and vehicles employed by private guards are inadequate for coping with the terrorist threat. The DES offers no meaningful response.

16. Nevertheless, the DES (VII-6) makes the bold assertion: "Licensee guards are expected at all times to (1) interpose themselves between SNM and any adversary attempting entry and (2) intercept anyone exiting with such material. A sufficient degree of force should be applied to counter that degree of force directed at them, including the use of deadly force . . . Considering the number of personnel and the weapons selection likely on both sides in a confrontation with terrorists, it would be tantamount to suicide for licensee guards to act in the manner suggested by defendant.

17. Plaintiff has previously demonstrated the wide dissemination of information regarding future SNM shipments (Affidavit of Peter Skinner, 2 May 1975) and emphasized the danger which this presents. The DES makes no response. Plaintiff has also pointed out the inadequacy of current communication systems used in commercial SNM transport. Again, the DES fails to respond.

18. The DES (VII-10) asserts that local law enforcement agencies located along a truck route would supply a secondary response. This is all well and good but for the fact that the regulations do not require communication equipment or frequency of contact which assures that such persons would be alerted when required. In connection with truck transport from airports to facilities, the DES (VII-11) states that convoys will have the additional protection of the facility's security force to act as a response capability, but fails to deal with the practical aspects involving distance, transport, communications, and on site responsibilities. The DES statement (VII-11) that "airplane security personnel" would be present during airport SNM transfers in addition to the guards accompanying the truck is not supported by the regulations. The regulations do not provide for armed airplane security personnel.

19. With regard to deterring an attack the DES places great emphasis on psychology (VII-8); this is ironic in light of the reluctance of the DES to give any meaningful consideration to use of military capabilities.

20. The statement in the DES that hardware and techiques are currently available to allow an effective recovery effort is inexplicable in light of the admission that recovery cannot be relied upon as the strong link in the security system. (VII-9)

21. With regard to monitoring and inspection of safeguard systems, the statements in the DES (VII-5) appear to be wishful thinking. Not even the DES claims this monitoring and inspection of SNM transport actually occurs.

Conclusion

22. The fact that the DES fails to respond to the plaintiff's previous affidavits is not surprising when one notes that the DES admits that an "in depth analysis of safeguards" is currently being undertaken (VII-9) and that studies are being completed to determine "the cost and effectiveness of alternative systems" to safeguard SNM (VII-15). Thus, at this late date, NRC admits that it has not yet analyzed and studied the safeguards issue involved in the air and related connecting transport.

Dated: New York, New York
April 9,1976

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

-----------------------------------x

THE STATE OF NEW YORK,

Plaintiff,

-against-

THE NUCLEAR REGULATORY COMMISSION, et al.,

Defendants.

-----------------------------------x

AFFIDAVIT IN FURTHER SUPPORT OF PLAINTIFF'S MOTIONS

STATE OF NEW YORK)
: SS.:
COUNTY OF NEW YORK)

JOHN F. SHEA, III, being duly sworn, deposes and says:

1. I am an Assistant Attorney General in the office of LOUIS J. LEFKOWITZ, Attorney General of the State of New York, and I make this affidavit in further support of plaintiff's motions for a preliminary injunction and summary judgment.

2. The January, 1976 affidavit of Robert F. Barker of the Nuclear Regulatory Commission ("NRC") states that the preparation of an Environmental Impact Statement on the Transportation of Radioactive Materials By Air ("EIS") "is intended to satisfy the procedural and substantive requirements of the National Environmental Policy Act of 1969." (p. 1) It is still not clear, however, whether this "study" will include an assessment of several items such as ERDA shipments by air of special nuclear materials ("SNM"). Compliance with NEPA is, of course, an impossibility if ERDA actions are not subjected to scrutiny under the Act.

3. The NRC may or may not issue further environmental

impact statements, in addition to the generic EIS, in an attempt to satisfy the NEPA mandate. Compliance with NEPA would be an impossibility if all that was conducted was a generic review of these federal actions. Many issues not amenable to generic treatment are involved in the air transport of SNM. For example, the site-specific problems of such transport through the individual metropolitan regions of New York, Los Angeles, Detroit or Minneapolis-St. Paul, do not lend themselves to treatment in a single generic EIS. Similarly, for example, the issuance of at least some licenses by NRC, and at least some ERDA shipments, will demand NEPA assessment in individual EIS's. It must be remembered that plaintiff maintains that individual federal actions of licensing, approving, allowing or executing, directly or indirectly, the air transport of special nuclear materials constitute separate major federal actions significantly affecting the environment and requiring environmental impact statements.

4. Finally, procedural compliance with NEPA will only be possible when environmental review procedures implemented, including EIS preparation, are truly adequate under the Act. This issue may not be prejudged.

5. The Jackson Amendment restricting certain air shipments of plutonium by ERDA was signed into law on December 31, 1975.

6. In defendant's memoranda of law in opposition to plaintiff's earlier motion for a preliminary injunction, air transport of SNM was seen as being vital to the U.S. role of being a "dependable supplier" of SNM abroad. "Our role as a principal supplier of nuclear materials permits the United States to further its foreign policy objective of curtailing the proliferation of nuclear weapons." (Def. Mem. of Law, June 6, 1975, p. 5).

It is significant that, on Monday, January 19, 1976, the first chairman of the former Atomic Energy Commission, David E. Lilienthal, said that the United States must immediately and unilaterally "Order a complete embargo to the export of all nuclear devices and all nuclear material" to avoid the "impending disaster" of the rapid international spread of nuclear bombs. (New York Times, January 20, 1976, p. 2, cols. 4-6, copy attached as Exhibit "A").

7. It is respectfully requested that the affidavit of Messrs. Mason and Leamer, dated 20 January, 1976, be sealed.

JOHN F. SHEA, III

Sworn to before me this
20th day of January, 1976

Assistant Attorney General
of the State of New York

NEW YORK TIMES, JANUARY 20, 1976, p.2, cols.4-6.

U.S. Export Ban on Nuclear Equipment Urged by Former Atomic Energy Chief

By DAVID BURNHAM
Special to The New York Times

WASHINGTON, Jan. 19—The first chairman of the Atomic Energy Commission said today that the "impending disaster" of the rapid international spread of nuclear bombs required that the United States immediately and unilaterally end the shipment of nuclear equipment to all foreign countries.

The call was made at a Senate hearing by David E. Lilienthal, chairman of the commission from 1947 to 1950.

Two fellow panelists at the hearing, Dr. Hans A. Bethe and Dr. Herbert F. York, said they would support a temporary embargo of nuclear shipments, now estimated to earn the United States more than $1 billion a year, if it was the first step in a major diplomatic effort to develop an effective international system to control the spread of nuclear weapons.

Dr. Bethe, a Nobel Prize winner, director of theoretical physics for the Manhattan Project in World War II and professor of physics at Cornell University, has been an outspoken advocate of nuclear power as a source of energy. Dr. York, director of the Lawrence Radiation Laboratory at Livermore, Calif., during the development of the H-bomb, is a professor of physics at the University of California, San Diego.

"If a great number of countries come to have an arsenal of nuclear weapons, then I'm glad I'm not a young man and I'm sorry for my grandchildren," Mr. Lilienthal, now the head of an international consulting firm, said at the Senate Government Operations Committee hearing.

Six countries are known to have developed atomic weapons—the United States, the Soviet Union, Britain, France, China and India. But within four years, 25 countries are expected to be operating nuclear power reactors and developing within their borders a growing familiarity with nuclear technology.

"The tragic fact is that the atomic arms race is today proceeding at a more furious and more insane pace than ever," Mr. Lilienthal said. "Proliferation of capabilities to produce nuclear weapons of mass destruction is reaching terrifying proportions."

"We have to decide now what we can do, now, within our own capabilities, to prevent a very bad situation from becoming a disastrous and inevitable one," he said.

"I therefore propose as a private citizen that this committee, with its great prestige, call upon the Congress and the President to order a complete embargo to the export of all nuclear devices and all nuclear material, that it be done now, and done unilaterally," Mr. Lilienthal continued.

"Further, unilaterally, the United States should without delay proceed by lawful means to revoke existing American licenses and put an end to the future or pending licensing to foreign firms and governments of American know-how and facilities paid for and created by American taxpayers' funds and American brains."

Asked about the proposed embargo, Dr. Bethe said: "When I first heard about it and read it, I didn't like it. But I now like it when Mr. Lilienthal said the embargo was temporary until we worked out real controls. But we have to make clear that the embargo is temporary until a treaty can be concluded between nuclear countries that really assures control over proliferation."

Dr. York, in response to the same question, said, "My views are similar to Dr. Bethe's. As the first part of a major initiative to try to do something, it seems good."

Mr. Lilienthal said that if the United States, the world's major nuclear supplier, unilaterally embargoed the export of nuclear equipment, the other countries that have gradually begun selling reactors and other nuclear equipment to less developed nations such as Brazil would also cease their exports.

The two other panelists also [illegible] about [illegible] the United States should take to curtail the spread of weapons. Dr. York recommended that it cut off all nuclear shipments to the scores of nations such as France and Japan that have not ratified the 1968 treaty on the nonproliferation of nuclear weapons.

Dr. Bethe recommended that Congress immediately pass a law forbidding the export of the so-called "breeder reactor." This reactor, now under development by the United States, is designed to create more plutonium than it burns. In addition to serving as reactor fuel, plutonium can be fashioned into atomic bombs.

Senator Abraham A. Ribicoff, the Connecticut Democrat who heads the committee, called for a detailed study of the present weapons controls. "If the system is inadequate—and there are several experts who insist it is—then we must acknowledge these inadequacies and organize our Government to deal with them effectively and fast," he said. "Otherwise our nation and the world are in peril."

EXHIBIT "A"
J-86-18

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

---x

THE STATE OF NEW YORK,

Plaintiff,

-against-

THE NUCLEAR REGULATORY COMMISSION,
et al.,

Defendants

---x

AFFIDAVIT IN SUPPORT OF MOTION FOR PRELIMINARY INJUNCTION AND SUMMARY JUDGMENT

75 Civ. 2121 (WCC)

STATE OF NEW YORK)
: SS.:
COUNTY OF NEW YORK)

JOHN F. SHEA, III, being duly sworn, deposes and says:

1. I am an Assistant Attorney General in the Environmental Protection Bureau of the New York State Department of Law and am assigned to this action. I make this affidavit in support of plaintiff's motion for a preliminary injunction and for summary judgment.

2. The State of New York is making the instant motion for a preliminary injunction notwithstanding the Court's previous denial of a motion for a preliminary injunction by an order dated September 9, 1975. In making the motion, we rely on all previous affidavits, letters and memoranda submitted to the Court in the action, as well as an additional affidavit by Theodore T. Mason and Robert R. Leamer, sworn to November 30, 1975, which we respectfully ask to be sealed, an affidavit by Captain James A. Eckols, sworn to November 28, 1975, and this affidavit. In this motion we seek to clearly set forth a distinction between the

preliminary injunctive relief which we seek with regard to plutonium and that which we seek with regard to uranium, other than uranium enriched in the isotope U-233. U-233 is not a subject of the preliminary injunction motion because at present we are unaware of any immediate plans to transport such material by air.

3. Plaintiff continues to seek the cessation of all air transport and related connecting transport of plutonium, because the danger of dispersion of this highly toxic material in an aircraft accident poses a grave threat to human life quite apart from the threats of terrorism. As for the threat of terrorism regarding plutonium, the Mason/Leamer affidavit sworn to July 16, 1975, pointed out that military assisted surface transportation is significantly less vulnerable to terrorist acts than the present commercial air transport system.

4. With regard to uranium (other than uranium enriched in the isotope U-233), plaintiff seeks a lesser remedy, i.e., the cessation of all commercial air transport and related connecting transport. This lesser remedy is sought because such uranium materials do not present the same toxic threat as plutonium. Nevertheless, as indicated in the Mason/Leamer affidavit sworn to June 16, 1975, and the affidavit of Peter N. Skinner sworn to July 31, 1975, uranium, like plutonium, could be fashioned into a practical nuclear explosive by terrorists. As also indicated in that Mason/Leamer affidavit, the commercial air transport system is highly vulnerable to terrorist interception of uranium. Finally, as indicated in the Mason/Leamer affidavit sworn to November 30, 1975, submitted herewith, military assisted transportation alternatives are far less vulnerable to such terrorist interception. Plaintiff particularly urges that alternative (1) suggested by Messrs. Mason and Leamer for the transport of uranium, i.e., the

use of military airplanes flying between military airfields with short hauls by military helicopter, is appropriate (Mason/Leamer Affidavit, sworn to November 30, 1975, pp. 4-5).

5. In addition to clearly setting forth a distinction between the preliminary injunctive relief sought with regard to plutonium and that sought with regard to uranium, we submit in this motion additional facts, set forth in the Mason/Leamer and Eckols affidavits submitted herewith, which demonstrate the irreparable harm which may result from failure to grant the requested relief as to plutonium and uranium.

6. I should also point out that the Congressional bill which the Court described at page 10 of its opinion of September 9, 1975, as restricting air shipments of plutonium by the Energy Research and Development Administration ("ERDA") has not become law. On December 3, 1975, I spoke with John Bell, Legislative Aide to Congressman James H. Scheuer. Mr. Bell informed me that the ERDA legislation, to which the Jackson Amendment regarding ERDA's shipment of plutonium by air transport was added, had been held up in a Senate-House Conference Committee since early fall. The delay in that Committee, Mr. Bell noted, was not due to the Jackson Amendment, but rather due to other Senate amendments. On December 2, 1975, the Committee reached final agreement on all issues but the Report had not reached the House and Senate. The Report retains verbatim the language of the Jackson Amendment.

7. The State of New York is also making a motion for summary judgment which declares that defendants' actions in licensing, approving, allowing and executing, directly or indirectly, the transportation by air and related connecting transport of special nuclear materials without having prepared, circulated for comment and filed adequate Environmental Impact Statements concerning the transport of all special nuclear

materials to, from, in, or over the City and State of New York and the United States and its territories are in violation of the National Environmental Policy Act, 42 U.S.C. § 4321, et seq. ("NEPA"), and the Council on Environmental Quality Guidelines, 40 C.F.R. § 1500, et seq. ("CEQ Guidelines"). It is significant that, notwithstanding the defendants' statement in their memorandum of law of June 6, 1975, page 16, that they did not concede that an Environmental Impact Statement is required by NEPA, defendants failed to adduce one argument in the 47 page memorandum which is directed toward that issue. The memorandum as a whole, in effect, did concede that defendants violated the law and concentrated solely on whether the preliminary injunctive relief ought to be denied for other reasons. Only defendants Civil Aeronautics Board and U.S. Customs Service later moved to dismiss the complaint and in their supporting memorandum of law (undated) asserted that they had not violated NEPA. At page 5 of that memorandum, however, they conceded that no facts were at issue. As demonstrated in plaintiff's opposing memorandum of law of September 5, 1975, on the facts admitted by defendant and on the law, these two defendants have also violated NEPA and the CEQ Guidelines. The motion to dismiss has not yet been decided.

8. The State of New York further moves that the summary judgment direct that defendants make available a draft generic Environmental Impact Statement concerning the transport of all special nuclear materials to, from, in or over the City and State of New York and the United States and its territories on or before December 31, 1975, that defendants hold hearings thereon during March 1976 in various parts of the country, including New York City, and accept comments thereon through March 31, 1976, and that defendants file an adequate final generic Environmental Impact Statement concerning the transport of all special nuclear materials to, from, in or over the Ci

and State of New York and the United States and its territories on or before June 21, 1976. Such a direction by the Court is required in order to ensure that the law will be complied with by a date certain. The date selected for making available a draft statement and for filing a final statement should not be burdensome to the defendants, since the Court noted at footnote 4 of its memorandum of September 9, 1975, that it had been represented to the Court that the draft would be available by the end of this year and the final by the summer of next year. The inclusion of dates for making available the draft and for hearings and the submission of comments by interested parties thereon is designed to assure that the date for filing the final statement will not be used as an excuse to curtail the extensive study and comment which a draft statement on this important topic will require.

9. On November 7, 1975, plaintiff filed a notice of appeal from the Court's order of September 9, 1975. The record on appeal is presently scheduled to be filed in the Court of Appeals on or before December 16, 1975. If the relief requested in the instant notice of motion is granted, prosecution of the appeal from the earlier order may not be necessary. If the relief requested in the instant notice of motion is denied and plaintiff appeals from that denial, it may be desirable to prosecute the two appeals simultaneously. Accordingly, plaintiff respectfully requests that the Court extend the time for transmitting the record on appeal to the Court of Appeals to and including February 5, 1976, pursuant to Rule 11(d) of the Federal Rules of Appellate Procedure.

[signature]

JOHN F. SHEA, III

Sworn to before me this
11th day of December, 1975

[signature]

Assistant Attorney General
of the State of New York

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

THE STATE OF NEW YORK, Plaintiff,	:	
-against-	:	**AFFIDAVIT**
THE NUCLEAR REGULATORY COMMISSION, et al., Defendants.	:	75 Civ. 2121 (WCC)

STATE OF MISSOURI)
:SS.:
COUNTY OF ST. CHARLES)

CAPTAIN JAMES A. ECKOLS, being duly sworn, deposes and says:

1. I am a pilot with an American flag commercial air carrier and am Chairman of the Hazardous Materials Committee of the Air Line Pilots Association (ALPA) which represents the professional interests of 32,000 airline pilots on 34 airlines. ALPA is a member of the International Federation of Air Line Pilots Associations which represents pilots from 60 nations. I make this affidavit in support of the State of New York's motion for a preliminary injunction and motion for summary judgment.

2. I will, in the ensuing pages, set forth the reasons why airline pilots believe that there exists an imminent and severe danger of catastrophic harm from the continued shipment of special nuclear materials ("SNM") by commercial air transport. My discussion will center on two areas of inadequacy of this method of shipment: I. Safeguards, II. Containment, Control, and Handling.

I. Safeguards

3. Critical to the safety of commercial air transport of SNM is the severely inadequate security within the air cargo industry. Presently, regardless of cargo, multi-million dollar aircraft and pilots are subject to selection at any time as a "target of opportunity" by skyjackers, extortionists, terrorists or saboteurs. We received a clear lesson as to the very real terrorist threat as 3 Boeing 747's burned to ashes on a patch of Jordanian desert while crew and passengers were held hostage under the muzzles of terrorist sub-machine guns. We have seen as well:

- -mid air sabotage
- -grenade attacks on land
- -attacks on terminals
- -abductions
- -diversions
- -over 370 global acts of terror endangering 16,000 people.

As I have stated, the lesson is clear, SNM must be removed from commercial air transport.

4. As it stands now, without waivers from the FAA certain materials would be strictly forbidden from carriage aboard any aircraft other than those under the direct jurisdiction of the Department of Defense. Often information as to the presence of SNM is not properly disseminated to crew members actually flying the aircraft and, in some cases, their exposure to danger is shocking, moreover, the related danger to the cargo itself is appalling. The crew members involved in this transportation have not volunteered for this extremely hazardous duty for the benefit of industrial shippers.

5. If these materials must be moved by air transportation, they should be moved by military personnel, in military aircraft from military airports that do not constitute a hazard to the public.

6. Data found in studies prepared by the former Atomic Energy Commission ("AEC") support the contention of the State of New York that the hazards involved with the commerical air transport of SNM, due to such transport's vulnerability to theft, organized crime, terrorism and cargo loss, warrant immediate suspension of such transport of SNM. Sam Edlow, President of Edlow International Company, which company shares a virtual monopoly of the SNM shipping business with the Transnuclear Company, was contracted by the AEC to prepare A Factual Study of Special Nuclear Material Patterns of United States Commercial Organizations and Of Unclassified Exports By The AEC and Its Contractors. ("Edlow Rept."). The report, prepared by that major industry spokesman, contains several specific findings:

> -The commercial airline industry is stuck with the fact that enroute terminal use and attendant security risks cannot be avoided.
>
> -Commercial airlines do not find it feasible to disqualify high risk individuals.
>
> -Commercial airlines do not find it feasible to equip vehicles with simple alarms or more sophisticated anti-hijack devices. (In this connection, two well-known national companies providing armed car services were interviewed. Neither company saw "any purpose to be served by equipping armored cars with alarms or other anti-hijack equipment."
>
> -Similarly, commercial airlines do not find it feasible to provide special locks for vehicles.

> -Nor do they find it feasible to provide constant communication.
>
> -The airlines do not seal off "driver's" compartments on any vehicles. (Edlow Rept. pp. 24, 25, 42)

7. It has been stated by defendants in their affidavits that the reasons for shipment of SNM by air, "as with any material involves factors of economics, reliability, convenience and speed in delivery" (D. Aff. of Leland Rouse, p. 4). This glosses over real reasons for air shipment as determined by Mr. Edlow. According to him, <u>cost is the most important consideration to shippers</u> in the selection of shipping method. (Edlow Rept. p. 13)

8. The defendants further state that "containers are less likely to be delayed or misrouted when transported by air than by surface transport, particularly when long distances are involved" (D. Aff., Leland Rouse, p. 4). This statement is utterly without basis, and is contrary to the facts of which defendant DOT is fully aware. Sam Edlow authoritatively related the details of several incidents which show such statements by the defendants to be gross distortions of what really goes on in the SNM cargo industry.

> "Have you heard about the three famous UF_6 shipments of March, 1969? One was mine. 33 kgs. U enriched to 90%, aboard an international flight to New York to Frankfurt, had been loaded on a mixed London-Frankfurt pallet. At London, the pallet was removed from the aircraft, and the London cargo was removed. The balance of the pallet just sat there while the aircraft took off and continued to simply sit at London. We were notified by consignee that the flight arrived without the shipment, and we swung into action. The airline quickly found the cargo, still sitting in London. No airline personnel at London or elsewhere had initiated any action. <u>We</u> had to tell the airline that the cargo was missing. [illegible] -- you can bet your bottom dollar.

"Second famous shipment of March, 1969. Three containers of strategic material, gross weight 850 lbs., left Goodyear on Wednesday, reached Columbus, were taken to Dayton, where they were loaded aboard air freighter for St. Louis for onforwarding to consignee by special truck. Two containers were delivered on Thursday. The third container appeared to be irretrievably lost, but was eventually found nine days later in Boston under a load of shoes. And how was it found -- a shoe store was tracing a lost consignment of shoes and Thank God -- they found the shoes -- with the strategic material underneath. Incompetence -- what else?

"Third March shipment. Four containers of strategic material were loaded aboard air freighter at Dayton for St. Louis on Friday. Saturday -- two of the four were delivered to consignee. No one with the air line could figure out what happened to the other two containers. Tracing followed, and the missing containers were located on Monday at St. Louis Airport, right where they were supposed to be. Incompetence -- nothing else.

"To sum up -- the environment of the transportation industry is one of incompetence, criminality, and unreliability." (Plutonium Diversion, Geesaman, Donald P.; Report before California Legislative's Assembly Science and Technology Council's Energy Panel, June 15, 1972, pp. 15, 16).

9. Incompetence and inefficiency are obviously not the only problems associated with the commercial air cargo industry. William Brobst former Deputy Director of the Office of Hazardous Material, DOT, now with the Energy Research and Development Administration ("ERDA"), in commenting on the then AEC's set of procedures to be followed in protecting special nuclear materials in transportation, stated:

"Although these procedures might be somewhat effective in discouraging the diversion of nuclear material by some bystander who is curious as to the contents of the package, I do not believe that they have any meaningful degree of effectiveness in even discouraging an intentional diversion by any person whose motives are subversive or economic." (Ibid. p. 11).

10. In this regard, Sam Edlow has confirmed Mr. Brobst's opinion on the effectiveness of safeguards procedures and "signature service" and has described the condition of the transportation industry into whose hands SNM were being committed. As he points out, the procedures are only as effective as they are wanted to be by those in the industry who implement them.

> "I was part of an informal meeting some few months ago attended by government personnel, representatives of major truckers, railroads, one airline, insurers, and freight claim agents. It was agreed that the transportation industry is so thoroughly infiltrated by the Cosa Nostra that any cargo which organized crime determines to obtain will be obtained. To put it another way no material is safe during transportation if organized crime decides to lay its hands on the material.....
>
> "How very often we read of thefts of bullion, jewelry, watches from secure rooms at air cargo terminals. The hijacking of aircraft is now a weekly occurrence. Today aircraft are hijacked to provide escape means to Cuba. Who here dare say that aircraft will not by hijacked for the nature of the cargo aboard - because of its high value or its strategic nature?
>
> "Gentlemen, the transportation industry is infiltrated by organized crime and must be adjudged incapable of providing reasonable protection for valuable or strategic cargo. The transportation industry is untrustworthy....
>
> "The high level of incompetency which has been achieved by surface and air carriers staggers the imagination. The inability of the air carrier industry to properly handle the cargo handed to it for air carriage now approaches a national scandal...
>
> "Signature service cannot and will not prevent loss, diversion, or mishandling of cargo. Further, signature service will not give early notice that shipment is lost, unaccounted for, or diverted. At most, it will single out a shipment as being something other than routine. That the regulation provides any more in the way of security, I question." (Ibid, pp. 13, 14, 17).

11. It is widely recognized in the industry and among defendants that a nuclear black market, if not already in existence, is bound to develop as SNM is successfully stolen in small or larger quantities. Commissioner Larsen, when still with the former AEC, publically conceded the point. (Atomic Energy Commission's Symposium on Ssafeguards, Research and Development, October 1969).

12. May 1970, the Institute of Nuclear Materials Management published a report on safeguards in transportation. The abstract of that report stated in part:

> "the transportation industry is characterized by its own press as... 'rotting at its core'...., law enforcement agencies advise that $1 billion dollars of merchandise is being hijacked or pilfered during transportation each year in the United States, and federal agencies acknowledge that organized crime has a strangle hold on the United States transportation industry. Into this milieu, professional managers of nuclear materials are currently shipping sufficient quantities of nuclear materials to produce nuclear weapons or to direct toward possible nuclear blackmail. The INMM Safeguards Committee explores these issues in this document and concludes that the postulated problem is real, current, at the alarm level now, and increasing in scope and risk."

13. Dr. Theodore Taylor, one of the foremost experts in the area of clandestine nuclear weapons use has noted professional criminals can be motivated, simply by the prospects of large profits, to steal fissionable material, for sale to high bidders. "Practically every highly valuable material has been traded in illegal national and international markets. It is hard to see why inadequately protected fissionable materials should be any exception." (December, 1971 AANS Symposium on the Energy Crisis).

14. The irony of the present situation, particularly with reference to ERDA shipment of SNM, is pointedly addressed by former AEC Director Crowson, Division of Nuclear Materials Security. One of the anachronisms of the NRC policy is that strategic nuclear materials which are to be used for military purposes are shipped under military rules. But, if the same materials are to be used for civilian purposes - although they too could fuel a bomb - they are usually shipped in the words of Crowson "like a special delivery letter" (Science, April 9, 1971, p. 145).

II. Containment, Control & Handling

15. ALPA's independent investigation of the air cargo industry and the present scheme for radioactive materials handling has resulted in a number of findings all of which have been indisputably confirmed by Congressional investigations. Eight of these ALPA findings are as follows:

1) Most hazardous material shipments are carried in violation of federal safety precautions.

2) Shippers, freight forwarders and carriers routinely ignore or misinterpret the law and do not even have a copy of the applicable regulations available where they were needed.

3) The regulations themselves are outmoded, confusing and allow the carriage of materials which do not belong on passenger or cargo aircraft.

4) Inadequate fire-fighting equipment on airlines and the inaccessibility of hazardous

cargo make many potential in-flight emergencies impossible to deal with.

5) The entire regulatory scheme is threatened by the pervasive issuance of exemptions from the regulations, without any notice to the public or opportunity to protest unsafe operations.

6), The overlapping jurisdiction of government agencies hampers effective regulation.

7) The Federal Aviation Administration's inspection program in the field is virtually non-existent.

8) FAA's laxity in enforcement leaves hazardous materials regulation violators totally undeterred.

16. This situation is severely aggravated by the fact that the FAA, the agency that purports to be the safety regulation agency for the industry, only regulates safety on a spot-check basis between the official business hours of 8:30 a.m. to 5:30 p.m. Yet most of the major air freight activity, for example at John F. Kennedy International Airport, takes place between midnight and 6:00 a.m. The Washington office of ALPA can document numerous instances of inaction by the FAA after specific requests for attention to certain shipments had been made to appropriate FAA personnel.

17. On January 5, 1975, the Deputy Secretary of DOT established a Task Force to review the movement of such hazardous materials in air commence. Its report, filed on March 19, 1975 contained a number of significant findings:

1. Based on inspection of carrier

facilities and carrier personnel, many of the receiving agents, who in most cases are the first persons to physically examine these materials, have received only a minimum amount of training and their acceptance of freight was determined by consulting CAB tariffs or IATA regulations, not the DOT regulations as required by federal law. As a matter of fact, of seven air carrier facilities visited at JFK and Philadelphia airports, only three had copies of the DOT regulations.

2. Although notification to the pilot in command has been required for more than 25 years, there is no uniform notification form and many of the notificiation forms checked contained discrepancies which were in violation of the requirements of 14 CFR 103.25.

3. The Task Force reported that it examined training programs which varied in duration from 30 minutes to 16 hours. However, many of the longer programs required that the student to do a lot of the work on a home study basis and included that time in the total. The Task Force found that, although the awareness of air carrier personnel has improved, the person receiving the least training time was the agent on the receiving line who, by the very nature of his job function, comes into first contact with the hazardous materials. This same criticism has been noted in every

study made on the hazardous materials problem since the Pan Am crash of 1973. The training requirements have been in effect since December 6, 1973 and all programs must be approved by the FAA; yet this problem has not been rectified.

18. The practices, attitudes and performance records of the industry and the federal regulatory agencies only increase the hazards inherent in the commercial air transport of such cargo As recently as June 19, 1975 Assistant Secretary of the DOT bemoaned at a speech in San Francisco the continued poor compliance record of hazardous materials shippers. General Benjamin O. Davis Jr. said that DOT had found ". . .that about 75 percent of all shipments checked on air terminals and elsewhere were in violation. . .of applicable safety rules."

19. As a final note, with regards to the repeated statements by defendants that radioactive materials shipment has gone on for 25 years with complete safety, this is another distortion of the real facts by NRC and others. As to SNM, there have been, to my knowledge, no catastrophic releases of plutomium other than the Thule and Palomares spills (See Affidavit of John F. Shea, III, June 16, 1975). However, we have experienced disasters involving the air shipment of other radioactive materials where human error defied all computations as to the probabilities of such events. Attached is a report concerning just one of such instances where radioactive materials, caused a serious emergency involving contamination of hundreds of persons and valuable property in several cities. Specifically the report describes the Delta incident of December 31, 1971 which resulted in the radiation exposure of 917 passengers who had been on board a plane carrying liquid radioactive materials. As the report notes, "an unfortunate chance combination of human errors

resulted in this incident" (Exhibit "A", p. 48).

20. The defendants argue a dangerous line. We are to wait for the purportedly "remote" event of an accident or diversion of SNM in commercial air transport rather than preclude the event by removing SNM from such commercial mode now. I personally and professionally believe that to continue to follow such a scheme would be an irresponsible course of action on the part of defendants and, accordingly, support the State of New York's request for injunctive relief and summary judgment.

Capt J A Eckols
CAPTAIN JAMES A. ECKOLS

Sworn to before me this
28 day of November, 1975
St. Charles Mo
Arthur Bennet

My Comm expires 7/31/77

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D. C.

EXHIBIT A

REPORT OF AIRCRAFT RADIOACTIVE CONTAMINATION INCIDENT, DELTA AIR LINES, INC., DECEMBER 31, 1971

TABLE OF CONTENTS

Appendix A

REPORT OF AIRCRAFT RADIOACTIVE CONTAMINATION INCIDENT DELTA AIR LINES, INC., DECEMBER 31, 1971

I. SYNOPSIS

A small quantity of radioactive material leaked from a bulk shipment onboard Delta Air Lines Passenger Flight 925 of December 31, 1971, while the shipment was en route from the manufacturer in Tuxedo, New York, to the consignee in Houston, Texas. The aircraft, Convair 880, N8801E, was contaminated and 917 passengers had traveled aboard it before discovery of the leakage and removal of the aircraft from service at Chicago, Illinois. O'Hare International Airport on January 2, 1972. The aircraft was ferried to Atlanta, Georgia, where it was decontaminated under the supervision of the Georgia Department of Public Health and the United States Atomic Energy Commission (AEC). By telephone contacts and press releases, passengers who had flown on this aircraft between the time of aircraft contamination and its removal from service were afforded an opportunity to determine the extent of exposure to themselves and to their baggage.

II. INVESTIGATION

A. BACKGROUND

The investigation of this incident was conducted in a sequential manner beginning with the manufacturer's packaging through shipment, discovering of excessive radioactivity, subsequent action, to corrective measures as a result of this incident.

B. FIELD INVESTIGATION

1. Manufacturer/Shipper

The Union Carbide Corporation (UCC), Sterling Forest Research Center, Post Office Box 234, Tuxedo, New York, is licensed by the AEC to operate a nuclear reactor in the State of New York. The AEC retains licensing authority over reactor operations. New York is an Agreement State under Section 274 of the Atomic Energy Act of 1954, as amended, and can, therefore, regulate possession and use of nuclear materials within the state.

Radioactive Material

UCC advised that the subject shipment was a routine bulk shipment of molybdenum 99 (Mo 99) in 3 normal sodium hydroxide solution, which had a 66.5 hour half-life. This had been a standard Friday afternoon shipment to Bio-Nuclear Laboratories in Houston, Texas, on a weekly basis for the past 12 to 18 months for consignee pickup at the airport.

Processing

The material was processed in the UCC reactor and moved from there under water (shielding) to hot cell #2 where it was placed into two 500 ml. (or 1 pint) polyethylene screwcap bottles.

Bottling
(Primary Container)

The bottles were approximately 7 inches high and 3 inches in diameter with a 7/8-inch inner diameter and 1 3/8-inch outer diameter neck. The bottling operation in the hot cell was performed behind a 4-foot-thick window, using a pair of mechanical manipulators each of which has two wide opposing metal fingers. The manipulators exert a force similar to that applied by the operator as they provide no mechanical advantage.

To cap the bottles, the neck of a bottle was held by one manipulator while the screwcap was closed down as tightly as possible, "finger tight," with the other manipulator. The plastic cap was 1 3/8 inches high and 1 5/8 inches in diameter.

Packaging
(Secondary Container)

The bottles were placed on a conveyor cart and transported to the conveyor station at the back of the hot cell complex, where each bottle was placed, with the aid of a single manipulator, into a secondary, shielding container. This was a stainless steel/lead lined container called a "pig." The outer dimensions of the pig were 12 inches high and 8 1/2 inches in diameter. The inside space was 3 1/4 inches in diameter with a 1 7/8-inch deep inner ledge at the top. The pig had been decontaminated thoroughly and was placed in the receiving station, which was just below the conveyor station, before the bottles were moved from hot cell #2.

A shielding plug top with a neoprene type gasket was then put in place and the pig was lowered onto a dolly. The heavy shield door was opened and the shipment was wheeled out of the conveyor station to the packaging area. The plug top was bolted down onto the pig with four ½-inch bolts. Smears (paper swipes) were taken to verify that there was no contamination on the outside of the pig.

Outside Wooden Protective Jacket

The pig was then lowered into a wooden overcoat or jacket, the top of which was bolted down onto six 1/2-inch steel bolts. The outer jacket was a 4-inch-thick layered plywood container, the dimensions of which were 23 inches high by 23 inches in diameter. It was secured to a 5-inch-high, 28-inch square pallet to facilitate handling by forklift. Readings were then taken of the radioactivity on the surface (200 mR/hr) and at 1 meter distance (8 mR/hr). The packages were labeled, sealed with a lead seal, and moved onto the loading dock where they were smeared once more before being loaded by crane onto a company truck for forwarding. An illustration of the containers appears in Attachment A-1.

UCC had no written procedures for the maintenance of reuseable Type B pigs and wooden jackets. When these containers were returned by motor freight, they were checked for any contamination, decontaminated if necessary, and examined by personnel from the packaging area to assure that these containers appeared to be in satisfactory condition for reuse.

Contents

Each of the two polyethylene bottles in this shipment contained 283.5 ml. of Mo 99 in liquid form and the calibrated isotope specification for each was 65,200 mCi (millicuries). When packaged for shipment, each completed piece weighed 430 pounds and had a Transport Index (TI) of 8. The total shipment was two pieces at 860 pounds with a TI of 16.

The labeling of the packages was as follows:

a. Metal tag secured to outside of jacket (reproduced below)

RADIOACTIVE MATERIAL		
U.S.A.	D.O.T.	S.P. 5800
Type -B		Wt. 90 kg
UNION CARBIDE CORPORATION TUXEDO, NEW YORK		

b. Two Radioactive Yellow–III labels on opposite sides of each jacket, (see Attachment A-2a).

c. One address label glued to jacket. (see Attachment A-2b).

d. "Packing" slip envelope (white with red print) glued and taped to jacket (containing UCC Order - Invoice 28856 and a copy Airbill Number 006 JFK 432 4103, prepared by the shipper) (see Attachment A-3).

e. Manila envelope taped to jacket, rubber stamped in red, "Department of Transportation Special Permit No. 5800," containing copy of the permit, (see Attachment A-4).

Transport

At 2:10 p.m., Friday, December 31, UCC delivered the subject shipment to the Delta Air Lines air freight dock at John F. Kennedy International Airport, Jamaica, New York (JFK) in their own Chevrolet Carryall, a 3/4-ton truck.

Other UCC shipments were also delivered to Delta Air Lines in the same movement. These shipments included 4 cartons of radioactive material weighing 515 pounds which were consigned to Hastings [illegible] JFK 4327 4114. One piece was a pig slightly smaller than, but similar to, that consigned to Bio-Nuclear Laboratories.

The larger radioactive shipments were moved by forklift from the truck and placed onto an airline cargo cart with dropsides.

2. Carrier

Delta Air Lines, Inc., Atlanta Airport, Atlanta, Georgia, 30320, is a Delaware corporation with headquarters [illegible] in Atlanta, Georgia. The company operates as a scheduled air carrier under a currently effective certificate of public convenience and necessity issued by the Civil Aeronautic Board, and an operating certificate issued by the Federal Aviation Administration (FAA).

Delta personnel received the Bio-Nuclear shipment at their air freight terminal at JFK and signed for it in good order with no exceptions noted.

Receipt

The shipment was received on the Delta ramp and moved from the delivery truck onto a Delta Wollard Baggage Cart, Model BC-450, where it remained until it was taken out to the flight line for loading into the aircraft. It was not taken into the warehouse.

Load Planning

The load agent, in working the load, found he had more than 50 TI's, which is the maximum allowable on one aircraft. Therefore, he held one shipment of radioactive material destined to Houston until Delta's next departure, passenger-carrying Flight 981 of December 31, which was scheduled to depart only 2½ hours after Flight 925. This shipment was shown on airbill JFK 4327 4136. It weighed 33 pounds and had a TI of 8. Flight 981 loadpapers are Attachment A-5

Dispatch

Flight 925 was dispatched with a total TI of 48, consisting of two shipments to Houston in Cargo Bin 3:

No. of Pieces	Weight (lbs.)	Airbill No.	Transport Index
2	575	JFK 4327-4114	17
2	860	JFK 4327-4103 *to Bio-Nuclear	16*
and one shipment to New Orleans in Cargo Bin 4:			
6	228	JFK 4377-3811	15

The captain was so advised by the Restricted Articles Notice form attached to his clearance release (see Attachment A-6). Other freight, air mail, and first class mail were also loaded in bin 3 (see Flight 925 dispatch records which are Attachment A-7).

Cargo Bins

The Convair 880 has two cargo bin areas below the passenger compartment floor, one forward of the wing and the other behind the main landing gear and hydraulic compartments (see Attachment A-8). They are each 19 feet long by 3 1/2 feet high and each has one 38-inch wide access door in the middle of the bin on the right side of the aircraft. However, the push-in door, cargo net, and fuselage limit the height of the entrance to 20 inches (see Attachment A-9). For convenience, Delta numbers their cargo bins #1 through #4. The forward section of the for[illegible] bin is #1; the aft section of the forward bin #2; #3 is the forward section of the aft bin; and the aft section of the aft bin is #4.

Passenger Load

On departures from New York and New Orleans, the aircraft was occupied as shown in the following chart:

Crew: 3 Flightcrew (cockpit)
3 Stewardesses (cabins)

From New York	1st Class (Forward Cabin)	Coach (Aft Cabin)
No. of seats available	24	96
Passengers to New Orleans	1	30
Houston	0 + 1 (Nonrevenue)	19 + 1 (Nonrevenue)
Total	2	50
From New Orleans to Houston	0 + 2 (Nonrevenue)	22 + 1 (Nonrevenue)
Total	2	23

Cargo Loading

The Ramp Agent and two Ramp Service Agents who loaded the three heavy Bio-Nuclear and Hastings radioactive pieces of freight reported that the loading procedures for bin 3 were as follows:

The International Scout Conveyor - Model TC-476 was placed at the cargo bin door (see Attachment A-10). The sides of the baggage cart (in this case freight cart #12) were dropped to make it more nearly a flat bed and it was maneuvered to a position directly under the low end of the conveyor belt (see Attachment A-11). From there the first 430-pound piece was tipped on its side and lifted by two men until it started up the belt, at which time it was rolled over onto its flat top because the pallet on which it was secured extended 2 1/2 inches beyond the wooden jacket and hampered the operation by digging into the belt. It was balanced by one man as it progressed up the belt to the cargo bin door. The conveyor height was adjusted lower so that the pig could then be rolled over onto its side and worked into the cargo bin from where it was pushed all the way forward in the bin. There was no apparent damage done to th shipments during loading, and handling was held to a minimum because of the weight. Afte the heavy pieces were placed, the following Houston cargo was loaded into bin 3:

No. of Pieces	Weight (lbs.)	Class
12	214	Air Mail bags
5	132	First Class Mail
9	207	Air Freight

Intermediate Stop

The compartment was opened in New Orleans; however, there was no freight or mail to b off-loaded from the forward section, bin 3, so New Orleans personnel were not involved with an of the contamination.

Radioactive Material Training

The Delta Air Lines training supervisor at JFK was not interviewed personally because he wa out of town on a business trip, but he prepared a statement which reads as follows:

"My training schedule at JFK follows prescribed company schedules and material. All ne employees with Delta who have contact with radioactive materials are given training in the first week of employment. In addition all employees are given recurrent training once eac year on radioactive materials.

"Our source of material for training are:

1. Hazards of Radiation in Shipping Radioactive Cargo, (Book).
2. Radioactive Materials (Standard Practice 805).
3. Air Cargo Restricted Articles (Standard Practice 891).

"Included in this training our employees are shown the shipping labels used, the total amoun of Transport Index allowed on our aircraft, and the bins we allow radioactive materials in.

"Also I instruct employees in handling, distances, and dangers should package becom damaged.

"Our Load Agents, Ramp Agents and Supervisors are instructed on the above, however, the receive additional training such as notification of Pilots of all restricted articles onbo[illegible] proper entries on our load message (teletype), and those agencies to notify in case of damaged shipment."

Cargo Off-Loading

At Houston, the four Ramp Service Agents who off-loaded the Houston cargo reported [illegible] luggage from bins 1 and 2 was off-loaded first, then the freight cargo from bins 3 and 4. [illegible] reported that the three heavy containers of radioactive materials in bin 3 were lying on [illegible] and were not standing in upright positions. "Nothing unusual was thought of this as they [illegible] be turned sideways, tilted, etc., to get them in and out of Convair 880 plane cargo b[illegible] There also was moisture noted on bin floor, but this is not uncommon as many times [illegible] loaded in the rain or bad weather and moisture is carried into a bin area on cargo." The two men at the foot of the conveyor belt slid the containers off the belt onto a cart. "Since these articles are very heavy, 430 lbs. each, we had to slide them off the belt and in doing so they have a tendency to fall on their side." As each container was off-loaded the men got up on the cart, set them upright, and positioned them on the cart.

Warehouse Storage

The three heavy containe.s of radioactive material and several small boxes containing radioactive material were then taken to the freight warehouse where they were left on the cart overnight, separated from any other airfreight. A shift change followed this activity, but the next morning, January 1, the Bio Nuclear shipment was unloaded from the cart in the warehouse by the same man who later helped load it on the consignee's pickup truck the following morning, January 2.

Aftermath

The handler who worked inside cargo bin 3 during the off-loading at Houston was contacted at 4:30 p.m. on Sunday, January 2, and advised of the contamination problem. His work clothing was found to be contaminated, and he was given a medical examination which revealed no apparent injury. He subsequently reported a burn area on one leg which had been exposed to the contamination. An examination of this condition revealed that it was "...a chemical reaction from the solution the radioactive material was in."

3. Consignee

Bio-Nuclear, Inc., 6006 Schroeder Road, Houston, Texas, 77021, is a subsidary corporation of the American Biomedical Corporation, Dallas, Texas. It is a Texas State licensed radioactive materials processor. At the time of the incident, Bio-Nuclear did not have a Health Physicist on its staff.

They have been receiving from UCC weekly bulk shipments of liquid Mo 99 for over a year and use it to process Technetium (Tc 99), a daughter of Mo 99 with a 6-hour half-life. Tc 99 is a radioisotope used by the medical profession for diagnostic purposes. Routinely, the shipment is sent on Fridays. The consignee's plant is closed on Saturdays. The shipment is picked up early on Sundays, for Sunday night processing and early Monday distribution to customer hospitals and doctors.

About 7 a.m. Sunday, January 2, the Bio-Nuclear shipment was picked up by their driver from the Delta freight dock at Houston Intercontinental Airport. Hastings Radiochemical had previously discovered that its consignment was contaminated, and that company notified Bio-Nuclear of the possibility that the Bio-Nuclear consignment was also contaminated. The Bio-Nuclear packages were surveyed with a Ludlum Geiger counter (?000 mR range), and the reading was off the top of the scale. Traces of white powder also were found on the rim of the pig. The liquid remaining in the two plastic bottles was transferred to the extractors as quickly as possible to minimize radiation exposure. No measurements were made of the amounts actually in the bottles, but it was noted that the liquid level in one bottle was lower than those of previous shipments, and the inside of the pig was wet. The packaging containers and absorbent papers used for handling were removed to a remotely located warehouse.

Bio-Nuclear called Delta Air Lines, informed them of the findings, advised them to check the employees who handled the shipment, and gave interim instructions on decontamination procedures. After moving the contaminated containers to the warehouse, Bio-Nuclear notified the Texas State Health Department.

4. Activities After Discovery of Contamination

a. Notification

There are specific requirements for the carrier to make immediate notification to the nearest FAA facility by telephone in certain cases of dangerous article incidents. Breakage of a shipment calls for immediate notification to the shipper and the Department of Transportation (DOT) and a report within 15 days to the DOT, Hazardous Materials Regulations Board. It is required that a copy also be sent to the FAA facility which was first contacted (14 CFR Part 103.23, Part 103.28 and 48 CFR Part 171.16).

Since the shipment appeared to be in good condition at the time of consignee pickup, and the carrier was not immediately alerted to the possibility of contamination, it was several hours before all concerned parties were notified of this incident. Official records of the first few original notifications are either nonexistent or very sparse. Consequently, the attached notification chart (Attachment A-12) is a reconstruction of the approximate sequence of events since almost all times shown are estimates.

b. Postincident Activity

(1) Aircraft Movement Until Taken Out of Service

Delta Air Lines did not know that their plane, Convair 880, N8801E, was contaminated when it arrived in Houston before midnight on December 31, 1971. Consequently, the aircraft was continued in regularly scheduled passenger service until it landed at O'Hare International Airport, Chicago, Illinois, about 8 p.m., January 2. Following is a chart which shows the flight numbers and cities involved during this period of operation while the aircraft was contaminated:

Flight/Date	Origination	Intermediate Stops	Termination
#925 Dec. 31, '71	New York, N.Y.	New Orleans, La.	Houston, Texas
#998 Jan. 1, '72	Houston, Tex.	Atlanta, Ga. Dayton, Ohio Columbus, Ohio	Miami, Fla.
#952 Jan. 1, '72	Miami, Fla.	West Palm Beach	Chicago, Ill.
#939 Jan. 1, '72	Chicago, Ill.	Louisville, Ky. Atlanta, Ga.	Tampa, Fla.

Flight/Date	Origination	Intermediate Stops	Termination
#992 Jan. 1, '72	Tampa, Fla		Atlanta, Ga.
#1951 Jan. 2, '72	Atlanta, Ga.		Miami, Fla.
#1942 Jan. 2, '72	Miami, Fla.		Atlanta, Ga.
#955 Jan. 2, '72	Atlanta, Ga.		West Palm Beach, Fla..
#954 Jan. 2, '72	West Palm Beach, Fla.	Tampa, Fla.	Chicago, Ill.

The aircraft arrived in Chicago, Ill., at 6:30 p.m., was surveyed, and taken out of service.

Ferry Jan. 2	Chicago, Ill.		Atlanta, Ga.

(2) Aircraft Contamination

The aircraft was initially surveyed by the AEC at Chicago, O'Hare International Airport after 7:00 p.m. on Sunday Jan. 2.

Instrument: Juno Model #7 survey meter
Readings:
- at rear cargo door - 50 mR/hr.
- In center of cargo bin 3 - 500 mR/hr. to 3R/hr.
- In aft passenger cabin at seats 34 & 35 - 200 mR/hr.

The scheduled flight was canceled and the aircraft was moved to the hangar area until it could be ferried to Atlanta.

On arrival of the ferry flight at Atlanta, the Georgia Department of Public Health, and the AEC, assisting in the emergency, again surveyed the aircraft.

Instrument: Eberline [illegible] (Geiger-Muehler scanner) with 30 mg/cm² probe.
Readings:
- Contact reading on floor under seat 34-140 mR/hr.
- Highest reading on bottom of seat 35-60 to 70 mR/hr.

Instrument: Eberline E-120 (maximum range of 50 mR/hr).
Readings:
- Forward end of cargo bin (without handprobe) - 3 to 4 R/hr. (estimate based on state of reading).
- Smear at forward end of cargo bin - 2R/hr.
- Smears on spots generally in middle of cargo bin - 4 mR/hr. to 10 mR/hr. (contaminant could be wiped out).

- Air inlets (at side of cabin just below hatracks) above seats 34 & 35 - low level traces of smearable contaminant.
- Air exit vents (outboard of and below the seats) at seats 34 and 35 - little more than a trace (see Attachment A-13 for seat locations).

Seat and floor readings were the result of direct radiation from the leaked radioactive liquid source. Smearable contamination resulted from airborne radioactive particulate (e.g., dust).

There was no contamination found at the adjustable ventilators installed over the individual passenger seats. (See Attachment A-14 for details of Convair 880, Air Distribution System.)

The only access route for air movement between the cargo compartment and the aircraft ventilating system was a 2 3/4-inch breather hole provided in the sidewall above the cargo door to permit pressure equalization between the passenger compartment and the cargo area. On depressurization, air from the cargo compartment exhausts into the outflow side of the system to the outflow valve. Air in the cargo compartment is generally static except during cabin pressure changes. (See Attachment A-9 for location of breather hole.)

(3) Aircraft Decontamination

The Georgia Department of Public Health, Radiological Health Service in Atlanta, took charge of and actually decontaminated the aircraft and was assisted by Delta Air Lines personnel. The AEC Regional Compliance Office in Atlanta, although primarily a regulatory organization, served as coordinating office. They worked with DOT, FAA, and the carrier. AEC Operations Division personnel furnished Radiological Assistance Team support where necessary.

After determining that the cargo bin was constructed with a fiberglass liner taped to the structure and a metal floor, it was decided to remove the liner from bin 3 and strip out the old tape.

Personnel who were to enter the cargo bin were dressed in full length cover-alls, rubber boots, rubber gloves and were equipped with a Martindale respirator. two dosimeters (instruments for measuring doses of radioactivity) and a film badge. The first man into the bin was allowed a maximum exposure time of 15 minutes. His dosimeters read 38 mR. Consequently, the next man in was allowed 45 minutes to work and his exposure was [illegible] mR. The man in charge of the operation who was in the midst of the activity the entire time had a 100 mR reading on his self-dosimeter.

The fiberglass floor liner, when removed, showed 2-plus R/hr., as did two panels of the metal underfloor and cargo tiedown rings, which were also removed. Air tools were used and insulating material was vacuumed out. The inside was then scrubbed with liquid soap and rinsed, but was not flushed, to avoid possible spreading of the contaminant. On Monday, January 3, 1972, at 3:30 p.m., the aircraft was released. When surveyed, the readings on the aircraft structure (excluding the cargo bin liner, which was removed) had ranged from 160 mR/hr. to 2-plus R/hr. On completion of the decontamination, the maximum contact reading was only 50 mR/hr. under the aircraft belly.

On January 6, one week after the incident and more than 3 days after decontamination, the aircraft made its first landing in Tampa, Florida, where it was checked for radioactivity and was found to be contaminated. Accordingly, the aircraft was sent back to Atlanta for further checking and decontamination, as necessary. There were two spots in the cargo bin where contact readings could be found. The tape was stripped out and no removable contamination was present. The aircraft was again returned to service.

This incident provided an example of the differences in response to tests for radioactive contamination resulting from different scanning equipment utilized, proximity to the source, and the interpretation given to the various readings.

(4) Employee and Passenger Involvement

The first consignee (Hastings Radiochemical) to receive a shipment from the subject flight, discovered the contamination by normal scanning. They checked the employees and equipment before the contamination had time to spread in their facility. By the time Bio-Nuclear was notified the following day of the possibility of contamination, their driver had picked up the shipment at the airport. However, on receipt of the shipment at the plant, they handled it as a "hot" shipment. Consequently, there was no contamination spread throughout that facility.

The first word of this incident received by the manufacturer was followed by a check of their facilities which revealed no contamination on their equipment or employees.

By the time the carrier was notified, the contaminated aircraft had been through airports in 10 cities; many employees had serviced it with numerous pieces of airline equipment; and much freight, express, and mail had been moved in its cargo compartments. Most of these could be traced, but the mail was the exception. However, the major problem confronting the airline was the 917 passengers who had flown onboard the aircraft and had their baggage in one of the cargo compartments.

The AEC established scanning stations in the various cities involved and established a set of guidelines for Delta to implement (see Attachment A-15). Meanwhile, Delta personnel started with the ticket flight envelopes and started backtracing the people who were shown to have been onboard the aircraft. More than two-thirds of the total number were contacted personally by telephone, and the press was used in certain off-route areas to advise passengers of the problem and offer professional assistance to scan them and/or their baggage.

Survey check stations were set up in the ten cities at which the contaminated aircraft had stopped. The personnel from these check stations also surveyed eight homes on request. Passengers were advised by phone and the news media that they could either come to the check stations or contact their state health agencies. Arrangements were made for the employees who had actually worked the shipment to have total body scans performed at other places, such as local hospitals or medical schools which had the facilities to perform this task.

The results of the passenger survey indicated that neither passengers nor employees had been subjected to a personal health hazard although some had been exposed to more radioactivity then is acceptable under the concept of the lowest practical exposure of people to radiation. This information was also reported in the press.

(5) Baggage Involvement

One hundred twenty-four passengers brought 271 various articles plus two dogs to the survey check stations for examination. Numerous bags were found with a small amount of contamination, and there were some with comparatively high levels of contamination.

Subject of observation.	Unit identified as #40	Unit identified as #16
Polyethylene bottle (primary container).	Reportedly, water had replaced radioactive liquid to the top of bottle and top had been secured finger tight: Bottle resting down in beaker with some liquid in the bottom. When the bottle was squeezed between fingers, liquid escaped.	

Thirty-eight days after the shipping incident, the containers were viewed again after they had been returned to UCC. They were in the plant, but isolated in a roped-off quarantine area. The container parts were still too radioactive to be handled.

During this visit to the plant, a demonstration of the polyethylene bottle filling process was conducted by the hot cell operator who had filled the bottle for the subject shipment. For this demonstration, however, water was used instead of a radioactive material. The process followed that which was described earlier in this report. After the demonstration bottle was removed from the hot cell and checked for any contamination, it was picked up with gloves, and when tipped upside down, the water leaked rather freely. Then the "tightness" of the screw-cap was checked. Although it had appeared to be on securely, it was only "manipulator-finger" tight. It released and unscrewed with only very light fingertip pressure. Subsequently, the top was tightened with fingers and the thumb around the cap and the seal then contained the liquid inside.

III. CORRECTIVE ACTION

Subsequent to the incident, there was a concerted effort toward eliminating the potential for another incident involving a radioactive material leak which could contaminate cargo and baggage areas in aircraft and/or endanger passengers or the public at large.

The manufacturer, UCC, took several actions that included:

- Meeting with the Atomic Industrial Forum, which is an industrial trade association comprised of radioisotopes manufacturers, shippers, processors, etc. The Radioisotope Committee agreed to develop new, effective, and workable container leak-tests that could be adopted by the American Standards Association.
- Discontinued use of the old polyethylene filler bottle for a new one with a different sealing arrangement.
- Evaluation of an induction-welded sealing cap for the primary container.
- Primary container for liquid shipments are now leak checked to 25 inches of mercury before they leave the hot cell.
- Changed from handmade neoprene gasket for the pig to manufactured natural gum [illegible]

gasket for better seal.

- Consideration of a change to a plug type gasket that would fill the remaining space around t top of the polyethylene bottle.
- Pigs with gaskets to be leak checked once and then rechecked again each time a gasket changed.
- Consideration of a leak-check for the bottle and secondary container pig for each liquid, Ty B and Iodine shipment.
- Initiating a preventive maintenance program with records kept, using newly assigned se: numbers to pigs.
- Instituted an administrative change which requires two people (packer and man who work hot cell) to check the packaging of each shipment.

The carrier proposed to the Civil Aeronautics Board that shippers of radioactive material in Ty B packages be required to conduct a leak-test at the point of origin; and state in writing that : consignee will perform a wipe-test within 3 hours of shipment arrival at destination. This will ass: that packages are safe to carry on aircraft and determine if leakage has occurred during flight. T tariff became effective March 12, 1972 and is to expire June 12, 1972. CAB Order No. 72-3- dismissed the complaint against it.

IV. ANALYSIS

Of primary concern in this analysis are the conditions leading to the leakage of a bulk radioacti shipment in liquid form which contaminated equipment and exposed the public to higher levels radiation than the generally acceptable minimum. Reports of all the authorities concerned with : incident assured those people who were involved that the exposures encountered did not constitu health hazard. It did, however, create many harrowing hours of activity and concern for the passeng on the flights; for employees who handled the contaminated package and subsequently used : contaminated equipment; and for the personnel responsible for decontaminating of equipment : scanning people and baggage for radioactivity.

There is no shortage of regulations governing the manufacture, transportation, and use radioactive materials. Admittedly, the regulations are rather complex and spread throughout seve different volumes, but they are specific in the requirement that the radioactive material must contained.

The manufacturer was thoroughly familiar with the product, how to handle it safely, and the Ty B packaging being used, because this had been, for more than a year, a routine weekly bulk radioact shipment to the same consignee.

The manufacturer's employees reportedly had operated a nuclear reactor and packaged the prod for shipment over the year without injury or incident. The redundant (primary and second container) Special Permit authorized packaging was designed to survive major accidents transportation without releasing the contents. These requirements covered impact, as well subsequent fire.

Possibly the aforementioned familiarity with the reusable Type B containers led to a relax approach in the maintenance of the stainless steel/lead-lined pigs. There was no written comp procedure for assuring that each pig met the standards for reuse. The plastic inner bottles apparently served well, and there seemed to be no reason to especially mistrust them or their secur: Even for the demonstration filling of a typical plastic bottle; the liquid (water) was not contained the screw cap as it was installed by the operator/manipulator combination. However, it was noted the top could easily be screwed down tightly enough with bare hands to have satisfactorily contai the liquid. Apparently, the final [illegible] bottle seal had not been [illegible].

"This Side Up" labels were not required on the outside of the packages. If the containers are satisfactory, there should be no need for this addition. However, the outside wooden protective jacket is shaped with a pallet/platform bottom which would tend to indicate which way it should be carried, if for no other reason than to spread the load over a larger section of the cargo bin floor.

The bulk of the individual 430-pound package necessitated normal upright handling by forklift and crane. However, it did create problems when it came to loading the 28-inch-high package into a 20-inch-high access door of a CV-880 cargo bin. There was room, once inside, for the package to have been turned upright onto its pallet base. If this had been done, the bottle would have had only about 10 minutes to leak rather than approximately 4 hours. Accordingly, the radioactive liquid probably would not have leaked outside the secondary container. This would also have prevented subjecting the bottle to air pressure changes while it was upside down.

The carrier indicated that it had a training program wherein the employees were instructed in handling radioactive shipments. The AEC in Atlanta reported that they had given instruction on this subject to the carrier's management personnel for relaying to the cargo handler (Ramp Service Agent) level. Some of the Ramp Service Agents interviewed had received such instructions, but others of the cargo handling personnel indicated that the instruction had not been given to them.

Although it was preplanned, the delay by the consignee in picking up the shipment added to the magnitude of the problem, as did the loose notification procedures and the lack of a specific emergency procedures plan. These aspects delayed a timely discovery and immediate initiation of remedial measures.

Subsequent to the original interview of the Georgia Department of Public Health personnel, the Radiological Health Service representative, who was in charge of the aircraft decontamination in Atlanta, was contacted for some additional information and for clarification of some reports. During discussion of the "traces" of contamination reportedly found in the passenger cabin air inlets and air exit vents, it was determined that air vent contamination was not a problem since the trace readings were insignificant, and the origin of the contaminant was questionable. It was explained that the smears/wipes of the upper and lower grids of the ventilating system were made and placed in envelopes, then into a bag. Following this activity, the smear/wipes were made in the highly contaminated cargo compartment. These were then placed in envelopes and *all* envelopes were taken to the laboratory.

At the laboratory, the contents of the 20 to 30 envelopes, some of which were "extremely hot," were then placed inside glassine envelopes. The multichannel analyzer with a 5-inch sodium iodide crystal indicated only traces, approximately 300 counts/min. or less. This is considered to be an insignificant amount, and it is suspected that this trace amount was the result of cross-contamination of the specimens, especially since the entire air flow is into the cabin through the inlet, out of the cabin by the exit vent, past the cargo bin breather, to the outflow valve.

V. FINDINGS

- The reusable Type 2 packaging used for transporting the subject radioactive bulk shipment in liquid form did not fulfill the containment requirements of the regulations.
- The manufacturer did not have a standard maintenance procedure for overseeing the condition of the returned Type B pigs before reuse.
- An unfortunate chance combination of human errors resulted in this incident, i.e., plastic bottle top too loose, pig gasket in unsatisfactory condition, package rolled onto and left on its side during transport. The removal of any one of these steps from the sequence would have prevented this incident.

o The carrier's training program for handling radioactive materials had not reached all cargo handling personnel.

o A routine delay in pickup of the shipment by the consignee and the lack of a specific emergency plan for incidents such as this prevented timely discovery of the situation and initiation of immediate remedial action. This resulted in increasing the magnitude of the problem.

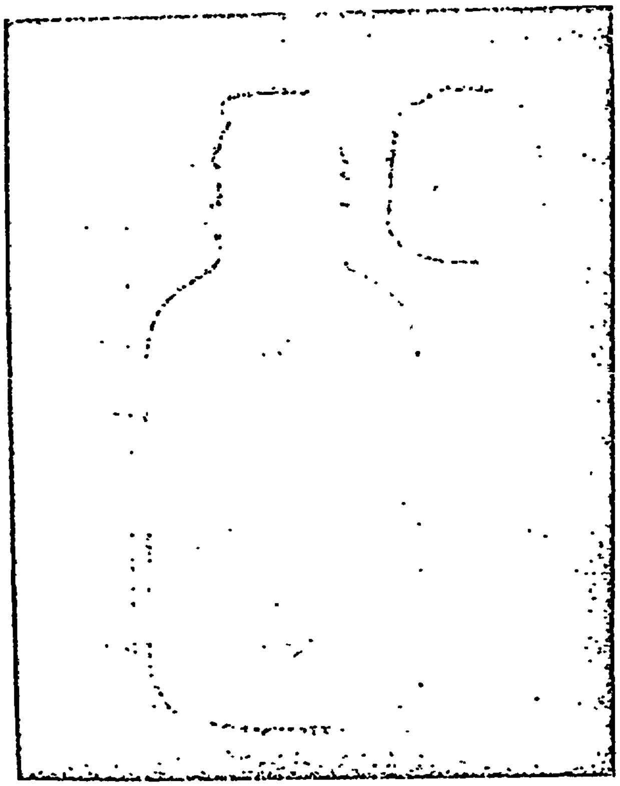
o Trace indications of radioactive contamination in the passenger cabin ventilating system were the result of cross-contamination of the specimens as they were taken to the laboratory.

o Reportedly, there was no health hazard to passengers or employees involved in this incident.

VI. CONCLUSION

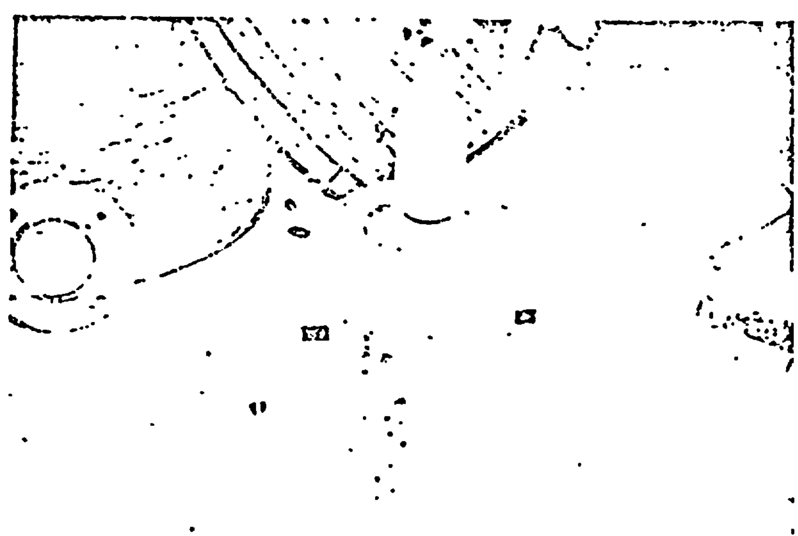
It is concluded that this incident occurred because of the improper packaging of a bulk liquid radioactive shipment in a poorly maintained reusable Type B container. A contributing factor was the transport by air with the package lying on its side.

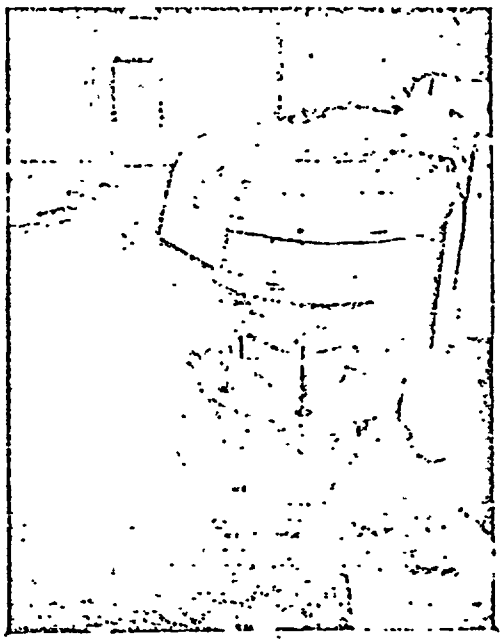
ATTACHMENT A-1



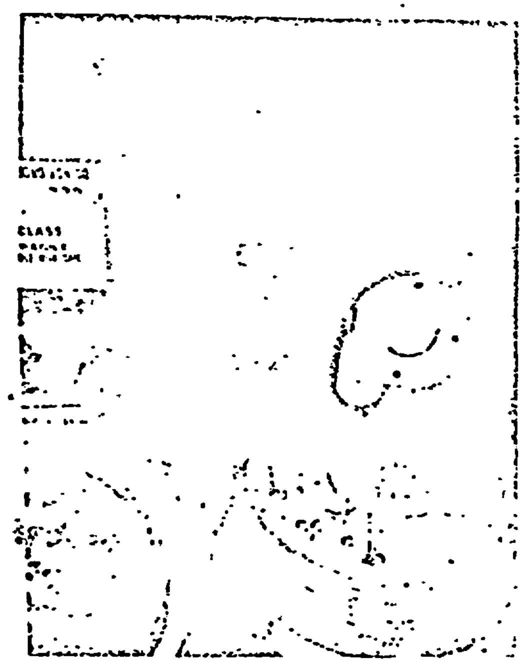
Typical PRIMARY CONTAINER
Polyethylene bottle

SECONDARY CONTAINER "PIG"
Stainless steel/lead lined
Bio-Nuclear package = 40

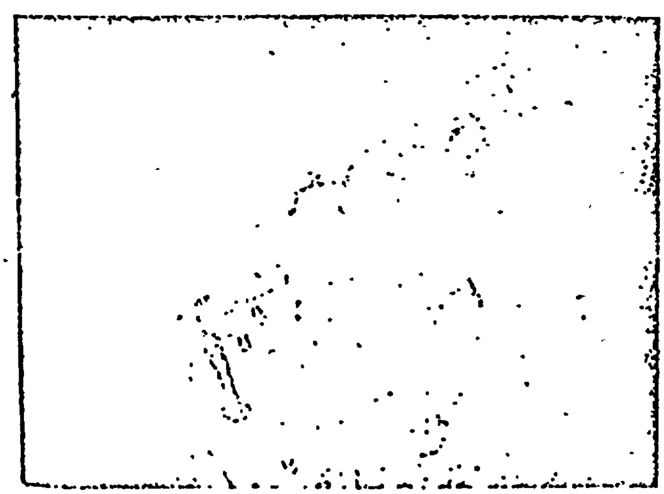




Typical - DOT SP-5800
SHIPPING CONTAINER
Wooden protective jacket



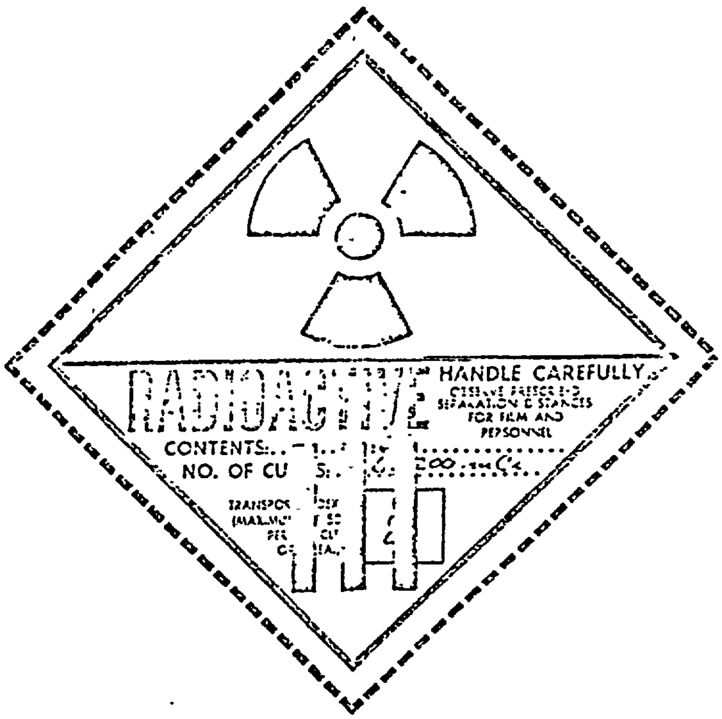
CONTAINER #16 - Bio-Nuclear
Neoprene gasket missing



CONTAINER #40 - Bio-Nuclear
Section of neophrene gasket missing

51

a.



Package Label
RADIOACTIVE - YELLOW III

Bright yellow upper half
White lower half

b.

FROM
UNION CARBIDE CORPORATION
STERLING FOREST RESEARCH CENTER
P. O. BOX 324, TUXEDO, NEW YORK 10987

To:

BIO-NUCLEAR LABORATORIES
HOLD AT AIRPORT
HOUSTON, TEXAS

Address Label

ATTACHMENT A-3

RETURNABLE CONTAINERS ARE TO BE RETURNED TRANSPORTATION PREPAID TO UNION CARBIDE WITHIN 7 DAYS OF RECEIPT. A CHARGE OF $10.00 PER WEEK WILL BE MADE FOR CONTAINERS HELD MORE THAN 7 DAYS

UNION CARBIDE CORPORATION
STERLING FOREST RESEARCH CENTER
P. O. BOX 324, TUXEDO, N. Y. 10987

ORDER-INVOICE
28856

INVOICE TO
Diagnuclear Laboratories
Box 20634
Houston, Texas 77025

SHIP TO (IF DIFFERENT FROM INVOICE TO)
Houston

CUSTOMER BILL TO NO	ORDER		TERMS	DATE
00321-5	1203	2	NET 30 DAYS	12/31/71

CUSTOMER PURCHASE ORDER NO				DATE
72179	C-3720			12/22/71

BATCH NO	PRODUCT CODE	PRODUCT DESCRIPTION	QUANTITY SHIPPED	QUANTITY ORDERED & BILLED	UNIT PRICE	AMOUNT
M 26	MO-99-P-3	Molybdenum-99	130,000 mCi	82,000 mCi		

CONCENTRATION 230 mCi/ml
VOLUME 567 ml in 2 bottles, 283.5 Each
SPECIFIC ACTIVITY 1.0 mCi/mg
CHEMICAL FORM Na₂MoO₄ in 3N NaOH
STABILIZER —
CARRIER —

65,000 mCi Each Bottle

ISOTOPE SPECIFICATIONS 1800 HRS 12/31/71
CALIBRATION TIME

SPECIAL INSTRUCTIONS
Calibrate to 1800 Sunday
Ship in 2 bottles of equal quantity

Open 24 hrs.

TRAFFIC: Notify customer of waybill info

PACKAGING AND SHIPPING INFORMATION

DESCRIPTION
☐ RADIOACTIVE MATERIAL N.O.S.
☐ RADIOACTIVE MATERIAL SPECIAL FORM
TRANSPORT GROUP
ACTIVITY
LABEL
☐ RADIOACTIVE YELLOW III
☐ NO LABEL REQUIRED
☐ THIS IS TO CERTIFY THAT THE ABOVE NAMED ARTICLES ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED AND LABELED AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION AND TO THE IATA RESTRICTED ARTICLES REGULATIONS
☐ THIS SHIPMENT IS WITHIN THE LIMITATIONS PRESCRIBED FOR PASSENGER CARRYING AIRCRAFT

SHIPMENT APPROVAL
RECEIVED BY
DATE

Shipped in ___ Packages
SURVEY OF SHIPPING CONTAINER(S)
MR/HR AT SURFACE
MAX PER PKG.
TOTAL UNITS PER PACKAGE
(MR/HR AT ONE METER)
☐ NO SIGNIFICANT REMOVABLE CONTAMINATION

GROSS WEIGHT
Returnable

53

UNIFORM AIRBILL

DELTA AIR LINES, INC.
ATLANTA GEORGIA

Air Bill Number	006 JFK 4327 4103
Routing	DL Flt. 925 Lv. 6:55 PM
Prepaid / Collect	[X] PREPAID [ ] COLLECT
To / Via	IAH / DL
Consignee	CONSIGNEE
Name	Bionuclear Laboratories
Street Address	HOLD AT AIRPORT
City / State	Houston, Texas
Special Instructions	NOTIFY ON ARRIVAL TEL 713-717-1271
Shipper	SHIPPER
Name	Union Carbide Corp. 591
Street Address	PO Box 324, Tuxedo
City / State / Zip Code	Tuxedo, New York 10987
C. O. D. SHIPMENT	IF AMOUNT ENTERED HERE BY SHIPPER

No. Pcs	Weight	Description of Pieces and Contents, Packing, Marks, Number
2	866	Radioactive Material
		16 Units
		(RESTRICTED ARTICLE'S CERTIFICATE ATTACHED)

THIS IS NOT AN INVOICE

Executed at/by	Date	Time
JFK L. Mujo	12/31/71	1410

006 JFK 4327 4103

ATTACHMENT A - 4

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5800

This special copy permit is issued pursuant to 46 CFR 146.05-4 of the U. S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.13 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended.

1. The U. S. ATOMIC ENERGY COMMISSION (USAEC) and its contractors and licensees, the DEPARTMENT OF DEFENSE and its contractors, and licensees of "agreement states" as approved by the USAEC, are hereby authorized to ship Type B quantities of any non-fissile radioactive material in either normal or special form, as provided for herein.

2. Each user of this permit must register his identity with this Board prior to his first shipment under the permit.

3. The authorized packaging consists of an interim DOT Specification 20WC wooden protective jacket, as described in Appendix A hereto, when used with any single one of the following types of inner containment vessels which must fit snugly within the jacket:

a. A DOT SPECIFICATION 55 (or equivalent) metal-encased shielded inner containment vessel;

b. A DOT Specification 2R (or equivalent) metal inner containment vessel; or

c. A DOT Specification 7A inner packaging which has a metal outer wall (not authorized for normal form radioactive materials).

4. The packaging design is based upon the ambient conditions as prescribed in Marginal C-2.4.3 of the Regulations for the Safe Transport of Radioactive Materials, 1967 Edition, International Atomic Energy Regulation (IAEA).

5. The authorized package meets the criteria of the International Atomic Energy Agency for Type B packaging [illegible]

6. Prior to each shipment authorized by this permit, the shipper shall notify the consignee and, if export shipments, the competent authority of any country into or through which the package will pass, of the dates of shipment and expected arrival. The shipper shall notify each consignee of any special loading/unloading instructions prior to his first shipment.

7. The outside of each package must be plainly and durably marked "USA DOT SP 5800" and "TYPE B", in connection with and in addition to the other markings and labels prescribed by DOT regulations. Each shipping paper issued in connection with shipments made under this permit [illegible] "DOT SPECIAL PERMIT NO. 5800", [illegible] description thereon

8. Each package of gross weight in excess of 50 kilograms (110 pounds) must have its gross weight in kilograms plainly and durably marked on the outside of the package.

9. Shipments are authorized only by vessel, cargo-only aircraft, passenger-carrying aircraft, rail, and motor vehicle.

10. No special operational transport controls are necessary during carriage except as specified herein, and no special arrangements have been made under Marginal C-6.5 of the IAEA Regulations.

11. For shipments by water, the shipper or agent shall notify the USCG Captain of the Port in the port area through which the shipment is to be made, of the name of the vessel on which the shipment is to be made, and of the time, date, and place of loading. When the initial notification is given in a port area through which the shipment is to be made of the name of the vessel on which the shipment of the Port.

12. Any incident involving loss of contents must be promptly reported to this Board.

13. This permit does not relieve the shipper or carrier from compliance with any requirement of the DOT regulations, including 46 CFR Parts 146 to 149 of the USCG Regulations, except as specifically provided for herein, or the regulations of any foreign government, into or through which the package will be carried.

14. This permit expires January 15, 1971.

Issued at Washington, D.C., this 3rd day of January 1969.

/s/E. G. Grundy, Capt.
For the Commandant
U. S. Coast Guard

/s/S. Schneider
For the Administrator
Federal Aviation Administration

/s/D. W. Morrison
For W. R. Fiste
For the Administrator
Federal Highway Administration

/s/Austin H. Banks
For Mac E. Rogers
For the Administrator
Federal Railroad Administration

Continuation of SP 5800

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department of Transportation, Washington, D.C. 20590. Attention: Special Permits.

cc:
U. S. Coast Guard
Bureau of Explosives, AAR
Federal Highway Administration
Federal Railroad Administration
Federal Aviation Administration
Atomic Energy Control Board, Canada
U. S. Atomic Energy Commission, Mr. Kaye
Department of Defense, Mr. Edwin T. Loss

ATTACHMENT A - 4 - 4

DEPARTMENT OF TRANSPORTATION
HAZARDOUS MATERIALS REGULATIONS BOARD
WASHINGTON, D.C. 20590

SPECIAL PERMIT NO. 5800
FIRST REVISION

Pursuant to 46 CFR 146.02-25 of the U. S. Coast Guard (USCG) Dangerous Cargo Regulations and 49 CFR 170.15 of the Department of Transportation (DOT) Hazardous Materials Regulations, as amended, and on the basis of the October 14, 1970, petition by the Idaho Nuclear Corporation, Idaho Falls, Idaho and the November 5, 1970, petition by Westinghouse Electric Company, Pittsburgh, Pa.:

Special Permit No. 5800 is hereby amended by revising paragraphs (1), (5), and (14) and by adding new subparagraphs (1a), (9a), and (11a), to read as follows:

"1. Shipments of Type B quantities (S 173.389 (L)) of any radioactive material, in normal or special form, are hereby authorized, as further provided for herein. This packaging, when constructed and assembled as prescribed herein, with the contents as authorized herein, meets the standards prescribed in the DOT regulations, Sections 173.394(b) (3), 173.395(b)(2), and 173.396(c)(3), and 173.398(c). The fissile radioactive material content of each package may not exceed those quantities and material types as limited and prescribed in subparagraphs (a)(2)(ii), (a)(2)(iii), and (b)(2) of S 10 CFR 71.6 of the USAEC Regulations, with such packages to be shipped as either Fissile Class II or III, in accordance with the package transport index limitations or shipment limitations prescribed therein.

"1a. Each shipper, under this permit, other than the petitioners named above, and the other previously identified petitioners, shall register his identity with this Board prior to his first shipment, and shall have a copy of this permit in his possession before making any shipment.

"5. The authorized package described herein is hereby certified as meeting the specific requirements of the International Atomic Energy Agency's (IAEA) "Regulations for the Safe Transport of Radioactive Material", Safety Series No. 6, 1967 edition, as follows:

a. Marginal C-6.2.2 - The package design meets the requirements for Type B packaging for radioactive materials.

b. Marginal C [illegible] ...tents as limited by paragraph (1) meets the requirements for Fissile Class II or III shipments.

"9a. For shipments by air, a copy of this permit must be carried aboard any aircraft transporting radioactive materials under the terms of this permit. Fissile Class III shipments by cargo-only aircraft must conform to S173.396(g)(1). Fissile Class III shipments by passenger-carrying aircraft are not authorized.

"11a. For shipments by water, a copy of this permit must be carried aboard any vessel transporting radioactive materials under the terms of this permit.

Continuation of 1st Rev SP 5800

"14. This permit expires January 15, 1973."

All other terms of this permit, as revised, remain unchanged. The complete permit currently in effec consists of the original issue and the First Revision.

Issued at Washington, D.C.:

/s/ R. G. Schwing, Capt. R. G. Schwing, Capt. For the Commandant U. S. Coast Guard	25 November, 1970 (DATE)
/s/ S. Schneider For the Administrator Federal Aviation Administration	18 DEC 1970 (DATE)
/s/ D. W. Morrison for W. R. Fiste For the Administrator Federal Highway Administration	2 December 1970 (DATE)
/s/ Quentin H. Banks for Mac E. Rogers For the Administrator Federal Railroad Administration	9 December 197 (DATE)

Address all inquiries to: Secretary, Hazardous Materials Regulations Board, U.S. Department Transportation, Washington, D.C. 20590. Attention: Special Permits.

Dist: a, b, c, d, e, h, i
Kelekct/CGR Corporation, Waltham, Mass.
Rutgers University, New Brunswich, N.J.
Department of the Army, Washington, D.C.
General Electric Co., Pleasanton, Calif.
The Ohmart Corporation, Cincinnati, Ohio

Continuation of 1st Rev SP 5800

Union Carbide Corporation, Tuxedo, New York
Radiation Products Division, Burlington, Mass.
Naval Research Laboratory, Washington, D. C.
J. L. Shepherd & Associates, Glendale, Calif.
Siemens Medical of America, Inc., Union, N.J.
Nuclear Engineering Co., Inc., Morehead, Ky.
Battelle Memorial Institute, Columbus, Ohio
Todd Shipyards Corporation, Galveston, Texas
Materials Evaluation Group, Phoenixville, Pa.
General Electric Co., St. Petersburg, Florida
Westinghouse Electric Corporation, Cheverly, Md.
Westinghouse Electric Corporation, Pittsburgh, Pa.
Cumberland Research Corporation, Port Norris, N.J.
Industrial Reactor Laboratories, Inc., Plainsboro, N.J.
Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

January 1, 1969

Interim DOT Specification 20WC

§ 178.194 Specification 20 WC wooden protective jacket

§ 178.194-1 General Requirements

(a) Each jacket must meet the applicable requirements of § 173.24 of this chapter.

(b) Maximum gross weight of the jacket plus the contents may not exceed the following:

(1) Spec. 20WC-1: 500 pounds

(2) Spec. 20WC-2: 500 pounds

(3) Spec. 20WC-3: 1000 pounds

(4) Spec 20WC-4: 2000 pounds

(5) Spec 20WC-5: 4000 pounds

§ 178.194-2 Materials of construction

(a) The general configuration of the wooden protective jacket is a hollow cylindrical shell constucted of one-piece discs and rings of plywood or solid hardwood reinforced with steel rods.

(b) Plywood must be exterior-grade, void-free, douglas fir (or equivalent) not more than one inch thick. Solid hardwood is authorized for Spec. 20WC-2 only.

(c) Discs and rings must be glued together with a strong, shock-resistant adhesive, such as either of the following:

(1) A resorcinol-formaldehyde adhesive, which has been bonded under heat *and* pressure: or

(2) A polyvinyl-acetate emulsion, which has been reinforced with cementcoated nails. The nails must be randomly spaced and must be at least 2-1/2 times as long as the minimum thickness of the plywood discs or rings.

(d) Full-length steel rods are required for reinforcement and lid closure. For Specs. 20WC-1 and 20WC-2, a minimum of six rods at least 0.25 inches in diameter are required. For Spec. 20WC-3, a minimum of 12 rods, at least 0.375 inches in diameter are required. For Spec. 20WC-4, a minimum of 16 rods at least 0.375 inches in diameter are required, and for Spec. 20WC-5, a minimum of 16 rods at least 0.5 inches in diameter are required. For Specs. 20WC-1 and 20WC-2, steel rods must be equally spaced around the circumference of the rings and discs, midway between the O.D. and I.D. of the rings. For Specs. 20WC-3 and 20WC-4, bolts may be staggered alternately in two rows, at ±0.5 inches from the line midway between the O.D. and I.D. of the rings. For Spec. 20WC-5, bolts may be staggered alternately in two rows at ± one inch from the line midway between the O.D. and I.D. of the rings. Rod ends must be threaded and secured with lock nuts and steel washers, or equivalent device, to provide at least a one inch diameter bearing surface on each end. Ends of the rods must terminate 0.75 inches below the surface of the plywood for Specs. 20WC-1 and 20WC-2. For Specs. 20WC-3, 20WC-4, and 20WC-5, the ends of the rods must terminate 1.5 inches below the surface of the plywood, and that portion of each end disc which extends beyond the rod ends must be further held in place with lag screws at least four inches long.

(e) Thickness of wooden shell:

(1) Spec. 20WC-1: At least four inches thick.

(2) Spec. 20WC-2: At least three inches thick. The jacket must be completely encased by a steel shell at least 18-gauge thickness, such as a Spec. 17H steel drum. The steel shell must be vented by at least four 0.25 inch diameter holes, which must be covered with a durable weatherproof tape.

(3) Spec. 20WC-3: At least five inches thick for the jacket wall, and at least six inches thick for the end discs. In addition, at least three plywood chines, two inches wide and protruding two inches beyond the outer surfaces, must be located at each end and midway along the length of the jacket.

(4) Spec. 20WC-4: At least six inches thick for the jacket wall, and at least six inches thick for the end discs. In addition, at least three plywood chines, two inches wide and protruding two inches beyond the outer surfaces, must be located at each end and midway along the length of the jacket.

(5) Spec. 20WC-5: At least six inches thick for the jacket wall, and at least eight inches thick for the end discs. In addition, at least five plywood chines, two inches wide and protruding two inches beyond the outer surfaces, must be located at each end and equally spaced along the length of the jacket.

(f) Figures 1 and 2 illustrate representative designs.

§ 178.194-3 Closure

(a) Closure for the wooden protective jacket is provided by the steel reinforcing rods. The end cap (lid) must fit tightly to the body of the jacket to prevent a heat path to the inside of the jacket. The lid joint for Specs. 20WC-3, 20WC-4, and 20WC-5 may not be co-planar with the end of the inner containment vessel.

(b) Spec. 20WC-2. Locking ring closure, if used, must conform to § 178.104-4. Flanged closure, if used, must have at least eight steel bolts (at least 0.25 inch diameter) and lock nuts (or equivalent devices), spaced not more than five inches between centers.

§ 178.194-4 Tests

(a) Each jacket must be visually inspected for defects such as improper bonding, cracking, corrosion of steel rods, an improperly fitting closure lid, or other manufacturing defects. Particular attention must be given to any separation of the plywood discs and rings which would provide a heat path to the inside of the jacket.

§ 178.194-5 Painting

(a) Each jacket must be completely painted with a high quality exterior weather resistant paint.

§ 178.194-6 Marking

(a) Each jacket must be marked on the external surface as follows: "USA DOT 20WC-( ) TYPE B" and "RADIOACTIVE MATERIAL". The appropriate numeral must be inserted in the marking to indicate the appropriate Spec. 20WC category; e.g., "USA DOT 20WC-2".

J-86-68

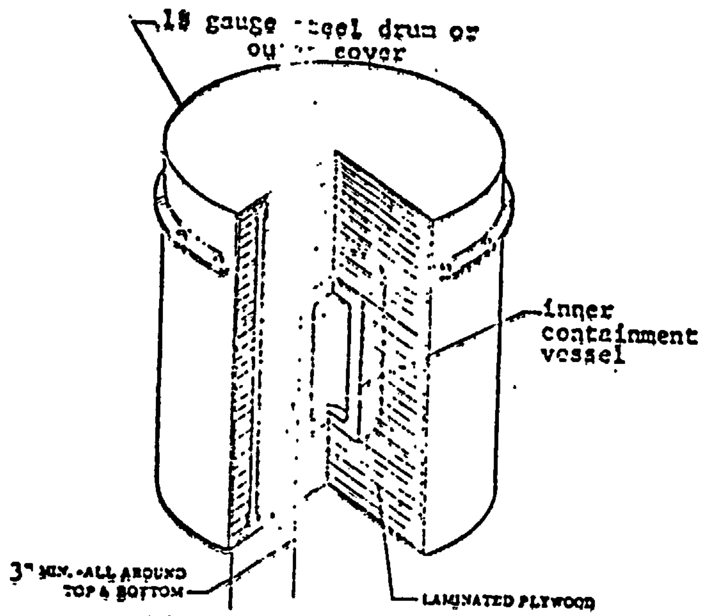


Figure 1. Spec 20WC-2

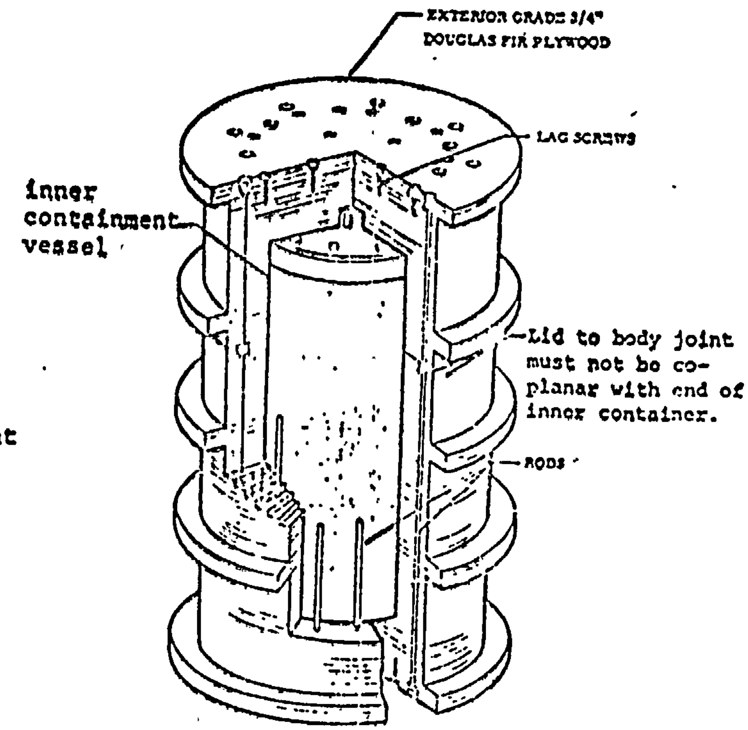


Figure 2. Spec 20WC-5

ATTACHMENT A-4-10

65

J-86-69

FLIGHT RECORD

LM AND CX

MSY CODE

IAH CODE

DATE 7/1/81

NO. 906

TRANSMIT INFORMATION IN THE UNSHADED BLOCKS ONLY

				TOTAL CARGO LOAD	BIN 1	BIN 2	BIN 3	BIN 4	BIN 5	BIN 6	BAGS		MAIL		EXPRESS					
OUT		34		2554	2392		162				38	893	40	640	4	4				
OUT	2	26	1-0	1245		1245		99			53	1246	15	360						
OUT	2	50	1-0	4279	2392	1245	162	99			91	2139	55	1000	4	49	31	1111		

BULK
1 MSY BGS - M - X - FLT
2 IAH BGS - M - FLT
3 MSY FLT 4/162 R/A - MSY
4 IAH FLT 3/99 R/A - IAH
1 DOG + 1 CAT - IAH BIN 2   1 DOG AS BAG - MSY BIN 1

RAMP

ATTACHMENT A-5

ATTACHMENT A - 5 - 2

Station JFK
FLT ______ Date 12/31/[illegible]
Agent ______

DELTA AIR LINES FREIGHT

Out #41

Page ______ of ______ Pages

3762

DEST ATL PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	DEST PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	DEST MSY PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER
1	38	JFK 4327 4131[illegible]	2		R.A. UNITS			
2	66	JFK 4327 4135[illegible]	16		R.A. UNITS			
2	40	[illegible] 2505 0256						
						13	407	[illegible]
						2	58	[illegible]
						6	321	[illegible]
5	139					21	786	TOTAL

66

J-86-70

Form 0412 8010Q
NOTICE 2-70

RESTRICTED ARTICLES/ARMED GOVERNMENT OFFICIALS NOTICE

DELTA AIR LINES

TO CAPTAIN 951, 31
FLIGHT DATE

FROM: LOAD PLANNER L. Cummings (SIGNATURE) CITY TPA

THE FOLLOWING ACCEPTABLE RESTRICTED ARTICLES ARE ON BOARD:

CLASSIFICATION: Radio Active Material AMOUNT 24 units BIN 3 DEST. IAH

CLASSIFICATION: Radio Active Material AMOUNT 10 units BIN 3 DEST MSY

THE FOLLOWING GOVERNMENT OFFICIALS ARE ON BOARD AND HAVE BEEN CLEARED TO CARRY CONCEALED WEAPONS:

NAME ______ GOVT. AGENCY ______ DEST ______

NAME ______ GOVT. AGENCY ______ DEST ______

Prepare In Duplicate
1. Captain
2. Station File (For Two Years)

J-86-71

ATTACHMENT A-5-3

Form 0412 K0166
NOTICE 7-70

RESTRICTED ARTICLES/ARMED GOVERNMENT OFFICIALS NOTICE

DELTA AIR LINES

TO: CAPTAIN 425, 31
FLIGHT DATE

FROM LOAD PLANNER L Cummings (SIGNATURE) CITY TPL

THE FOLLOWING ACCEPTABLE RESTRICTED ARTICLES ARE ON BOARD:

CLASSIFICATION: Radio Active Material AMOUNT 15 UNITS BIN 4 DEST. [illegible]

CLASSIFICATION Radio Active Material AMOUNT 33 UNITS BIN 3 DEST. [illegible]

THE FOLLOWING GOVERNMENT OFFICIALS ARE ON BOARD AND HAVE BEEN CLEARED TO CARRY CONCEALED WEAPONS:

NAME ______ GOVT. AGENCY ______ DEST. ______

NAME ______ GOVT. AGENCY ______ DEST. ______

Prepare in Duplicate
1. Captain
2. Station File (For Two Years)

J-86-72

ATTACHMENT A-6

J-86-73

DELTA AIR LINES

FLIGHT RECORD

LM AND CE

MSY

25 / 31

901

TRANSMIT INFORMATION IN THE UNSHADED BLOCKS ONLY

			BIN 1	BIN 2	BIN 3	BIN 4	BIN 5	BIN 6	BAGS		MAIL		EXPRESS		FREIGHT		COMAT		FIRST CLASS MAIL	
1	30	54	3511	956		487			43	1011	8	175			26	587	30	1500	12	351
	17-7-L	110	652	36	1892				29	682	12	214			15	1582			5	132
1	497-1	64	3193	992	1892	487			72	1693	20	389			41	2469	30	1500	17	483

1 MSY BAGS — C C [illegible] IAH [illegible]
2 MSY [illegible] FLT IAH [illegible] 1/86 [illegible] FLT
3 IAH FLT [illegible]
4 MSY [illegible]
[illegible] 6/1335 [illegible] 3

RAMP

ATTACHMENT A-7

ATTACHMENT A - 7 - 2

FREIGHT AND COMAT MANIFEST

FREIGHT

Station JFK

FLT ______ Date 12/21

Conml ______

Cont 17

Page ____ of ____

______ Pages

FRA PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER
[illegible]		[illegible]			[illegible] 410	2106		
2	860	JFK 4327 4113			RA units 17			
4	515	JFK 4327 4114			RA units 17			
					83 85 15 48			
6	1375		/			/		TOTAL /

'71 DEC 31 PM 4 13

BIN 3

COMAT

/			/			/		/

MANIFEST P.66

FREIGHT AND COMAT MANIFEST

ATTACHMENT A-7

Station JFK

FLT ______ Date 13/8/1/21

Agent ______

FREIGHT

Page ____ of ____ Pages

445Y PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	CAH PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER
6	220	JFK 11277211			15 R.A. UNITS			
1	38	JFK 02454064			C.A.G.P.T.			
1	2	1021857Y 5505						
2	41	JFK 4423 5365						
11	178	JFK 4423 5023			DAL			
						2	64	JFK 2097
					SJD	2	25	0241607
					LIVE DOG ELP	1	36	015 12225
						4	82	JFK 4423 5
21/487			1			9/207		TOTAL

COMAT

/			/			/		TOTAL /

1

FREIGHT AND COMAT MANIFEST

ATTACHMENT A-7

Station JFK

FLT ______ Date 12/21/71

Agent ______

Page ______ of ______ Pages

DELTA AIR LINES FREIGHT

Cart # 45

PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER	PCS	WT	AIRBILL OR SHIPPING TICKET NUMBER
6	228	JFK 4327 2311			15 RA UNITS			
1	38	JFK 32954364			C.A.G.P.T.			
1	2	062 1557 4 5505						
12	41	JFK 4423 5305						
11	78	JFK 4423 5273			JAL			
						2	64	JFK 5047
					SJD	2	25	024 1407
					LIVE DOG ELP	1	31	015 2235
						4	82	JFK 4423 5
21	487					9	207	TOTAL

Bin 1 Bin 2 Bin 3

COMAT

PCS	WT		PCS	WT		PCS	WT	
								TOTAL

71

```
V
ATLDDDL MSYDDDL IAHDDDL
.JFKDDDL
GK
S29/31 901 FC3000/ORIG-1900/AGDD3/03/21
1-49-1-1/0964/1-30/3954/LEHIND/MASON
```

```
GV
CHDDDDL MSYDDDL
.JFKDDDL
LM
S29/31 901
MSY/P1 Y30/L3954 1-2511 2-956 4-407 D43 MC/175 FR26/C37 C30/1500
A13/301
IAH Y39 TR-1 L2610 1-002 2-36 3-1002 D29 M12/214 FR15/1502 AS/132
IO7 Y1 Y39 TR1-1 L0964 1-3193 2-992 3-1002 4-407 D72 M20/300 FR11/2469
C30/1500 A17/513
DINLX
1- MSY DOS C C IS BALLAST  IAH DOS
2- MSY M A FR IAH DOG  1/36 AS FRT
3- IAH FR M A
4- MSY FR
--> 6/228 R/A MSY DIN FOUR  6/1573 R/A IAH DIN THREE 33 UNITS
```

```
ØV
SASRMDL MYCRADL
.JFKDDDL
FPS
S29/31DEC JFK
MSY 1/30
IAH 0/19
‡
```

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ØV
SASRMDL
.JFKDDDL
FS
0S29/31DEC 901 90 A JFK 1900 21 005
E 01 01 24 002 F 049 049 072
‡
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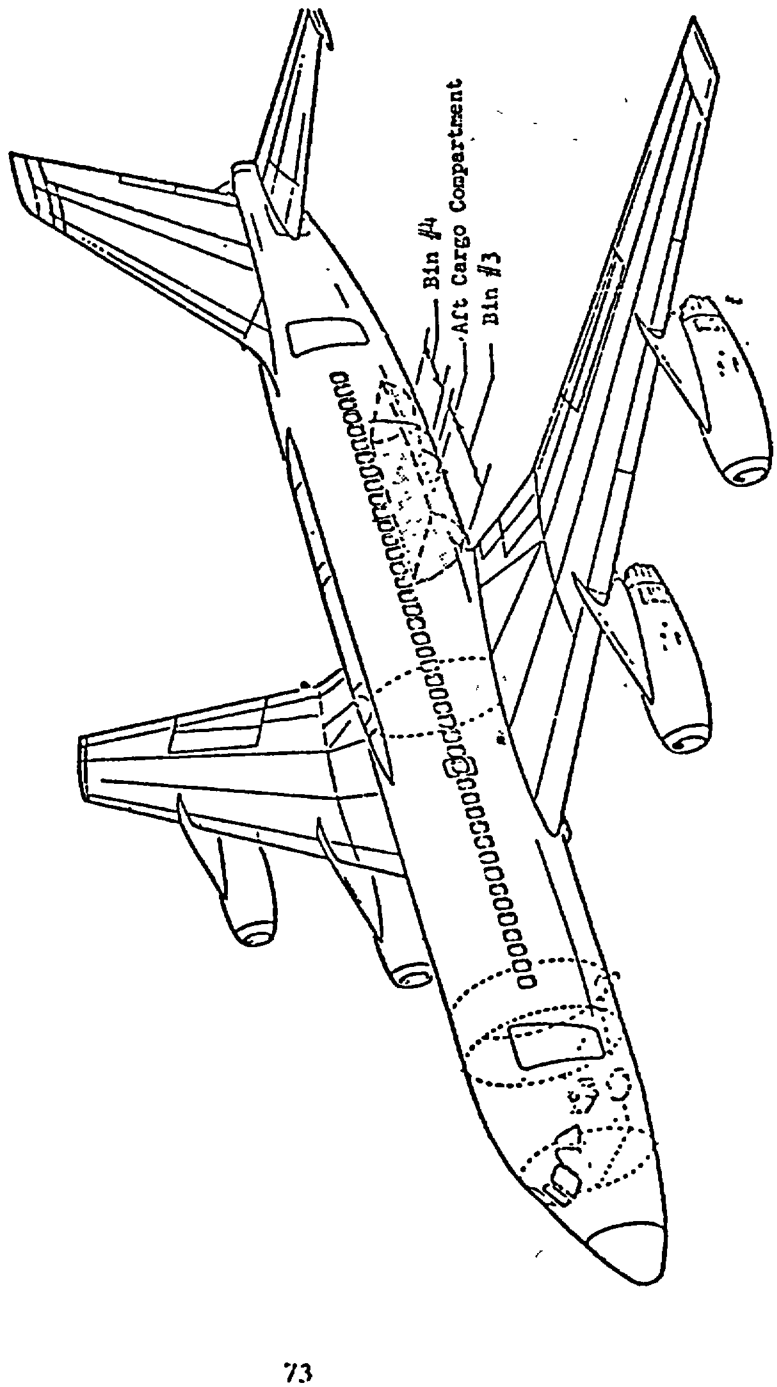
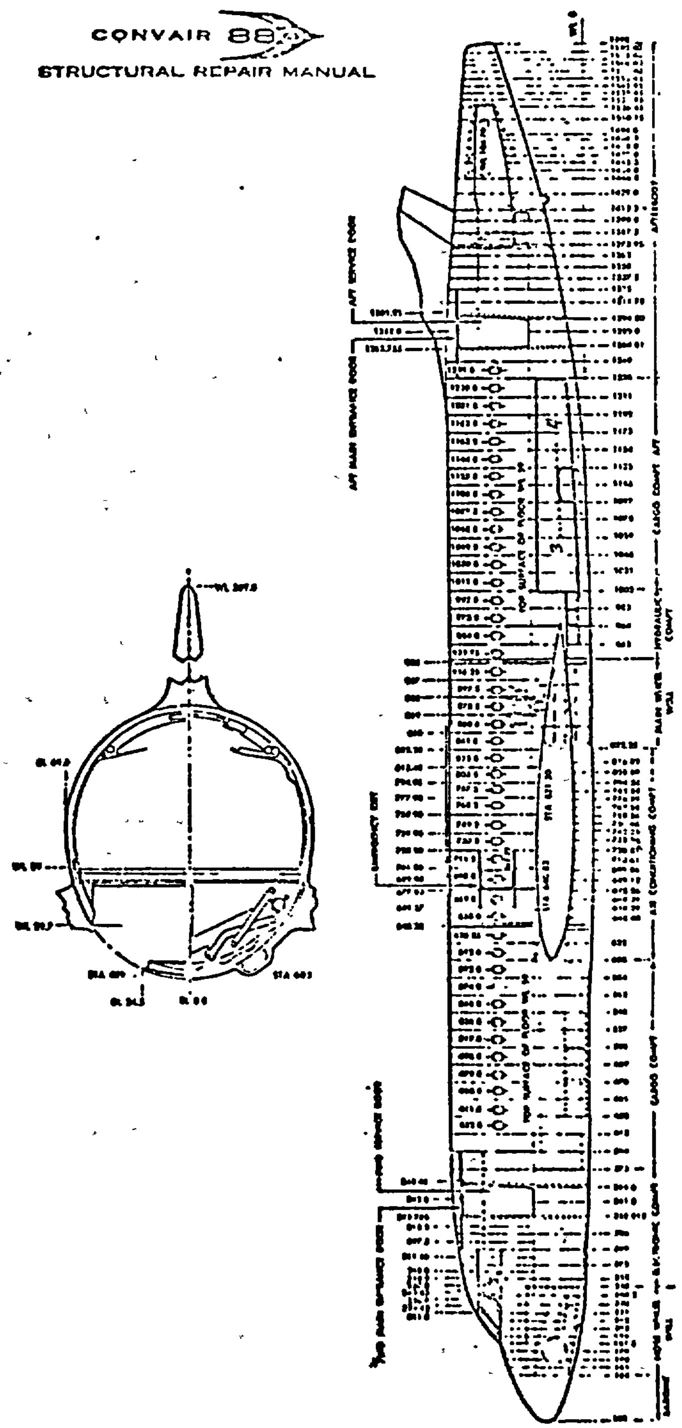
CONVAIR 880
MAINTENANCE MANUAL

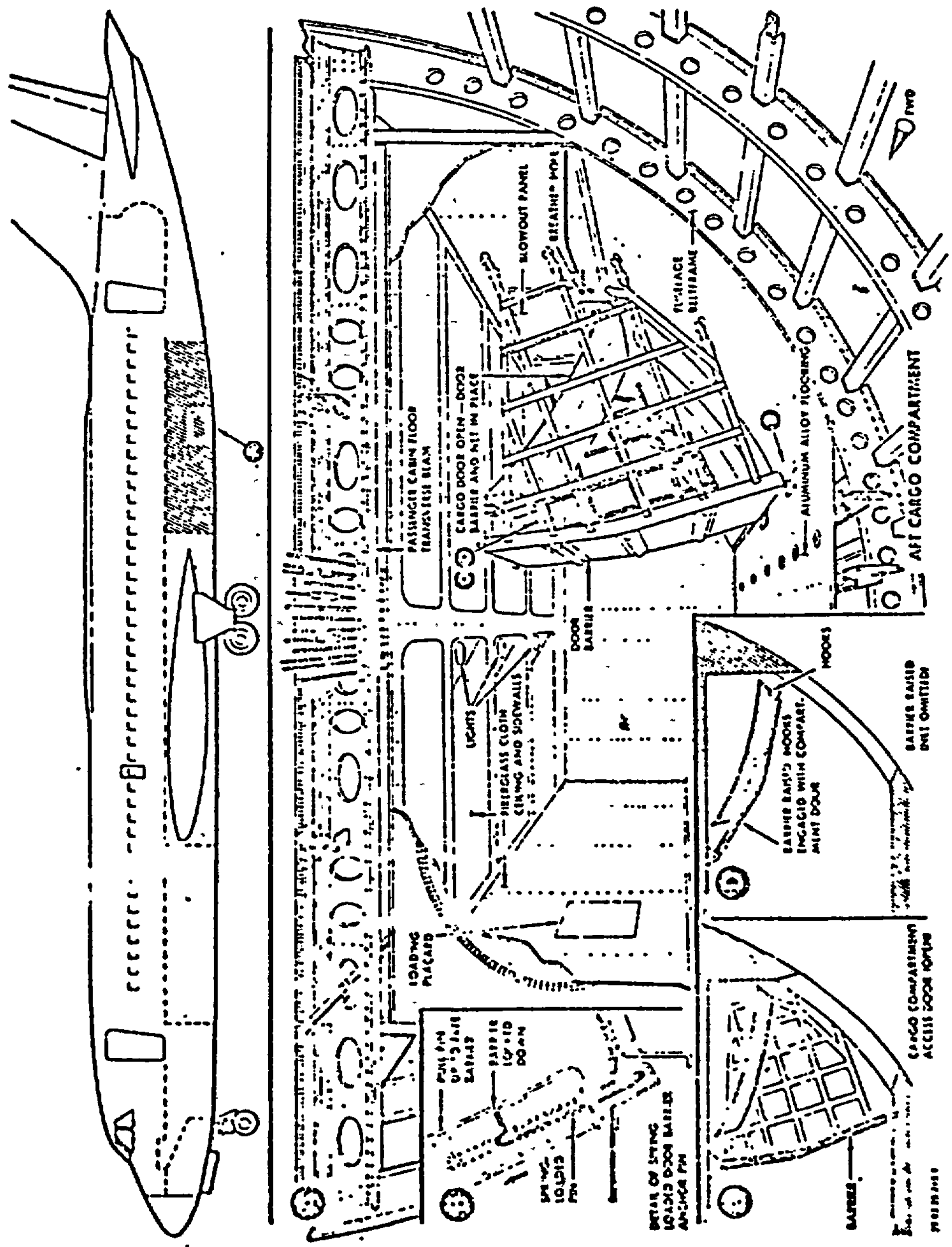


CONVAIR 880
STRUCTURAL REPAIR MANUAL



CONVAIR 880

MAINTENANCE MANUAL

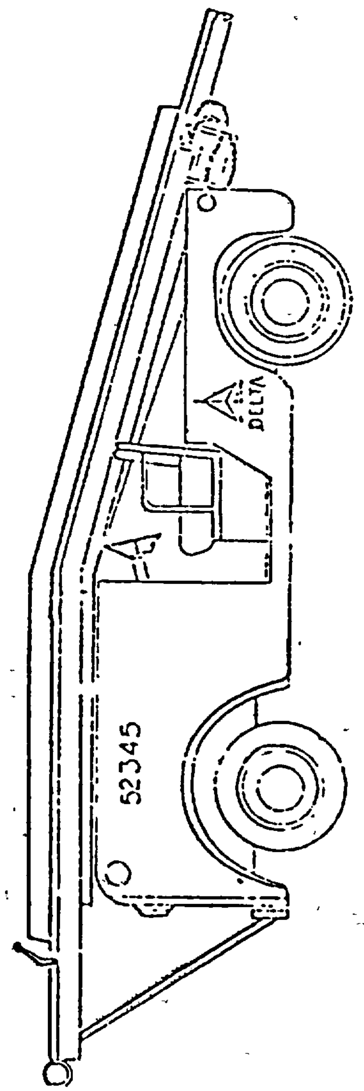


Cargo Compartments, Typical

STANDARD PRACTICE

CONVEYORS

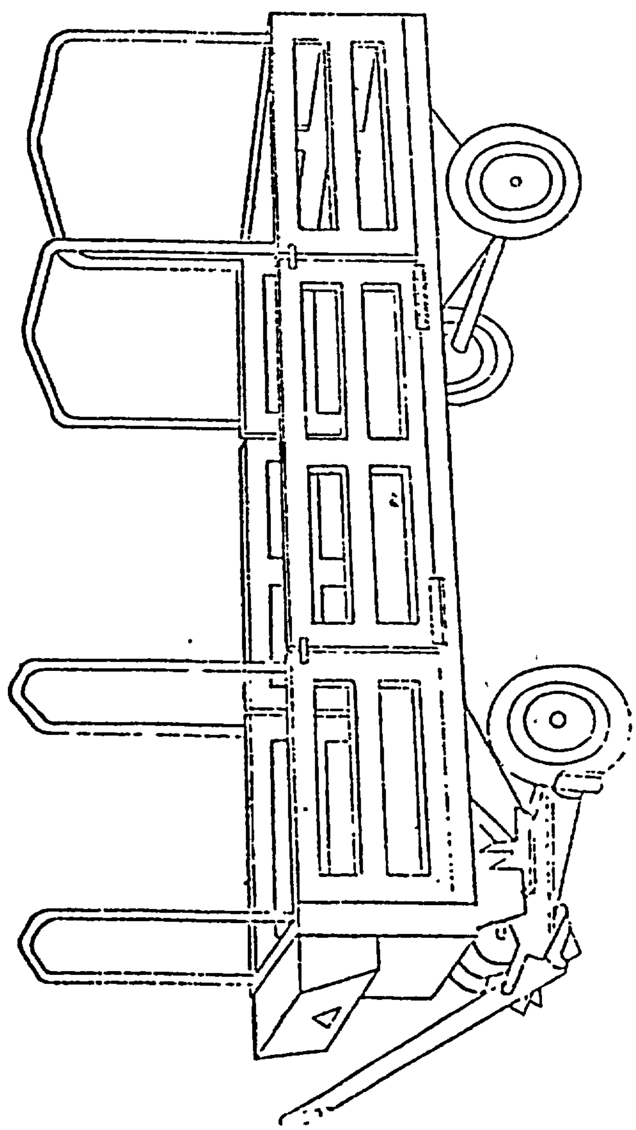
International Scout Conveyor - Model TC-476



DELTA AIR LINES, INC.

STANDARD PRACTICE

Wollard Baggage Cart - Model BC-450



ATTACHMENT A-12

RECONSTRUCTION OF SEQUENCE OF INCIDENT NOTIFICATIONS

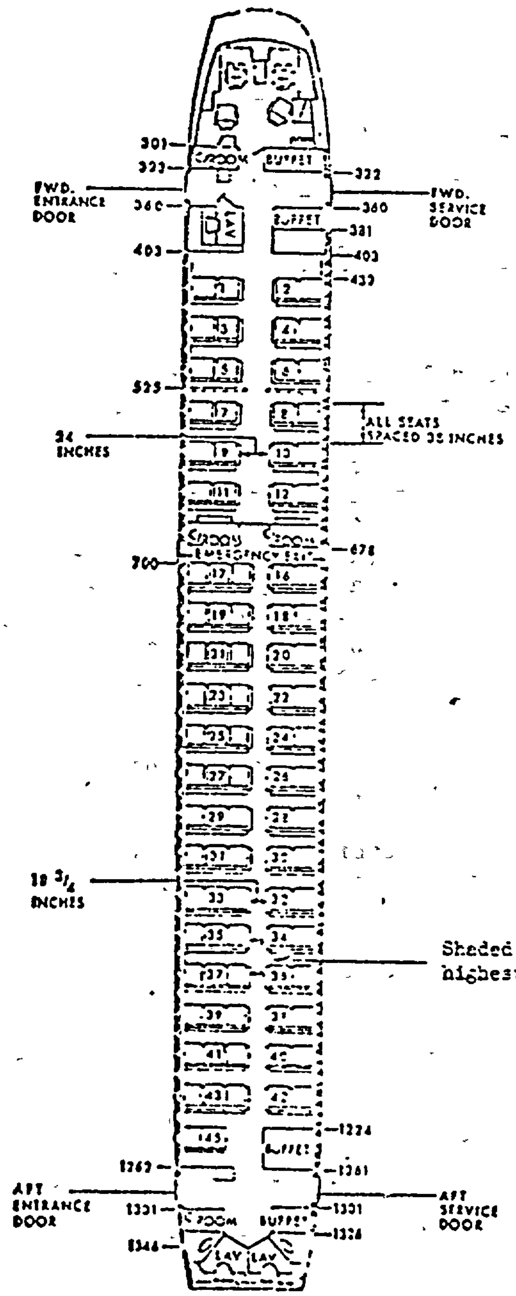
REF.*	DAY/DATE	TIME	CALLER	CALL RECEIVED BY	INFORMATION EXCHANGED
C	SAT./JAN.1	0800-0900			Hastings Radiochemical picked up shipment from airport. On return driver detected contamination during routine processing.
C	SAT./JAN.1	1330	Hastings	Hastings' Consultant HP-Radiation Safety Officer (RSO)	Advised him of probable contamination. (He came in, surveyed packages, and confirmed contamination.)
C	SAT./JAN.1	1430	Hastings-RSO	Texas State Health Dept.	Advised of external contamination
C	SAT./JAN.1	1445	Hastings-RSO	American Biomedical Corp Dallas (BioNuclear parent company)	Advised of contamination and alerted to possibility of BioNuclear shipment contamination.
C	SAT./JAN.1	afternoon	American Biomedical	BioNuclear	Advised of Hastings receipt of contaminated shipment in same consignment as theirs.
C	SAT./JAN.1	1500-1600	Hastings (Made UNSUCCESSFUL attempt to call)	Union Carbide Corp.	Apparently call got through to UCC boiler room. Caller would not identify problem or relay any information.
B	SUN./JAN.2	0700-0800			BioNuclear driver went directly to airport to pick up shipment. (Neither driver nor Delta knew of contamination at this time.) BioNuclear subsequently verified contamination and transfered remaining contents from containers.
A	SUN./JAN.2	morning			Texas State Health Dept. official traveled from Austin to Houston, visited Hastings, and confirmed contamination on packages.
B	SUN./JAN.2	morning	BioNuclear	Delta Air Lines (Freight)	Advised of findings of contamination, to check employees who handled shipment, and how to wash off contamination. (BioNuclear moved containers to quarantine in warehouse.)

*REF. - A - Time reference stated by individual company or agency representative.

B - Time reference approximated by company or agency representative.

C - Time reference approximate and reported by another party.

REF.	DAY/DATE	TIME	CALLER	CALL RECEIVED BY	INFORMATION REQUESTED
C	SUN./JAN.2	morning	Delta	Aviation Dept. Airport Security and Fire Dept.	Requested evaluation of condition at Airport Freight Facilities. (Fire Dept. decontaminated.)
A	SUN./JAN.2	1330	Hastings and Texas State Health Dept.	Union Carbide Corp.	To advise of contamination. UCC requested they call BioNuclear
A	SUN./JAN.2	1400	BioNuclear	Union Carbide	To advise package received contaminated.
	SUN./JAN.2	afternoon	BioNuclear	Texas State Dept.	To advise of contamination. (Representative, already at Houston, arrived soon after at BioNuclear.)
A	SUN./JAN.2		Texas State Health Dept. (called from BioNuclear)	Houston City Health Dept.	To advise of contamination. (Both proceeded to airport for survey which revealed additional areas of contamination.)
A	SUN./JAN.2	1500	Delta-Atlanta	Delta-Chicago	To advise of possible aircraft contamination. Requested AEC and Illinois Board of Health be contacted to inspect aircraft which was due to arrive at 1530. (AEC surveyed aircraft and found it contaminated. Aircraft was taken out of service and ferried to Atlanta for decontamination.)
B	SUN./JAN.2	2330	Delta-Atlanta	Union Carbide	Requested UCC call Delta VP to answer questions.
B	MON./JAN.3	0015	Union Carbide	Delta-Atlanta	In response to 2330 request.
B	MON./JAN.3	0400	Union Carbide	Delta, FAA & Georgia State Health Dept. (confer. call)	To determine course of action to pursue.
B	MON./JAN.3	0400	Union Carbide	BioNuclear (at Home)	To learn details regarding package as received.
B	MON./JAN.3	0810	Union Carbide	N.Y. State Dept. of Health Dept. of Transportation Atomic Energy Comm., Regn.I Compliance	To advise known details of incident to date.
B	MON./JAN.3	[illegible]	Union Carbide	Another Houston Consignee	To assure his packages were not contaminated. They had been routinely checked and found to be clean.



GENERAL ARRANGEMENT-PASSENGER AREA
(96 PASSENGER CONFIGURATION)

CONVAIR
MAINTENANCE MANUAL

CONVAIR 880

MAINTENANCE MANUAL

AIR DISTRIBUTION SYSTEM - DESCRIPTION AND OPERATION

1. General.

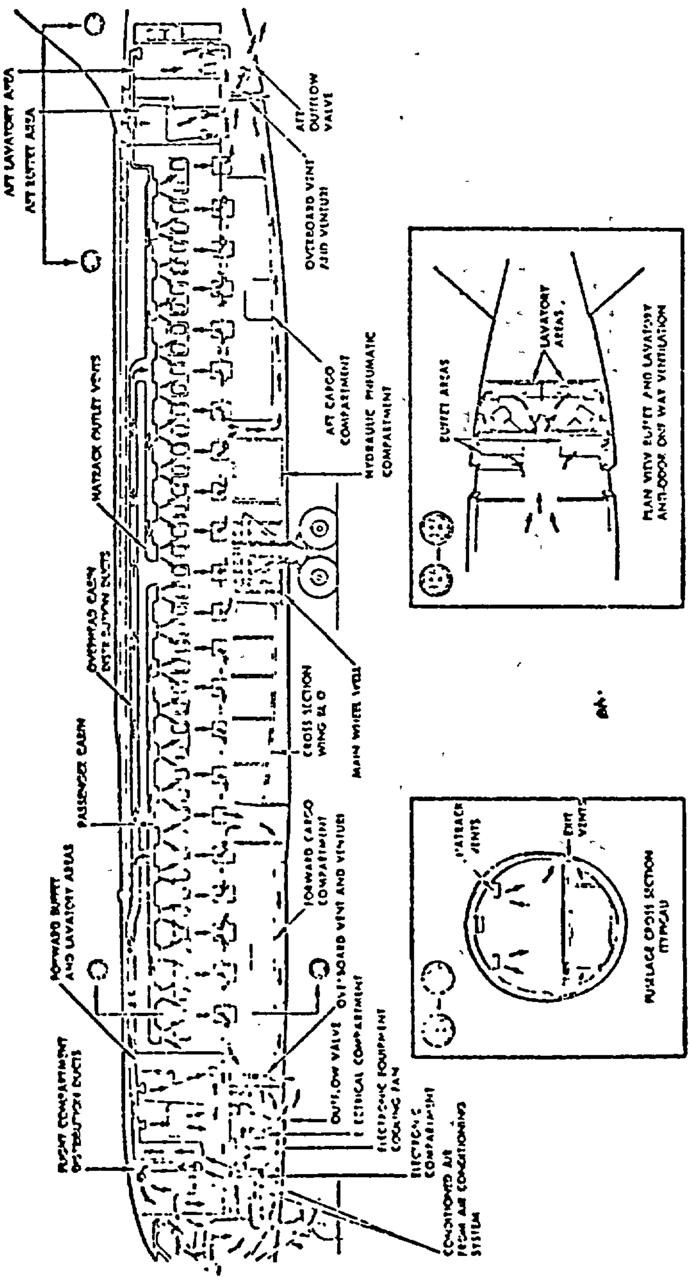
The air distribution system delivers conditioned air from the air conditioning packages to the crew and passenger compartments. A schematic of the air flow is shown on Figure 1. The air distribution system is illustrated on Figure 2. Aluminum and fiberglass ducting is used to deliver the conditioned air to air inlets along the sides of the cabin just below the hat-racks. The location and design of the inlets permit an even distribution of conditioned air throughout the passenger compartment with no drafts at any passenger location. The ducts and inlet vents minimize sound generation by the conditioned air as it moves through the ducts and out of the vents. Additional adjustable air inlets (ventilators) are installed above each passengers seat next to the reading light on lower surface of the hat racks. Conditioned air for the flight compartment is delivered by aluminum and fiberglas ducting and discharged above the flight crew's heads and at their leg level. Adjustable ventilators are installed above and forward of each crew seat (except observer).

Conditioned air in the passenger cabin is exhausted from the cabin through exit vents installed outboard and below the seats. These vents direct the exhaust air into the area below the floor. The flight compartment air is also exhausted to the area below the floor. The air exhausted below the floor in the forward area of the cabin is directed through the electronics compartment for cooling and ventilation of the electronics equipment and then through the electrical compartment and overboard through the forward cabin pressure regulator and out-flow valve, or the electronic equipment cooling valve. The air exhausted below the floor in the aft area of the cabin is directed aft, around and below the baggage compartments to stabilize temperatures in the baggage compartments, and then further aft to the aft pressure regulator and outflow valve where the air is ported overboard.

To prevent odors from entering the passenger areas, all lavatories and buffets are ventilated by a one-way ventilation system. The conditioned air directed to these areas is vented directly overboard through tubing, a venturi to limit flow, and overboard vents.

CONVAIR 88

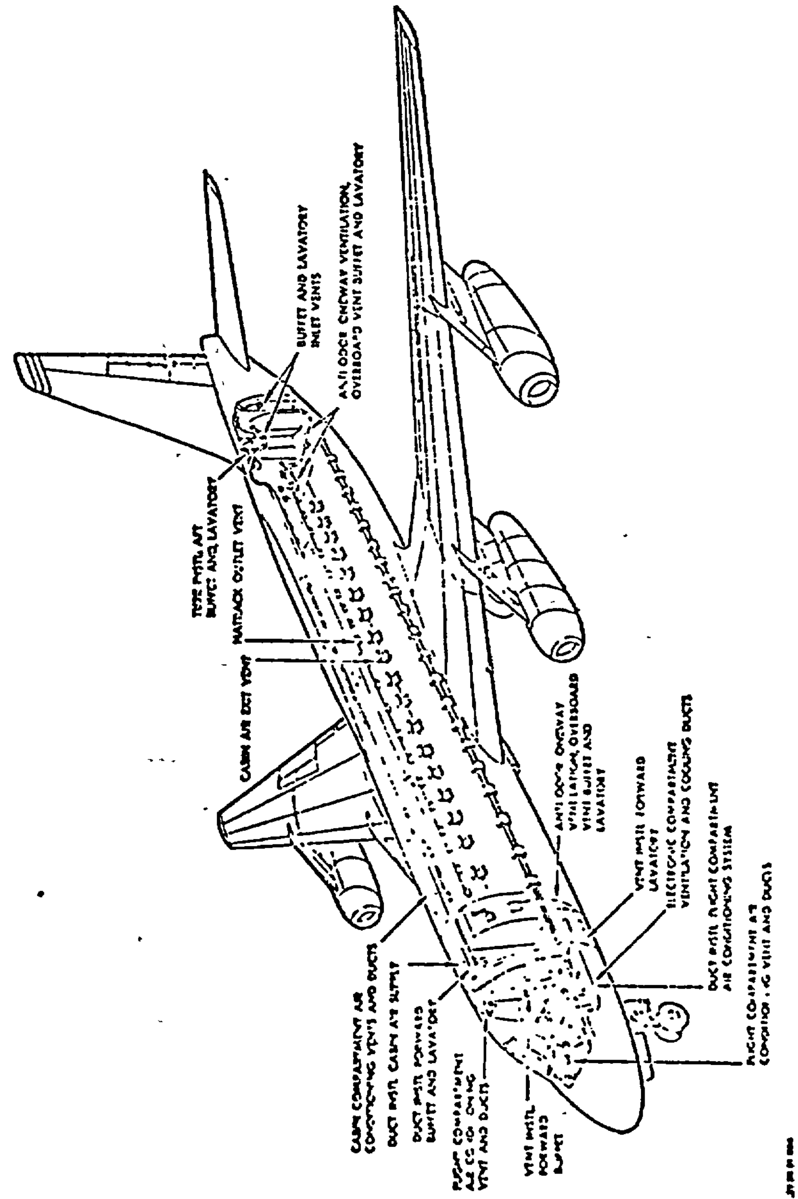
MAINTENANCE MANUAL



Air Flow and Pressurization Schematic

82

CONVAIR 880
MAINTENANCE MANUAL



Air Distribution System

INSTRUCTIONS FOR OPERATION OF THE AIRPORT SURVEY POINTS

THE ACTIONS OF THE SURVEY POINT TEAM ARE TO ASSIST DELTA AIR LINES (DAL) AND SHOULD BE AIMED AT ASSURING THE PASSENGERS OF THE AGENCY CONCERN FOR THE PASSENGER. JUDGEMENT MUST BE EXERCISED SO AS NOT TO UNDULY EXCITE THESE INDIVIDUALS. IT SHOULD BE BORNE IN MIND THAT THESE INDIVIDUALS ARE NOT INFORMED ON RADIATION CONTROL. CONSEQUENTLY, INSTRUMENT RESPONSE ON VERY SENSITIVE SCALES MAY CAUSE UNNECESSARY CONCERN IF OBSERVED BY THE INDIVIDUAL. ALSO, THE TEAM MEMBERS SHOULD BE AWARE THAT THEIR REMARKS AND CONVERSATIONS AS HEARD BY THE PASSENGERS ARE SUBJECT TO PASSENGER INTERPRETATION. REMARKS MADE IN JEST AND USE OF WORDS SUCH AS "HOT" OR EXPRESSIONS DENOTING SURPRISE OR UNDUE CONCERN BY TEAM MEMBERS MUST BE AVOIDED.

A DAL REPRESENTATIVE WILL BE THE PUBLIC CONTACT POINT FOR THE SURVEYS PERFORMED BOTH AT THE AIRPORT AND AT HOMES. IT SHOULD BE REMEMBERED THAT SURVEY TEAMS ARE SERVING IN AN ADVISORY CAPACITY TO DAL. ANY RECOMMENDATIONS TO PASSENGERS SHOULD BE MADE BY DAL. DAL WILL PROVIDE TRANSPORTATION OF TEAM REPRESENTATIVES TO HOMES FOR HOME SURVEYS.

1. Points are to be manned from 10:00 AM to 10:00 PM by qualified individuals daily beginning January 6, 1972, for 5 days or until no further requests are received and the survey point is shut down by the Delta Station Manager. The number of individuals making up this Survey Point Team should take into consideration, that Home Survey Teams may be drawn from the Survey Point Team.

2. Delta Air Lines Station Managers will provide space and will assure that passengers are directed to the survey point.

3. The area used for survey should have the floor covered with protective paper or plastic sheeting as a precaution.

4. Instruments, with appropriate check sources, capable of measuring from one mr/hr to 500 mr/hr, beta-gamma, are to be available.

5. Decontamination supplies consisting of absorbent pads, paper towels, rubber gloves, detergent solution, plastic bags, tags, marking pencils, and radiation tags are to be available.

6. A record, with copy to the Division of Compliance, AEC, will be made of the survey of each individual and article on the form attached.

7. Instrument surveys should be made of all articles returned by passengers on the affected flights. If articles are contaminated the passenger also should be surveyed.

8. The action point is a contact reading of 2 mr/hr, beta-gamma.

a. If no reading is detected above 2 mr/hr, the passenger is informed that there is no significant contamination and he is allowed to depart.

b. If a reading is detected in excess of 2 mr/hr, the team will:

(1) Attempt to decontaminate without destruction or damage to the item.

(2) If decontamination is successful to 2 mr/hr, the passenger will be so informed. He will be advised that some contamination was detected and removed and an offer will be made to have his home surveyed. Judgment *must* be exercised in the expression of this offer based on the level and extent of contamination found.

(3) If decontamination to 2 mr/hr is *not* successful, the passenger will be informed that contamination was found which was not easily removed and that fixed contamination is present. The contaminated article should be tagged with the release date that decay would result in a 2 mr/hr level. The passenger should be informed of this and the fact that the article should be stored and not used until the date. Delta Air Lines will store the article if the passenger so desires. An offer should be made to have his home surveyed. Judgment *must* be exercised in the expression of this offer based on the level and extent of contamination found.

9. Home Surveys

a. The home survey should be performed promptly. The passenger should be qualitatively informed of survey results by the Delta representative. Passenger property should NOT be destroyed nor confiscated. Rather, the passenger should be informed of acceptable cleaning practices, the fact that the radioactivity will disappear naturally to acceptable levels within a specified time, and some statement of hazard. The date on which decay will result in a 2 mr/hr level should be made known to the passenger.

b. Adequate records should be maintained of the home surveys. Delta Air Lines should be informed of the results and should serve as the contact point and make all arrangements for the survey.

c. Upon completion of a home survey, the member of the team that performed the survey should inform the AEC, Division of Compliance, HQ, telephonically of the result (301) 973-10[illegible]. The caller should ask for Mr. J. R. Metzger or Mr. G. W. Roy. Calls may be made collect.

d. If a team anticipates that a requested home survey cannot be accomplished within 48 hours, additional assistance should be requested by the AEC Radiological Assistance Team member through Radiological Assistance Team channels.

TENNESSEE VALLEY AUTHORITY
CHATTANOOGA, TENNESSEE 37401

June 2 . 1976

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D.C. 20555

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40FR23678)
Trans. Radioactive Mtl. by air

Dear Mr. Arlotto:

This is in response to your letter of April 26, 1976, to Dr. Lewis B. Nelson, regarding the Draft Environmental Statement on The Transportation of Radioactive Material by Air and Other Modes.

Pursuant to Section 5 of the Tennessee Valley Authority Act of 1933, [48 Stat. 58, as amended, 16 U.S.C. Sec. 831d (1970), Supp. IV, 1974], TVA is authorized to develop new fertilizer products and cooperate in the experimental research, development, and use of such products. In this connection, TVA's National Fertilizer Development Center has since 1967, under license from the U.S. Nuclear Regulatory Commission, prepared small amounts of fertilizer materials tagged with the radioactive isotopes of ^{32}P, ^{33}P, ^{35}S, or ^{45}Ca for research and experimental use and shipped them to many locations in the United States and foreign countries. The fertilizer materials used and shipped for this purpose usually are: (1) ordinary and concentrated superphosphates, (2) monoammonium and diammonium phosphates, and (3) calcium sulfate. Only solid materials are shipped. They have a low order of corrosivity, are nontoxic (except possibly when ingested), are nonexplosive, nonflammable, and not subject to spontaneous combustion. In fact, ammonium phosphates are used as fire retardants.

Our usual range of shipping weights, specific activity, surface radiation level, and transport index are tabulated below.

No. of containers/ shipment	Material wt./shipping container, g	Specific activity (mCi/g of material)	Surface radiation of package (mR/hr)	Transport index (mR/hr at 3-ft distance)
1-3	100-2500	0.5	0.5-25	0.05-1

Acknowledged by card 6/25/76 L.J

DOCKETED USNRC JUN 25 1976 Office of the Secretary Docketing & Service Section

Mr. Guy A. Arlotto June 2 1975

We expect that most of our future shipments will remain in this range, and we could commit ourselves to not exceeding these limits, if necessary. Although TVA is licensed by the Nuclear Regulatory Commission to handle and ship to authorized recipients materials containing as much as 3000 millicuries of ^{32}P, or 1000 millicuries of ^{33}P, or 1500 millicuries of ^{35}S, or 100 millicuries of ^{45}Ca, our usual shipments contain far lower amounts.

Our packaging, labeling, and inspection procedures are based on those outlined in the document, A Review of the Department of Transportation (DOT) Regulations for Transport of Radioactive Materials, printed December 1972 by the Department of Transportation.

We believe it is essential that regulations continue to allow shipment of these materials by passenger-carrying aircraft because air cargo transport is neither available from the local airport where the materials are developed nor at the location of many of the recipients of the materials. Additionally, brief transit time for these materials is necessary because decay of the radioactive elements is rapid, and it is important that the time between preparation and use be short. If the tagged materials are shipped by much slower surface transportation, it would be necessary to tag them at significantly higher levels, which would have the effect of increasing their hazard potential.

The short half-lives of these materials require very tightly coordinated transportation schedules, and in some cases, verification of progress. Larger shipments could not be as readily scheduled or traced in their progress.

We appreciate the opportunity to comment, and ask your very thorough consideration of the comments provided.

Sincerely,

Peter A. Krenkel, Ph.D., P.E.
Director of Environmental Planning

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40 FR 23768)
Trans. Radioactive Mtl. by Air

STATE OF NEW YORK

DEPARTMENT OF LAW

TWO WORLD TRADE CENTER
NEW YORK, N.Y. 10047

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LOUIS J. LEFKOWITZ
ATTORNEY GENERAL

PHILIP WEINBERG
ASSISTANT ATTORNEY GENERAL
IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

JUN 2 1976

Director
Office of Standards Development
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Comments on the Nuclear
Regulatory Commission's
Draft Environmental Impact
Statement on the Transportation
of Radioactive Materials
(NUREG-0034)

Dear Sir:

On May 17, 1976 the New York State Attorney General submitted comments to you on certain portions of the above-referenced document. At that time we informed you that additional comments were being prepared on other portions of the Draft Environmental Impact Statement ("DES") and would be submitted in the future. These comments are now complete and are enclosed herewith for docketing in the proceedings on the DES. Thank you for your cooperation.

Acknowledged by card 6/22/76

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
by

JOHN F. SHEA III
Assistant Attorney General

Comments by

John W. Gofman, M.D., Ph.D.

on

Draft Environmental Statement on The Transportation of Radioactive Materials by Air and Other Modes, Docket No. 71-73 (40 FR 23768), March 1976, U.S. Nuclear Regulatory Commission, Office of Standards Development

Submitted on behalf of
The Attorney General of the State of New York

John W. Gofman is Professor Emeritus, Medical Physics, University of California, Berkeley, California, 94720. Home address is 1045 Clayton Street, San Francisco, California, 94117

Prepared May 16, 1976

These comments will be limited to the subject of plutonium and its health hazards, in the context of the DES. The DES is totally unacceptable in its evaluation of the inhalation hazard of plutonium, since the errors in treatment of this subject are numerous and large. Consequently all the evaluations of the consequences of plutonium dispersal in the event of container failures are not only irrelevant to the true problem, but they do a severe disservice in grossly underestimating the true medical cost of such dispersals.

Point 1. The lung dose per curie inhaled is given as $2x10^8$ rems in Table III-7 (for insoluble PuO_2.)This value is manifestly incorrect. Gofman (1) and Cohen (2) agree that the dose is $2x10^9$ rems per curie deposited. Correcting this , from deposited to inhaled, we should reduce the value four-fold. Therefore, the correct value is $5x\ 10^8$, which is 2½ times as great a dose as presented in the DES. But this is only the beginning of the serious underestimate of dose from plutonium in the DES. All calculations of the DES are based upon the ICRP Model (Figure B-2 in Appendix B). That Model makes the erroneous assumption that no plutonium is retained for long-term delivery of dose to the bronchial region, an assumption based upon no evidence whatever and totally in contradiction with evidence concerning the impairment of bronchial ciliary function in cigarette smokers and in non-smokers . (See Gofman (1). When this is taken into account and when the small mass of the cancer-relevant bronchial tissue is taken into account, (one gram instead of the 570 grams of the whole lung), we end up with the following correction factors that must be applied to the DES estimates of dosage:

For cigarette smokers, dose must be multiplied by 103 times,
For non-smokers, the dose must be multiplied by 8.2 times.

Therefore, overall, incorporating these factors and the 2½ factor above, the DES underestimates the dose for plutonium inhalation by 257.5 times for cigarette smokers and by 20.5 times for non-smokers. These errors, alone, are sufficient to invalidate all the consequences of dispersion estimated in the DES But these are not the only serious errors concerning effects estimation.

Point 2 . In Table III-9 the DES estimates latent cancer fatalities as 22.2 deaths per 10^6 person-rems of exposure to the population. The data of reference 1 point to a more correct value of 762 deaths per 10^6 person-rems on the same calculation basis. Therefore, the DES estimate is some 34.3 times too low in its cancer estimate. If this underestimate of effe. is combined with the underestimates of dose, we arrive finally at the following error estimates for the DES evaluation:

For Cigarette smokers, effects must be 3533 times larger than DES estimates,
For non-smokers, the effects must be multiplied by 281.3 times to correct the DES estimates.

The final result of such corrections is to make the DES estimates totally meaningless as they stand in the report.

Point 3: In Appendix B , page B-12 the DES refers to " ... the median lethal dose of plutonium as 260 micrograms" This statement is not only meaningless, it is grossly erroneous. The dose that guarantees a lung cancer fatality is 0.058 micrograms of Pu^{239} for cigarette smokers and it is 7.3 micrograms for non-smokers. Thus, for cigarette smokers, a dose 4483 times smaller than the DES will kill all humans, whereas the DES estimates their dose will kill ½ those exposed. Thus the DES is much more than 4483 times too low on plutonium toxicity. For non-smokers the amount required to guarantee fatality is 35.6 times lower than the dose DES calculates will only kill one half of the exposed. Unless the Nucle Regulatory Commission learns something of the true toxicity of plutonium it is likely to continue to make such absurd statements as that on page B-12 that "Although plutonium is certainly a potentially dangerous material, it is not orders of magnitude more potent than numerous other existing materials".

Point 4. On page B-10, the DES states, " Cancers have been induced in laboratory animals, although no cancers attributable to plutonium have been observed in humans." This statement is not only meaningless, it is dangerous. What the DES should state is " No meaningful study has been undertaken to determine how many lung cancer fatalities have been caused by plutonium handling." For the population-at-large, the best estimate currently available is that plutonium fallout has condemned 1 million persons in the Northern Hemisphere to lung cancer deaths. (Gorman, (3).

Summary

The DES has so seriously underestimated both the dose and the effects for plutonium exposure that all of its comments on dispersal of plutonium must be regarded as worthless.

References:

(1) Gofman, John W., "The Cancer Hazard from Inhaled Plutonium May 14, 1975. CNR Report 1965-1R , Committee for Nuclear Responsibility, Yachats, Oregon.

(2) Cohen, B.L. "The Hazards in Plutonium Dispersal" Report of the Institute for Energy Analysis, Oak Ridge Associated Universities, March , 1975, Oak Ridge , Tennessee.

(3) Gofman, John W. "Estimated Production of Human Lung Cancer by Plutonium from Worldwide Fallout" , July 10, 1975, CNR Report 1975-2, Committee for Nuclear Responsibility, Yachats, Oregon.

COMMENTS OF THE NEW YORK STATE ATTORNEY GENERAL ON THE DISCUSSION OF TOXICITY OF MATERIALS, CONTAINERIZATION, RELEASE OF MATERIALS AND GENERAL RISK ANALYSIS IN THE NUCLEAR REGULATORY COMMISSION'S DRAFT ENVIRONMENTAL IMPACT STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIALS BY AIR AND OTHER MODES

NUREG 0034

BY

DR. MARVIN RESNIKOFF
PETER N. SKINNER, P.E.

Introduction

1. Previously numerous affidavits were submitted by the State of New York to the United States District Court for the Southern District of New York in the Case of the State of New York v. The Nuclear Regulatory Commission, et al. Copies of these affidavits have been provided to the Nuclear Regulatory Commission ("NRC") in the course of this proceeding dealing with the transportation of radioactive materials as originally noticed in the Federal Register. 40 Fed. Reg. 23768. References to the "plaintiff" in these comments on the Draft Environmental Impact Statement ("DES") are, of course, to the State of New York. Occasionally references are made to the "defendants" and "defendants' affidavits"; these references are to the NRC and its sister agencies which are involved with the transportation of radioactive materials and the affidavits which this agency and its sister agencies have filed in the litigation initiated by the State of New York.

2. We have examined certain parts of the DES dealing with toxicity of materials, containerization, dispersion, crash environments and risk analyses of various modes of transport and it is our conclusion that the DES is a fatally defective document and, as such, cannot be relied upon as an accurate or adequate document by the Congress or the public.

Shipment Size

3. For the purposes of the DES the authors assumed an air shipment of plutonium with a size of four packages containing five kilograms each for a total of 20 kgs. (Tables V-13, V-12, V-7). Actual practice seems to indicate that larger sized shipments are more realistic. For instance, two JFK PuO_2 shipments on July 29, 1974 and February 24, 1975 weighed 48.3 kilograms and 45.1 kilograms respectively, each more than twice the size assumed by the DES. This assumption undercuts the credibility of the "worst case" scenario.

Containerization

4. Whether or not plutonium powder will escape its container during an air accident is dependent on two factors, the strength of the container and the severity of the accident environment. Considering the first of these, the DES makes only a passing reference to the wealth of material available as a result of the work done by Sandia Laboratories, and others, as well as a great deal of data supplied by the many experts appearing in the case of State of New York v. Nuclear Regulatory Commission, et al., United States District Court for the Southern District of New York (75 Civ. 2121 [WCC]). No data whatsoever can be found in the DES to dispute the criticism in the affidavits previously filed by the State in that case and in the Nuclear Regulatory Commission ("NRC") proceeding on transportation noticed at 40 Fed. Reg. 23768.

5. It has been determined under performance test conditions that the integrity of these containers are breached by levels of test crash environment intensity which are significantly less severe than actual air crash environments (Def. Aff., Nussbaumer, Exh. D; Pl. Aff., Pinkel, p. 6; Resnikoff, [6/12/75], p. 3). In fact, during test drops done for NRC at speeds of only 130 feet per second, even the inner pressure vessels were caused to leak (Pl. Aff., Resnikoff [6/12/75], p. 3; Def. Aff., Nussbaumer, Exh. D.). The Sandia Laboratory Report, "Special Tests for Plutonium Shipping Containers", annexed to the

Nussbaumer affidavit as Exhibit D, candidly admits that, if impact speeds were raised to 150 feet per second, spillage of nuclear material is likely (Pl. Aff., Pinkel, p. 6; Def. Aff., Nussbaumer, Exh. D). Yet the DES classification scheme for accident severity categories assumes that no material will leak from cannisters in such accidents. Hence, these assumptions in the DES directly contradict the earlier affidavits of defendants submitted to the Federal District Court and the NRC.

6. No thought has been given to the potential of penetration damage due to shrapnel-like fragments of disintegrating airplane components resulting from an air accident (Pl. Aff., Pinkel, p. 7). Dr. Chapman, formerly of the Cornell Aeronautical Laboratory, is in agreement with Mr. Pinkel and Dr. Resnikoff when he concludes that, given the present containers, there is little assurance of containment of materials in air crash environments, which are clearly more severe, more complex and of greater impact than accidents in other modes of transport (Pl. Aff., Chapman, pp. 2-3; see also Pinkel, Resnikoff) The containers now in use by the NRC, their agents and licensees are clearly not designed from a complete knowledge of the air crash environment and continued use of such containers in air transport jeopardizes human life (Pl. Aff., Pinkel, p. 10).

7. Cannister strength is lightly treated by the DES on pages V-24, 25, and 26 and VI-48 and 49. At this late date the NRC admits that "only a limited number of containers [have been] tested." The DES assumes that "Model I" packaging (that is cannisters meeting current regulations) would fail (p. V-12). As to cannister "Model II", which is deemed by the NRC to be a conservative approximation of "real containers in an accident environment" (VI-26), and hence the critical link for NRC's allegations as to safety of containerization, the authors rely on unspecified "personal communications" for substantiation of their various assumptions. This totally undermines the validity of this analysis for the purposes of this DES. The authors arbitrarily define fractions of plutonium powder shipments which will l

released in the event of an air accident of a given severity class. Of the two references presented to support these arbitrary assumptions, one, (9) (p. V-24) is a private communication "private communication" is also refered to earlier on page V-1 in regard to population densities across the country. "Private communications" are a highly suspect source for a very important parameter for study of this area. No specific data is ever identified as stemming from this "personal communication"; and hence, no basis is given for the authors assumptions as to accident severity classes and release model fractions. These models are unverifiable and, as a result, highly questionable, to say the least.

Accident Environments

8. The DES presents an abbreviated analysis for the complex and controversial area of accident environments. The authors of the DES consider only that damage inflicted on the containers by assumed fire and speed of impact factors and do not consider crush and puncture damage, the very damage mechanisms deemed to be so significant in the earlier Sandia report which was placed on the record of the State's case by the defendants themselves (Def. Aff. Nussbaumer, Exh. C, D and F).

9. Nothing in the text of the DES indicates how the authors established accident type classifications on the basis of papers by "Clark et al." (p. V-60). Since the NRC has made the work of Clark et al. central to the determination of these "type classes", specific discussion of all relevant portions of that material must be provided if this part of the DES is to have any validity.

Release

10. It is significant that the earlier analyses by Resnikoff (Pl. Aff. April 25 and June 12, 1975), which only assumed 1/16 of the DES "worst case" release, resulted in the tens of thousands of Latent Cancer Fatalities ("LCF's"). Had he used a

20 kilogram release instead, hundreds of thousands of people would have become LCF's in all three cases of meteorological stability. (See Pl. Aff. Resnikoff, April 25, 1975, Appendix D).

Dispersion and Resuspension

11. The degree to which the public would become exposed to plutonium powder in the event of an air accident is dependent on the parameters discussed earlier and on several others as well; dispersion is one of them. The DES presents an almost incomprehensible complex of figures and explanations on this topic. A number of factors necessary for the reader's reproduction of the conclusions as to dispersion are omitted or inadequately described. The basic input term of deposition velocity, necessary for standard Gaussian analyses, is completely missing. Apparently Figure V-11, "Specific Dose vs. Area", is important to the DES's determination of areas which would be covered by plutonium powder after an accident. The term, Specific Dose (rem/gm), is depicted as varying with the area enclosing such a dose. This is an internally inconsistent concept (rems/gram of plutonium does not vary -- it is a constant). Yet the concept becomes, by the use of other vague factors, the basis for figures V-12 and V-13, which set forth the number of people affected. Because of the inconsistencies and lack of descriptive information contained in the DES on this issue, we have been precluded from further comment on this analysis.

12. Both Robert Barker of the NRC (Def. Aff. sworn May 30, 1975) and Dr. Marvin Resnikoff (Pl. Aff. sworn April 25, 1975 and June 12, 1975) (one of the deponents herein) utilized Gaussian models with full explanation of the input parameters and sensitivity thereto. The DES, inconsistent with the analysis of the NRC's own expert, Barker, does not even explain these differences in approach between the DES and the Gaussian analyses. The discussion of contradictions later in these comments shows that the DES predicts 617 Latent Cancer Fatalities, Barker 15,000, and Resnikoff 107,000. Since the DES arrives at conclusions different than either of those models, some

explanation is required before the DES can possibly be relied on as having any validity.

13. Dispersion is also dependent on the meteorological conditions assumed. Calm weather increases the amount of individual dosages and turbulent conditions decrease dosages. In the DES the authors state: "A year or more of data record (sic) for these parameters is used in the model which was obtained at two different locations" (p. V-29-30). Neither the data recorded nor the locations studied were presented; yet these factors quite obviously have tremendous impact on the conclusions presented in figure V-10. Such data were presented by Barker (Def. Aff. p. 17 and exhibits) and Resnikoff (Pl. Aff. April 25, 1975 Table 2). Once again this omission precludes reproduction of the DES's conclusions by the reader. The DES's use of only average conditions from the "year or more of data" recorded does not present scenarios capable of producing "worst-case accident consequences" found in figures V-11 and V-12.

14. Resuspension of the powder once it has settled out of the atmosphere onto buildings, vehicles, roads, etc. will plague decontamination and evacuation efforts and increase exposures to the public. The DES states only that "the contribution to the total dose from cloud shine, ground shine, and resuspension can be obtained by the application of established factors to the results shown in figure V-11 . . ." (p. V-39). No use or actual application of these highly important "factors" is to be found in the DES.

Respirability

15. Plutonium powder comes in various size gradations, depending on the source, some being more likely to settle in the lung than others. The more plutonium which settles in the lung, the greater the degree of risk of lung cancer. The authors of the DES assume 20% will be a candidate for deposition on the basis of particle size gradation of Fast Flux Test Facility ("FFTF") feed material (p. V-40), stated by the DES to be 20%

respirable. However, plutonium oxide shipments through JFK in 1974 and 1975 (p. V-43) were admitted by the NRC to be 40% respirable. Indeed even the DES assumption of 40% respirability for JFK shipments is far too low as the authors have based that figure on a statistical construct of a 3.3 micron mean size of particles in those shipments. However, uncontested information in the record of the State's case against the NRC indicates that the range of particle size (.92 - 1.12 microns) did not include 3.3 micron particles at all, much less a mean particle size of 3.3 microns (Pl. Aff. Skinner, Appendix B). Since particles below 3.3 microns are " . . . considered to be respirable and candidates for deposition in the pulmonary tissue . . . " (p. V-40), it is accurate to say that 100% of the JFK shipments were candidates for lung deposition. Use of a 20% respirability figure represents a significant underestimate of plutonium's dangers. Again the DES proves to be a document replete with invalid assumptions.

Population Concentrations

16. The DES assumes 10,000 people/square mile to be a "High Population Density" (p. V-30). Examination, however, of the Tri-State Regional Planning Commission 1970 Census population distribution shows that there are only a few square miles within a zone of maximum impact in New York City with 10,000 persons or less (Pl. Aff. Skinner-Wang sworn June 13, 1975, exhibit 7). The Skinner-Wang affidavit utilizes 40,000 persons/square mile as a more representative value for a "worst case" accident at JFK. According to that affidavit a four-fold increase in population density would result in a four-fold increase in the impact presented in figures V-12 and V-13 of the DES.

Biological Half-life

17. Radioactive material has a normal decay half-life of the material itself. In addition, when a radioactive material is taken up by the body, natural biological processes can expel a part of that uptake. The rate at which the expulsion takes place is known as the biological half-life. For the purposes

of the DES the authors chose 500 days (page III-16). This assumption appears to be a significant underestimate. In the appendix to the DES (page B-7), the authors admit the " . . . lung clearance half-time" is 200-1,000 days. In order to obtain the worst-case scenario as described in figures V-12 and V-13, the authors should have used 1,000 days, not 500. There is significant authority for the use of such a value. The U.S. Environmental Protection Agency ("EPA") reports in its publication, "Environmental Analysis of the Uranium Fuel Cycle, Part III - Nuclear Fuel Reprocessing, 520/19-73003-D, that the new International Commission on Radiation Protection ("ICRP") lung model assumes a 1,000 day half-life as does the NRC's WASH-1535 "LMFBR Program Environmental Statement" in that document's Table II.G-9.

Biological Effectiveness

18. Another area of disagreement lies in the biological effectiveness (i.e., effect on tissue) of given gram of plutonium. The DES uses a figure of 2.0×10^8 rems/curies. The NRC's WASH 1535 at Table II.G-10 presents a figure of 8.6×10^8 rems/curie. According to the USEPA (Id.), ICRP now uses 16.5×10^8 rems/curie for Pu-239. Since the DES relies on the Pu-239 value of 2.0×10^8 for its conversion calculation of the biological effectiveness of reactor type Pu (that shipped through a JFK) (Page B-4), it is clear that the danger of plutonium inhalation may be understated by the DES by over 8 times. At any rate, the resulting impact calculated from the 2.0×11^8 number cannot be considered a "worst case" impact.

19. Recycle of plutonium in today's light water reactor fuels will increase the concentrations of certain isotopes of plutonium in any shipments by air as shown below.

Plutonium Constituents

Constitutent	DES (B-5)	JFK*	WASH. 1327**
Pu-238	1.9%	0.6%	4%
Pu-239	63.0%	72.0%	43%
Pu-240	19.0%	18.7%	26%
Pu-241	12.0%	7.0%	15%
Pu-242	3.8%	1.6%	11%
Am-241	0.6%		1%
Rems/curie	10.6×10^6	39×10^6	83×10^6

(See April 25, 1975 Resnikoff affidavit - table 2 for calculations of Rems/curie)

These increases mean that the latent cancer danger of plutonium powder will increase by about 100% when plutonium recycle matures. This effect has not been taken into account in tables V-16 and V-17 of the DES.

Latent Cancer Fatalities

20. Latent Cancer Fatalities ("LCF") is an epidemiological factor. When a population receives a dose of radioactive material, the LCF factor can be used to predict the number of fatalities due to this dosage above the average one can expect from other causes. The authors of the DES chose 22.2 LCF/10^6 person-rems for lung cancer on the basis of the BEIR report (p. III-23). This number is smaller than a that in a number of other reports. USEPA has assumed 50 LCF/10^6 person rem. Dr. John Gofman reports that Cohen has used 39 LCF/10^6 person rem and assumes 762 LCF/10^6 person rem himself (Pl. Aff. Gofman, Exhibit B, p. 6). From these data it can be clearly shown that the DES has understated the danger of plutonium inhalation by as much as 34 times. The specific origin of the Latent Cancer Fatalities figure (20 per year for 30 years) (p.ii), which allegedly could be produced from the DES's plutonium

*Pl. Aff. Skinner-Wang affidavit, sworn June 13, 1975, Exhibit 7

**"Draft Generic Environmental Statement on Mixed Oxide Fuel", p. IV C-62.

accident scenario, cannot be found anywhere. Throughout the numerical presentations the reader is forced to do detective work to find the computational framework (often apparently guesswork) utilized by the authors, often without success.

21. Of interest as well is the DES's use of cutoff points for the production of LCF's from population exposure. Standard epidemiological analysis utilizes the formulas described above (LCFs/10^6 person-rems) based on the whole population exposed. This method is necessary to integrate the natural variability of people's response to carcinogens. Although the DES uses the above epidemiological tool, it applies that tool only to a part of the population, that part which has sustained more than a given dose, thereby eliminating a significant number of exposed persons (or person-rems) from consideration. Table V-13 employs a cutoff of 15 rem. That part of the exposed population, perhaps millions of people who, receiving less than 15 rem, are excluded from epidemiological consideration - i.e. they are deemed by the DES as not being potential cancer victims. Such a method is contrary to standard epidemiological practice (as utilized in the Skinner-Wang affidavit of June 13, 1975, Exhibit 1). The method employed by the DES significantly reduces the impact of a dispersion accident.

22. A similar cutoff or threshold was applied to calculations underlying figure V-10. The cutoff of .8 rem was used for depicting the area enclosing populations dosed at that level. Since this figure is based on a one kilogram release and the DES worst case scenario was based on a 20 kg release, one can readily see that the actual cutoff is not .8 but actually (1) 20 x (.8) or 16 rems or (.5) (20) x (.8) or 8 rems depending on the fraction of a shipment released (p. V-25).

23. Another significant underestimate in impact consequences can be found in Table V-13's use of the "Integrated 1 year dose" factor. Instead of presenting the number of people who would have suffered irradiation over their 50 year adult lifetime, the DES presents a smaller number on the basis of only a 1 year dose. The text of the DES does not describe how this integration was done, which precludes adequate analysis by ourselves at this time.

Sensitivity Analysis

24. The sensitivity analysis presented in Appendix G of the DES covers a number of factors which can be varied for an examination of the range of effects on calculated impact. The "theoretical basis" for this analysis is in equation (2) $\Delta I \cong \frac{dI}{dx} \Delta X$. This is an elaborate way of saying that, if the dependent variable (X) is changed by a certain amount (ΔX), ΔI will change on the basis of dI/dX. For the few variables analysed in this manner, none of the dI/dX components are presented and the methods and assumptions utilized to get them are missing as well.

25. Although many variables have been mentioned herein as being underestimates, only one of these, population density, is analyzed in the DES for sensitivity in the accident scenarios. As mentioned before (Pl. Aff. Skinner-Wang, sworn June 13, 1975, Table A) we maintain that 40,000 people/square mile is a more representative population density for the New York City region imperiled by plutonium air shipments. This represents a 400% increase over the baseline population density (10,000/mile^2) NOT 10% as the DES assumes.

26. Assuming a linear dI/dX term, the 5.1% increase in baseline value (Figure G-2) would ge increased by a factor of some 204%. Therefore LCF numbers would be doubled due to the four times greater density of population in the region at risk. The sensitivity of this parameter in the DES is contradicted by

an uncontested affidavit filed by the State in its case against the NRC (Skinner and Wang, sworn to June 13, 1975). That affidavit shows that a 400% increase in population density would occasion a 400% increase in lung cancer fatalities (see Tables 1-9). The analysis of Annual Early Fatality Probability increases (DES Figure G-3) does not consider population density in such a way as to be meaningful in terms of figure V-13.

27. This section in the DES on sensitivity analysis is totally inadequate, having failed to analyze those variables we have discussed herein and having further failed to consider other variables essential to a valid final impact assessment (e.g. shipments by barge, putting plutonium in "bulk" form).

28. The term "lung cancer fatalities" utilized in the Skinner-Wang affidavit sworn June 13, 1976 can be used interchangeably with the DES's term, latent cancer fatalities. Lung cancer fatalities utilized in the Skinner-Wang affidavit above also include the DES's fatality sub-group, annual early fatalities. This overlap between the DES and Skinner-Wang analyses is really academic because the fatality occurs either way.

Contradictions and Discrepancies in NRC Analyses of Impact

A. Barker's Affidavit

29. The DES presents accident impact conclusions which, in part because of the nature of the assumptions used, were smaller than those previously claimed by the NRC in the NRC affidavit by Barker (p. 5-12). Unfortunately lack of clarity and documentation in the DES precludes complete comprehension of all the origins of these discrepancies. Therefore preliminary analyses were made using known dispersion models with the major known impact assumptions used in the DES.

30. Utilizing the model presented by Barker in his affidavit (Memo dated 5/14/75 by J.H. Cusack from Brookhaven National Laboratory ["BNL"]), an impact consequence for a DES

"worst-case" release yielded more than 53,000 LCFs (see calculations attached).

31. We used Table No. 6 of that memo because it appears to be a "worst-case" analysis and DES purports to have "worst-case" analysis as its primary purpose.

32. Because of the lack of clarity and specifics in the DES model, we were unable to use that model and we utilized the Barker model instead, changing only the amount of plutonium oxide released. The Barker model originally used a release of approximately 1.25 Kgs. (page 1 BNL memo). We changed this amount to the amount utilized in the DES, 10 Kgs. All other inputs were kept the same. This changed the value of latent cancer fatalities of 15,000 people which the Barker model predicted in Table No. 6 of the BNL memo (Pl. Aff. Skinner-Wang, sworn to June 13, 1975, Table A) to an astounding total of 53,000 people. The DES on the other hand, on page ii, predicted only 617 fatalities. The only possible explanation for this conflict lies in the many assumptions used by the DES which remain secret and unavailable for scrutiny by Congress or the public.

B. <u>The NRC's Model in the Generic Environmental Statement on Mixed Fuel ("GESMO") WASH 1327</u>

33. On pages V-48 and V-49 of the GESMO, assessing plutonium recycle, an abbreviated model is presented which describes the dispersion of plutonium based on a 2 Kg. release. Although the model fails to calculate contaminated areas and the number of persons affected, one can utilize it to determine these impact parameters with the help of the Resnikoff methods in the Resnikoff affidavit (April 25, 1975), which are very similar to the GESMO method.

Assumptions

1.	Distance form point of release (GESMO, p. V-48).	40 miles
2.	Amount respirable (Skinner Affidavt sworn April 29, 1975, Exh. 7)	100%
3.	Amount expelled by lungs (DES V-42)	70%
4.	χ at 40 miles (GESMO, p. V-48)	8.1×10^{-4} gm-sec/m^3
5.	Release Height (DES p. V-31 and Barker BNL memo, p. 1)	Elevated
6.	Release Quantity, PuO_2 (DES p. V-25, Model II)	10 kg.
7.	Specific Dose Pu-239 (DES p. III-19)	2×10^8 rem/ci
8.	Specific Activity Pu-239 (DES p. B-5)	.06 ci/gram
9.	Reactor Pu Conversion factor (DES p. B-4)	11.2
10.	Standard man's breathing rate (Rad. Health Handbook)	3.3×10^{-4} m^3/sec

34. When we properly arranged the assumptions, the calculations yeilded the conclusion that the DES severely understates the impact consequences for a plutonium dispersion accident. Our calculations are as follows:

(1.0 - .7 = .3) [fraction remaining in lung] times

8.1×10^{-4} gm-sec/m^3 [χ] times

3.3×10^4 m^3/sec [Volume Breathed] equals

8.1×10^{-8} grams in the lung.

Then,

8.1×10^{-8} [grams in the lung] times

2.0×10^{-8} rem/curie [exposure] times

.06 curie/gram [specific activity] times

11.2 [conversion factor] times

10 kg [DES release] divided by

2 kg [GESMO release] equals

54 rems to a person @ 40 miles from the release site

35. Substitution of the χ value for a distance 1,800 feet yields the value of 115,000 rems exposure to a person located there.

36. Assuming GESMO utilized the worst-case conditions, stability Class F (Case B in Pl. Aff. Resnikoff, Table 2), over 1.4 million people would be exposed in the dispersion arc to 54 rems or more. On the other hand, the DES states in table V-13 that only 280,600 persons are being exposed to 15 rems or more. This massive inconsistency between the DES and other NRC documents totally undercuts the validity of the health effects model of the DES for air transport of plutonium.

Miscellaneous Questions and Comments

37. The alternative of transporting materials by water is given only minimal consideration in Chapt. IV, Section D.4 Page IV-34. No information is given about the present volume of material shipped by water. It seems clear that in certain localities, water transport may indeed be an alternative to conventional inter-city ground transport modes, and might result in significant reductions in exposure in both normal and accident situations. Although plutonium is the major contributor to accident latent cancer fatalities, it has a long half-life. Thus the shipment of plutonium by water may be economically feasible as well.

38. There is a major difficulty in determining the areas of sensitivity when the various parameters in the risk equation for accident scenarios, pg. V-8 are changed in alternative situations. We are provided with a set of figures for the baseline and alternative situations, but nowhere are there any intermediate or exemplary calculations which would show what, specifically, contributed to the change between the baseline and alternative figures. For example, in Table VI-3, page 41-7, we are given the set of figures for all air shipments being instead transported by truck. But it is impossible to tell from these new figure alone, just what contributed to the alternative results -- a difference in vehicle miles/year, probability of accidents, accidents of

different severity classes, etc. Without the benefit of intermediate calculations, it is impossible to determine why the proposed alternatives result in the changes given in the summaries.

39. The methods of obtaining figures for normal and accident L.C.F. in both baseline and alternative transport situations are quite unclear. There is no derivation given for the equation from which the baseline risk figures are obtained. (The equation itself is very difficult to find, especially in light of its exclusive use in determining the final figures). The variables used in this general equation are also hard to locate and several of them (e.g. vehicle miles/year for each type of shipment, probability/vehicle mile of a specific severity class accident) can only be obtained through a series of separate calculations. Calculations of the alternative results are made by changing a specific parameter in the original equation and following this through; this is obviously done with a computer program, but no program is provided, making it very difficult to reproduce these results. In addition, inconsistencies with the language used to show the changes between baseline and alternative situations make the results confusing and occasionally misleading. While most of the changes are represented in percentages, the very large reductions are not, e.g. a "factor of 16 decrease", which seems fairly small, actually represents a 94% decrease in the baseline figure, a very significant change. Particularly puzzling are the rankings of truck, rail, and passenger air transport (VI 53-55).

40. How are cancer fatality figures for normal and accident transport situations calculated? (Table VI-1, pg. VI-2)

41. What is the basis for figures in Table I-1 on annual person-rems in normal transport for each type of radionucleotide? How are the annual person-rem figures calculated in the alternative section (e.g. Table VI-4, pg. VI-10)?

42. How are mileage, exposure time and population dose figures detemined for alternative transportation modes? (e.g., switching from all passenger to all cargo air paragraphs 1 and 2, pg. VI-16).

43. For a diffusion model used to assess the consequences of release of radioactive materials, figure V-10, page V-31, what release height figures are used; and why are these chosen for each mode?

44. In the summaries of results for each transport mode, how are figures for "probabilities of ≥ 1 early fatalities/year" derived, e.g., Table VI-4, page VI-10.

45. Why are certain alternatives evaluated only with regard to cost, while discounting seemingly significant decreases in accident latent cancer fatality figures, e.g., Table VI-28, page VI-44.

46. In the release consequences analysis (chapter V, section E, page V-43), how do worst-case release heights vary from one mode of transportation to another (e.g., truck or helicopter accidents)?

47. On page VI-41, Section B.2-3.1, what procedure is used to determine reduction in truck accident rates due to the 3 alternatives given?

DEPARTMENT OF TRANSPORTATION
MATERIALS TRANSPORTATION BUREAU
WASHINGTON, D.C. 20590

DOCKET NUMBER PR-71,73(40FR23678)
PROPOSED RULE
Trans. Radioactive Mtls by Air

JUN 14 1976

Mr. Robert B. Minogue, Director
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Minogue:

This refers to your April 1, 1976 letter, enclosing a copy of the Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes (NUREG-0034). As you know, our staff has been kept informed of the progress of this effort during the past year and, in fact, met with your staff, along with the Federal Aviation Administration's representatives prior to the initiation of the associated rulemaking proceeding in June 1975. The document appears to be a very comprehensive treatment of the subject addressed. The radiological data presented are consistent with currently available information and the references cited are generally accepted within the scientific community. The statistical data on risk assessment, accident probabilities, exposures to transport workers, etc., are drawn from the various studies recently conducted jointly by NRC and DOT. Our review has not revealed any anomalies or inaccuracies. The conclusions drawn by your staff and the recommendations offered are, in some cases, subjective and do not readily lend themselves to critical review, however, they do appear to be justified on the basis of the study and the assumptions made.

Specifically, we were pleased to note that your staff had concluded that the radiation exposure of individuals from normal transportation is within recommended limits for members of the general public. As you know, the subject of transportation workers' exposure to radiation during normal handling of radioactive packages has been the subject of intensive review by our agencies for the past several years. This study should be very useful in supporting the continuation of the present system whereby transport workers are not considered to be radiation workers in the course of handling radioactive materials shipments.

The conclusions drawn from this study with regard to the environmental impacts associated with both normal transportation and accidents involving radioactive materials, are especially noteworthy. The infinitely small impact from normal transport, as well as the very small risk from

Acknowledged by card 6/25/76 J.F.

accidents, should be especially helpful in our continuing efforts to allay the fears of the public as to the adequacy of the existing regulatory framework for transportation of radioactive materials. The information and conclusions from factual studies such as this provide a sound basis for rational public judgment. We appreciate the opportunity to review this document and will be glad to provide you with any information you consider necessary to proceed with its final publication.

Sincerely,

Alan I. Roberts
Director
Office of Hazardous Materials Operations

(89)

1281 Emory St
San Jose, Calif. 95126
June 14, 1976

Subject: NUREG-0034
Draft Environmental Statement
on
Transportation of Radioactive Material
By Air and Other Modes

Attention: Mr. Donald Hopkins
Task leader for this statement.

Dear Sir:

A letter from Mr. Arlotto dated May 18 gave me an extension of time to submit comment on this draft which I appreciate. I am one of the few private citizens who received copies of the draft and have given it serious study, desiring to make a responsible comment. Since I don't type and do not have access to a typist please forgive the informal appearance of this letter. I am deeply concerned about a particular matters and will make myself as clear as possible.

In the Detailed Summary, p. xxvii it is stated that the impetus for the revision includes, "a need to respond to current national discussions of safety and security aspects of nuclear fuel cycle materials." This statement suggests to me that your statistical conclusions include data concerning transportation of spent fuel from power plants. Ch. 1 pgs 10-15 Sec. 6 discusses the nuclear power industry. Fig. I-1 p. I-2 shows spent fuel moving to + from reprocessing plants. Fig I-1 beginning on p. I-16 also refers to materials traveling to and from reprocessing plants.

Yet in Table I-3 p. I-21 you have excluded fuel cycle shipments - stating in a footnote that "this data is expected to be updated by a more extensive survey now in progress." In other words you are not including fuel cycle shipments in this study because you do not have necessary data.

Then on page I-24 you point out that the studies of nuclear fuel cycle shipments from which you do take information has not considered air transport.

Then, still on page I-24 you state flatly, (2nd par.)
"Since there are currently no HLRW shipments and few, if any, are anticipated by 1985, they are not explicitly treated in the model."

So, your statistical conclusions reported in the Summary + Conclusions at beginning of the book do not include data about shipment of irradiated fuel from nuclear power plants. And your stated stated purpose of answering public concern about nuclear fuel cycle material is not answered.

My concern is that you lead the reader to expect something which does not happen. And what is worse, a perfunctory look at the early part of the book leads one to believe that the statistical conclusions cover all radioactive material shipments

To correct this situation, I suggest that you change the title

It seems to me your statement is actually concerned only with shipments which are or could be made by air + have compared the relative value of shipping these by other modes. Suggested title might be Comparison of environmental impact from shipment of radioactive materials by air + other modes.

Then in your early statements tell which materials are considered and why.

My next concern is that this book was published at great expense prematurely. I find 2 particular examples of this: Page I-3 tells of questionaires sent out requesting data — the results of which were not in when this book was made up.
and
the already mentioned footnote on page I-21 expecting

updated data. You are badly in need, it seems to me, of more current data. I ran an average of the dates for all references listed at ends of chapters. The average age of your data is 4 years. Some of your references date back to 1955. Yet you went ahead & published your draft without fresh material. It's just a rehash of old studies.

In correspondence with the state agencies who were sent copies I learned that very few would be studying it and making any comment. They tell me they are understaffed and deluged with material of this kind.

With a little dedication & imagination as well as concern for the reader of your material you could write something much shorter & clearer. This book suggests that you intend to put people to sleep so they won't study & find out what you are trying to say.

I will be interested in hearing from you about further development of this statement

Very truly yours,

(Mrs) Virginia Karstolt

P.S. I note that table I-3 p I-21 is based on a speech presented in 1974 concerning Transportation of hazardous material in Air Commerce. yet in the table you do not make this clear. It looks like these are all pkgs shipped by any mode!

V.K.

DOCKET NUMBER PR-71,73 (41 FR 23768)
PROPOSED RULE
Transportation of [illegible] By Air

ASSOCIATION OF
AMERICAN RAILROADS
LAW DEPARTMENT
AMERICAN RAILROADS BUILDING · WASHINGTON, D.C. 20036 · 202/293-4096-97

HARRY J. BREITHAUPT, JR.
Vice President and General Counsel

June 25, 1976

DOCKETED USNRC JUN 28 1976 Office of the Secretary Docketing & Service Section

Mr. Samuel J. Chilk
Secretary
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chilk:

This refers to NUREG-0034, Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, and particularly to statements on pages VI-44, 45 regarding the use of special trains for irradiated fuel shipments.

That draft appears to be the product of a rule-making proceeding that was initiated by notice in the Federal Register on June 2, 1975, Vol. 40, No. 106, p. 23768. At that time the Statement was to be directed to air transportation. The Association of American Railroads (AAR) was not aware of this Statement until recently during proceedings before the Interstate Commerce Commission in ICC Docket No. 36325, Radioactive Materials, Special Train Service, Nationwide.

In view of some of the statements contained in the draft concerning special train operations, it appears most unlikely that anyone with actual railroad experience was consulted. In particular, the statements on the pages referred to above appear to be based on a complete misunderstanding of the nature of special train service. There is a conclusion in the draft that ". . . the use of dedicated trains does not appear to be cost-effective." Such a conclusion is based on an assumption that the shipments would be in regular trains "dedicated" solely to radioactive material, and does not indicate a familiarity with the special service that is provided by the railroads as outlined in the attached excerpts from a special train tariff.

Acknowledged by card 6-28-76 cro

The draft states:

> "Almost 90% of all derailment accidents occurred at speeds less than 40 m.p.h. Thus, it is difficult to see how the use of special trains at reduced speeds (35-40 mph) could substantially reduce derailment accidents." (VI-44)

That conclusion was based on the erroneous assumption that there is no difference between special train service at 35 m.p.h. and regular train service at that speed. The fact is that the special handling and supervision given to special trains moving under the Special Train Service Tariff virtually eliminates accidents. The attached verified statements, which were filed by railroads in the ICC proceeding referrred to above, will provide additional information regarding the nature of special train service and show why, regardless of the mathematical theories applied on pages VI-44-45, in actual operations there is a great difference between regular train service and special train service as far as safety is concerned. As shown by these statements, a survey of five major railroads failed to disclose any indication that there had <u>ever</u> been an accident of any sort involving a special train operation, with the single exception of a heavy off-balanced load which derailed because of its off-balance nature, resulting in minor track and equipment damage, but with no damage to the lading and no injuries.

The conclusions on pages VI-44-45 were predicated on regular train service and a number of accidents (most of which were assumed not to be of a serious nature), but should have been predicated upon special train service with <u>no</u> accidents.

We would appreciate the Draft Environmental Statement being corrected accordingly.

Very truly yours,

[signature]

cc: Ms. Janice K. Corr, Attorney
Office of the General Counsel
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555
w/o attachments

Subject to increases in rates and charges as provided in Items [illegible]

V.C.C. S-430
(Cancels V.C.C. S-382)

I.C.C. S-1155
(Cancels I.C.C. S-1057)

SOUTHERN FREIGHT TARIFF BUREAU

(Southern Freight Association, Agent)

FREIGHT TARIFF S-842-N

(Cancels Freight Tariff S-842-M)

RULES AND CHARGES
COVERING
SPECIAL TRAIN SERVICE

BETWEEN POINTS IN

ALABAMA	ILLINOIS (Southern portion)	LOUISIANA (East of Mississippi River)	OHIO (Cincinnati, Portsmouth and vicinity)
ARKANSAS (Helena and West Helena)	INDIANA (Southern portion)	MISSISSIPPI	SOUTH CAROLINA
DISTRICT OF COLUMBIA	KENTUCKY	MISSOURI (St. Louis and vicinity)	TENNESSEE
FLORIDA		NORTH CAROLINA	VIRGINIA
GEORGIA			WEST VIRGINIA

This tariff applies on intrastate traffic only in the States of Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee and Virginia.

SPECIAL TRAIN SERVICE TARIFF

ISSUED FEBRUARY 27, 1974

EFFECTIVE APRIL 8, 1974

ISSUED BY
Z. C. BERRY,
Tariff Publishing Officer
151 ELLIS STREET, N.E.,
ATLANTA, GA. 30303

(The provisions published herein will, if effective, not result in an effect on the quality of the human environment.)

RULES AND OTHER GOVERNING PROVISIONS

GENERAL RULES AND REGULATIONS

ITEM	SUBJECT	APPLICATION
20	References embrace changes by supplement	Where reference is made in this tariff-- To an item, page rule or other provisions, such reference will also embrace reissues or amendments of said item, page, rule or other provisions. To "this tariff" or "herein", such reference will also embrace supplements thereto, unless otherwise specifically indicated. To another tariff, such reference will also embrace supplements to or successive issues of such other tariff, unless otherwise specifically indicated.
75	Method of canceling items	As this tariff is supplemented, numbered items with letter suffixes cancel correspondingly numbered items in the original tariff or in a prior supplement. Letter suffixes will be used in alphabetical sequence starting with A. Example: Item 445-A cancels Item 445 and Item 365-B cancels Item 365-A in a prior supplement, which in turn canceled Item 365.
100	Method of denoting reissued matter in supplements.	Matter brought forward without change from one supplement to another will be designated as "Reissued" by a reference mark in the form of a square enclosing a number (or letter, or number and letter, in the case of intrastate supplements), the number (or letter, or number and letter) being that of the supplement in which the reissued matter first appeared in its currently effective form. To determine its original effective date, consult the supplement in which the reissued matter first became effective.

RULES AND CHARGES GOVERNING SPECIAL FREIGHT TRAIN SERVICE OR SPECIAL MIXED FREIGHT AND PASSENGER TRAIN SERVICE.

ITEM	SUBJECT	APPLICATION
120	Furnishing of Special Freight Train Service or Special Mixed Freight and Passenger Train Service.	Carriers parties to this tariff will, upon request as provided in Item 130 and at their convenience, furnish Special Freight Train Service or Special Mixed Freight and Passenger Train Service between any two points on their respective lines, locally (one carrier hauls) or jointly (two or more carrier hauls), subject to the charges and conditions hereinafter specified.
130	Definition of "Special Freight Train Service" or "Special Mixed Freight and Passenger Train Service".	Special Freight Train Service or Special Mixed Freight and Passenger Train Service, as used in this tariff, means a train which is operated on an expedited schedule at a charge in addition to the applicable class or commodity rates or fares, or a train which is assembled in accordance with instructions given to a rail carrier by a consignor, consignee, or any agent of a consignor or consignee. When a Special Freight Train or Special Mixed Freight and Passenger Train movement is requested, or the operation of Special Freight Train or a Special Mixed Freight and Passenger Train is necessary in order to comply with service or other transportation requirements specified, the charges shown in Item 140 will be applicable, subject to Note 1, this item. Note 1 - Consignor, consignee, or the agent of consignor or consignee must request Special Train Service (in writing, or by telephone confirmed by telegram or letter) as to each Special Train movement to be made under this tariff giving the involved carrier (or carriers) all necessary information as to such Special Train movement, including consist, date and time of movement, routing, and any other information and instructions pertinent to such movement, allowing sufficient time to enable said carrier (or carriers) to consummate whatever arrangements may be necessary to facilitate the movement of such train, including the assembly of equipment, personnel and other incidental requirements.

DOCKET NUMBER
PROPOSED RULE PR-71,73 (41 FR 23768) NRP

Ex. 5

See pp. 4-5

BEFORE THE

INTERSTATE COMMERCE COMMISSION

DOCKET NO. 36325

RADIOACTIVE MATERIALS, SPECIAL
TRAIN SERVICE, NATIONWIDE

VERIFIED STATEMENT OF

JOHN G. GERMAN (V.P. Engineering, Mo Pac)

ON BEHALF OF RESPONDENT RAILROADS

DUE DATE: MAY 27, 1976

Verified Statement
of
John G. German

My name is John G. German. I am Vice President-Engineering for the Missouri Pacific Railroad Company headquartered at 210 N. 13th Street, St. Louis, Mo. 63103. I hold a B.S. degree in Mechanical Engineering from Case Institute of Technology. From December, 1943 through August, 1961, I was employed in the Mechanical Department of the Great Northern Railway at various locations as Assistant to Master Mechanic, Traveling Engineer, Master Mechanic, Assistant to Chief Mechanical Officer and Superintendent of Motive Power. Since September, 1961, I have been employed by the Missouri Pacific Railroad at St. Louis, Missouri as Chief Mechanical Officer, Assistant Vice President-Engineering and more recently as Vice President-Engineering.

In my present position I have responsibility for the design, construction and general condition of locomotives and cars, track and structures and signal and communications, including compliance with all governmental regulations relating thereto. In this position and throughout my entire career I have been in close contact with the operations of the railroad. I have been involved in the instructions concerning the handling of radioactive spent nuclear fuel cores since the Missouri Pacific first became involved with these movements between St. Louis and Kansas City in 1965.. Within the past year we have handled movements between New Orleans and Kansas City. All of these movements have involved DODX flat cars carrying special AEC (now ERDA) approved casks. All have moved in regular freight train service, but with special provisos as follows:

Originally the AEC specified that these cars be handled on the rear of a freight train at a speed not to exceed 35 mph with the guard car immediately behind the shipment and just ahead of the caboose.

At the present time ERDA, who has replaced AEC, stamps on the waybill the following instructions: "Must not be humped. Do not switch with locomotive detached. Protection must be provided after classifications. Cars must be placed on rear of train next to caboose. Road conductor must periodically contact escort enroute. Speed restricted to 35 mph. This shipment must be placed in the clear of rail switch points when in a yard or siding."

In addition to these requirements Missouri Pacific added the requirements that the freight train not exceed 100 cars, that it would always be accompanied by an Operating officer, and that when meeting or passing other trains one of the trains must be stopped.

Obviously both agencies have recognized that from the standpoint of safety trains carrying the cask must not exceed 35 mph. These instructions are in accord with our own experiences gained through many years of handling large masses traveling at speeds up to 80 mph. Historically we have found it necessary to reduce speeds of shipments where the risk of high loss can be greatly reduced by lowering the speed. Even at 10 to 15 mph the impact of a heavy freight train against a standing freight train is so great that it causes complete destruction of locomotive units and many cars, therefore we have seen no engineering reasons to increase this speed for any style of cask produced today.

I am aware of the tests that have been used to develop approved casks and I understand that spent fuel cores from commercial plants will be much hotter from a radiation standpoint than those from the navy ships and that the high level waste shipments will be extremely radioactive. In my opinion those involved in the proposed movement of spent nuclear cores from power plants and high level waste from reprocessing facilities have not fully addressed the problems that can arise in railroad transit, and in particular there are three questions that need to be resolved.

1. In multiple track territory there is always the possibility of derailment of another train going in the opposite direction on an adjacent track. In the event of such accident should a tank car of LPG or some other such petrochemical rupture and torch against the cask, what temperature and time combination could the cask sustain without failure? In my opinion the fire test in a pool of oil at 1475°F. for ten or thirty minutes (according to type material) is a poor substitute for the torching condition which I know can occur at much higher temperatures in a very concentrated area for many hours.

2. We understand that should a cask rupture for any reason and the material goes on to the ground or perhaps even worse yet into a water supply, the area could be contaminated for many years.

Having seen the results of large masses colliding at speeds less than 35 mph, it is my opinion that the puncture test is still not a true measure of what could happen during the collision between another train and the cask car, be it a rear end, head on collision, or an oblique collision at railroad grade crossing.

3. Trains generally follow and cross many lakes and streams during their journey and of course these waterways generally serve as a source of drinking water for the general public. Considering the large amount of kinetic energy to be absorbed at time of collision what criteria have been established to allow the car and cask attachment to absorb this energy with a minimum chance of losing a ruptured cask from the car into a waterway.

After considering all factors involved in the movement of irradiated spent nuclear fuel cores from commercial power plants to reprocessing stations, and shipments of high level waste from the latter facilities, including the three above very questionable areas, we have reached the conclusion that for the best interest of the Missouri Pacific Railroad and our good neighbors located adjacent to our right-of-way that we should handle all movements of these materials in special train.

Missouri Pacific handles some 80 special trains per year and I do not recall a single incident or accident attributable to such handling. These movements for the most part involve loads of either excess clearances or excess weight or both and are generally operated at speeds up to 35 mph.

Our decision to handle spent nuclear fuel cores and high level nuclear waste in special train movements is based upon the fact that experience clearly indicates this is the wisest way to handle the movement. Switching of the cask cars would be greatly minimized and the entire movement can be controlled much more safely than at the end of a 100 car train. By greatly reducing the mass of the entire train the locomotive engineer can carefully control speeds entering and leaving sidings, yard tracks, slow orders, etc. Also by virtue of the fact that there is no switching involved and the special train can accelerate and decelerate to and from the 35 mph limit much better than a long heavy freight train, the overall transit time is considerably reduced. Furthermore this relieves delay to all other cars in revenue train service and greatly reduces chance of the operating crews having to be relieved due to the Hours of Service Act (not to exceed 12 hours.)

In the event that there should be a derailment for any reason it has been my experience that speeds not exceeding 35 mph permit stopping the movement before the car gets too far from the track and sustains too much damage. Here again, the ability to closely monitor and control speed in a special train movement is very important. Most of these cars have three axles per truck which in itself is rather difficult to rerail should one or more wheel derail. In addition, the mass of these cars equals and in some cases exceeds that of our larger locomotives. Rerailing such heavy cars takes special railroad cranes of large capacity, of which we only have two, and special off-track cranes which must be transported long distances to the scene of the derailment.

Obviously at the time of derailment it is necessary to immediately evacuate the area at least within a 1500 ft. radius and get assistance from ERDA and the shipper to monitor the area for any radioactivity spill. Presently the escort on DODX cars can monitor the area and therefore it is imperative that to quickly detect escape of radioactive material all spent nuclear fuel cars should be accompanied by an escort.

In the event of fire or rupture involving the cask it would be necessary to evacuate the area for several miles, especially on the leeward side and stop use of all potable water sources down stream until the scope of the contamination could be determined. In such event we could expect that our roadway in the immediate area would be out of service for a very long period of time. Rerouting of traffic could become very costly.

In no event could we commence wrecking operations until the area had been declared safe for the workmen and further that in case of minor contamination that the workmen had been given special clothing and instructions.

It is my opinion that the movement of both loaded and empty cars involved in handling irradiated spent nuclear cores from power stations and high level nuclear waste from reprocessing plants under the following conditions:

1. Must not be humped.
2. Must not be switched with locomotive detached.
3. Must be protected from undue impact after classification.

4. Must have one buffer car between locomotive and cask car.

5. Must have guard car with escort qualified to monitor for irradiation between cask car and caboose. 10 CFR §73.33

6. Road conductor must periodically contact escort enroute.

7. Shipment must be placed in clear of fouling point of all turnouts.

8. When meeting or passing other trains one train must be stopped and the other should proceed at not to exceed 35 mph.

9. Maximum speed restricted to 35 mph.

V E R I F I C A T I O N

State of Missouri)
) ss
County of St. Louis)

John G. German, being duly sworn, deposes and says that he has read the foregoing statement, knows the contents thereof, and that the same is true as stated.

John G. German

Subscribed and sworn to before me this 26th day of May, 1976.

Notary Public

My Commission Expires Sept 28 1978

R. C. MASON, NOTARY PUBLIC
County of St. Louis, State of Missouri
My Commission Expires September 28, 1978
This act performed in the City of St. Louis, which adjoins the County of St. Louis in which I was commissioned.

DOCKET NUMBER PROPOSED RULE PR-71,73 (41 FR 23768) (90)

MOVEMENT OF NUCLEAR FUEL CORES IN CASKS ON HEAVY-DUTY SPECIALLY-EQUIPPED FLAT CARS
I.C.C. DOCKET NO. 36325

My Name is George R. Hanson, Manager Operations Planning in the Operating Department of the Chicago and North Western Transportation Company ("North Western"), with offices at 500 West Madison Street, Chicago, Illinois, 60606. My railroad service commenced in 1951 with the Chicago and North Western as a Trainman. Until April, 1959, I served as a Brakeman, Switchman and Conductor, working in major Terminals and on road trains. Since April 1, 1959, I have been Assistant Trainmaster, Trainmaster, Assistant Superintendent, Superintendent, and Division Manager. In 1974 I was appointed to my present position. In this position I am responsible for the identification of operations planning needs, both short and long-range, for the Operating Department, including the scheduling and blocking of freight trains on the North Western System. I am also Chairman of our railroad's Hazardous Commodity Committee, whose responsibility is to advise and recommend to our management procedures in connection with the safe and efficient handling and transportation of potentially hazardous materials.

It is the decision of the management of Chicago and North Western to move nuclear fuel cores in casks on heavy-duty specially-equipped flat cars in special train service.

The North Western operates approximately 110 road trains per day on its 9,996 miles of railroad in the states of Illinois, Iowa, Nebraska, North Dakota, South Dakota, Minnesota, Wisconsin, Wyoming, Kansas, Missouri, and Michigan. These road trains contain between 100 and 150 cars and operate at a speed of approximately 40-50 MPH. Maximum timetable speed on lines equipped with Automatic Block Signals or Automatic Train Control is 60 MPH; on other lines operated by use of Train Orders and Timetables the maximum speed is 49 MPH. North Western operates approximately 70 terminals where trains or cars are marshalled into road trains or interchange receipts and deliveries.

The North Western's main objectives in handling the heavy nuclear cores in special train service are as follows:

Safety to the public and North Western's employees.

A car or cars to be moved in a special train would receive a minimum amount of handling in our terminals. Upon receipt of a car or cars containing nuclear fuel cores from a connecting railroad, North Western would place a caboose and engine to such car(s) and immediately depart from the terminal. Except for a minimal number of crew change points, this special train would operate in straightaway main track service.

Example (actual): On January 18, 1976, North Western received three cars containing nuclear cores from the P-C Railroad at Proviso, Illinois, Yard. Having already received advanced information of the these cars, a crew was on duty upon arrival to handle the special train forward. The train departed Proviso at 11:08 P.M. enroute to Council Bluffs, Iowa, where it was delivered to the UP Railroad. The total lapsed time these three cars were on our railroad, that is, from receipt to delivery, was less than 16 hours. Conversely, if the same three cars were handled in regular train service, we would have received them from the P-C Railroad on their regular interchange transfer assignment. Prior to the delivery, these three cars would have received approximately 16-24 hours' terminal detention in the P-C Yard. This transfer would be delivered to us in our Receiving Yard (9), wherein our Car Department carefully inspects each car to determine the condition of the running gear of each car. Depending on traffic conditions in the yard, this transfer will be slated to be humped; that is, to be shoved over our automated hump into our Classification Yard (5). Due to the extreme weight and "Dangerous" placarding of the nuclear cores prior to the humping of this transfer, a switch engine would be dispatched to Yard 9 and switch them out and handle them specially

3 crew changes

around the hump to Holding Yard (4) or Yard (1), where they would be held for a train destined to Council Bluffs. Normally traffic received at Proviso receives over 24 hours' delay until it actually departs. This time is needed to inspect, hump and actually place in an outbound train. The special handling described could cause additional delay of up to another 24 hours. During the time the nuclear cars are at Proviso, they would be handled five or more times -- 1) by the delivering road, 2) by the switch crew assigned to switch them out of Transfer Yard 9, 3) by a special transfer crew to a holding yard, 4) to the train yard, or 5) to block into the designated train. Each time cars are handled in the terminal, the possibility of a derailment or accident exists..The probability of such occurrences increases with the number of times cars are handled. That is, the vast number of train and engine movements within the confines of the yard increase the potential of an accident such as collisions or sideswipes. We presently handle at Proviso over 7,000 cars, about 50 trains per day, and have 45 to 50 switch engine assignments. Again, the extreme weight of the nuclear cask cars increases the potential of a derailment due to the breaking under weight of a track or switch. I estimate normal delay at Proviso would be 30 to 48 hours. We presently have two trains per day to Council Bluffs -- No. 253 and No. 255. Inasmuch as No. 255 is a high-speed manifest train handling TOFC, autos, etc., nuclear casks would have to be handled on No. 253. With the scheduled work enroute at various stations and terminals, No. 253's schedule from Proviso to Council Bluffs is 36 hours, 16 hours of which the train is at Boone, Iowa, a terminal where the train is reswitched and receives additional traffic from various trains throughout Iowa. Arrival at Council Bluffs to delivery to the UP would be approximately 8-10 hours. The same three nuclear casks which were handled in special train service in less than 16 hours on January 18 from Chicago to Council Bluffs, if handled in regular train service, would exceed 70 hours, based on a 24-hour or less delay at Proviso. The possibility of an accident again is increased due to operating in and out of various yards and switching operations. Another very important point in handling these cars in regular train service is that the more cars in a given train being pulled the more the involved cars are exposed to train dynamics, that is, the intertrain reaction which is caused by grade changes, the slowing down, stopping or accelerating of the train. Quite simply stated, is the running in or out of the slack between the engine and caboose or the rocking side to side of certain cars over irregular tracks. This is not a new phenomena, however; the increase in train lengths, car sizes and loadings has caused railroads to become more alert to the increased problems caused by dynamic train action. We have attributed many derailments to train dynamics. Obviously, train dynamics occurring in a two or three-car train is almost non-existent. Another equally important point in handling nuclear casks in special train service is the surveillance of the involved cars as they move across the railroad. During the entire trip our onboard train crews are able to devote their entire time observing the car(s) for mechanical defects which could develop enroute or other conditions which could jeopardize the safe movement of the train. In regular train service the above type of surveillance is not possible when one considers a train of 100 to 150 cars is over 1½ miles long and in-train mechanical failures are not readily noticeable to the head or rear end crew, particularly when they occur near the middle of the train. I have personally known many accidents where a derailed car in a train will be pulled for several miles undetected by the crew due to curves, weather or distance from the engine or caboose. In my opinion the nuclear casks handled in special train significantly increases the crew's ability to monitor the actual movement and thus detect any defects. In my 25 years of service in the Operating Department of the Chicago and North Western, I cannot recall one incident wherein a reportable accident has occurred when handling a car in special train service. This is very significant when we consider there are almost 50 reportable train accidents per month on our railroad. Special trains are operated on the North Western quite frequently, not only in the case of the nuclear casks, but also in handling high value dimensional loads, certain explosives and poison gases, precision equipment and loads wherein the shipper requests special handling. Expensive containers such as the nuclear casks and specially designed rail cars are moved over the railroad many times faster when handled in special trains, sharply reducing the number required to perform the service. Turnaround time of special equipment and cars is generally a savings to the shipper.

As I have previously stated, the North Western does have accidents. Train derailments or wrecks involve any number of cars from one to fifty or more. Determining factors in the number of cars involved in an accident include speed of train, train consist (number of cars in train), track structure at point of derailment such as main track switches, and also the ability of the train crew to promptly note and take action to stop the train at the time the derailment occurs. Major derailments immediately place a route of our railroad out of service until the involved cars can be rerailed or cleared from the main track or tracks and the damaged track and roadbed rebuilt. This must be accomplished as promptly as possible, as every lost hour a main track is obstructed results in several thousand dollars loss to our company -- similar to shutting down an assembly line in a large factory. Our work crews work around the clock until service is restored. If a car or cars of nuclear casks were involved in a major derailment, particularly if tipped over and disengaged from the rail car and/or other cars on top of the casks in a pile up, clearing operations could not commence until all procedures have been followed in connection with nuclear material involved in an accident. These procedures are found in the A.A.R. Bureau of Explosives Pamphlet No. 1. Briefly, the procedures state "Until the extent of the hazard can be determined, keep all persons the greatest practicable distance away." "Persons not properly protected against radiation shall not be permitted to approach the vicinity of any place where radioactive material is suspected to have been spilled." Protection of personnel will vary depending on circumstances and may consist solely of radiation monitoring. The North Western is not equipped, nor do we have trained personnel to monitor radioactivity. We would be required to leave our main line obstructed until assistance or further advice has been obtained from a competent authority. This authority most likely would be received from the nearest Atomic Energy Commission office, and it is quite evident that clearing operations could not commence until qualified persons arrived on the scene, which I have been told could be as long as 48 hours. Fires often time accompany railroad wrecks. These fires stem from the many flammable materials we handle in train or from a burning wheel on a freight car. I personally know of fires that have burned for more than 24 hours in a pile up of wrecked cars, the burning flammable material igniting other cars in the area. If nuclear casks were involved, particularly if underneath a burning pile of railroad cars, serious complications could occur. In reviewing the design of the special flat cars used to transport LMFBR Spent Fuel Shipping Casks, I note the fixed refrigeration units attached to the car. These units are used to control the heat generated within the core of the spent fuel. In a major derailment involving one of these cars it is very likely that the refrigeration units would become unserviceable. The core would be without this protection until a replacement car could be found and the cask transferred. I estimate the time required to perform this work would be at least five days, or as long as 10 days, depending on the availability of a replacement car and its location; also, special transfer equipment. If the special car merely becomes derailed, the railroad involved is required to change out the wheels which were derailed; this is due to the roller bearing assemblies on each wheel. This would result in a minimum delay of three to five days.

Railroads are constantly brought to criticism from the news media and public anytime an accident occurs in spite of the millions of miles of safe miles we operate daily. We work constantly to improve our safety records, particularly in the transportation of hazardous materials. Needless to say, if a derailment involving nuclear casks happens and is noted by the public or news media, the railroad involved would be subject to the public perception of the dangers in that particular situation, with the railroad probably receiving much unfavorable publicity and being the subject of much inquiry. Legislators, both in the Federal and State Governments, are daily adding new regulations and laws in connection with the transportation and handling of hazardous materials. As I stated at the beginning of this testimony, the North Western is insistent on handling nuclear cores in casks in special train service, thus doing everything possible to reduce the probabilities of an accident involving nuclear material.

George R. Hanson

GEORGE R. HANSON

STATE OF ILLINOIS)
) SS
COUNTY OF COOK)

GEORGE R. HANSON being duly sworn, deposes and says that he has read the foregoing statement, knows the contents thereof, and that the same are true as stated.

GEORGE R. HANSON

Subscribed and sworn to before me this 18 day of May, 1976.

Notary Public

My Commission Expires MY COMMISSION EXPIRES OCTOBER 17, 1976

DOCKET NUMBER
PROPOSED RULE PR-71,73 (41 FR 23768)

See p

BEFORE THE

INTERSTATE COMMERCE COMMISSION

No. 36325

RADIOACTIVE MATERIALS, SPECIAL TRAIN SERVICE, NATIONWIDE

AFFIDAVIT OF
H. L. LEWIS

My name is H. L. Lewis. I am employed by The Atchison, Topeka and Santa Fe Railway Company ("Santa Fe") as Superintendent of Transportation. My office address is Suite 902, 80 East Jackson Boulevard, Chicago, Illinois 60604.

I was first employed by Santa Fe at Chanute, Kansas in the year of 1940 in the position of mail clerk. Since then, I have held the positions of Transportation Inspector, Trainmaster, Assistant Superintendent and Superintendent before becoming Superintendent of Transportation in 1974.

Because of my vast operating experience over the past 36 years, I am intimately familiar with both regular train service and special train service as provided by the Santa Fe Railway and have set forth below several differences between the two types of service which relate to the safety of handling radioactive materials.

In my experience with the railroad, I have been aware of many train accidents involving trains in regular service. In my entire experience, however, I am not aware of any incident involving a derailment or damage to a car being handled by Santa Fe in special freight service. There are several reasons for this.

Even though our operating personnel do everything economically feasible to prevent accidents and to ensure the safety of the lading and personnel involved in regular train service, there is no way of guaranteeing that an accident will not occur. Accidents causing damage to railroad cars and the lading usually involve derailments or switching mishaps. Some factors which contribute to the rate of incidents or severity of any given incident are the train length, the amount of switching required, the speed of the train, the mixture of the lading contained in the train and the mixture of types of equipment in the train. Regarding each of these factors, there is an inherent safety advantage in special train service.

No authority need be cited for the proposition that higher speeds will result in more severe damage to train cars and lading if involved in an accident. In this respect, special train service has an advantage over regular train service, since special trains handling nuclear materials would be limited to speeds of 35 m.p.h. while the speed of regular train service is dictated by the schedule and track conditions. Most of Santa Fe's main trunkline trackage is designed and maintained to handle freight train traffic at 70 m.p.h.

Train length also plays an important part both in the frequency of rail mishaps and the severity of such mishaps. For Santa Fe in the years of 1974 and 1975, the average length of its freight trains was approximately 52 and 56 cars respectively. In special train service, the length of trains would be substantially shorter, thereby reducing the length and weight factors which effect the frequency and severity of train derailments. As pointed out above, other important factors in comparing the safety of regular train service to special train service are the types of equipment in the train and the mixture of the lading.

Insofar as regular trains are concerned, they are assembled and handled in everyday operations. With few exceptions, cars handled in regular train service are assembled and handled from industries or interchanged from trains from other railroad lines and placed in our regular trains without regard to location so far as the commodity is concerned. Generally, cars are gathered from various trains and switched onto other tracks by destination designation, then gathered by blocks and placed on a track where they are given mechanical inspections. Except for Class A explosives and open-top or flatcar loads, the shipper loads the car and closes the door, and therefore railroad personnel have no opportunity to inspect the lading or the method of loading. The consist of a regular train includes various lading commodities in different types of cars, some of which are railroad owned, some privately owned and some shipper owned.

The special trains handling nuclear casks, on the other hand, would consist of a few cars specifically selected and conditioned for that lading. Special handling means special attention being given to the movement and observation of the train by all personnel involved. In addition to being a much shorter train, there would not be mixed ladings and there would not be a variety of types of cars which could contribute to the frequency of accidents. Due to the train handling only the nuclear cask cars, there would be no switching or other yard handling in route, whereas with the normal or regular train it would be necessary to go into various yards to set out or pick up cars. These yard operations would expose the cars to additional switching operations.

Special trains would also be subjected to fewer switching operations at destination or at an interline junction. If the destination is served by the road-haul carrier, all that would be done would be to set the buffer cars aside and shove the cask cars to the consignee. This would not involve switching as would be the case with a regular train and the car could be delivered with a minimum of handling. If the car were to go to an interline junction railroad, it would be set at the interchange and picked up from the interchange without a mix of other traffic. The effect of minimizing handling of the cars would be to increase safety of the movement.

Another factor contributing to the increased safety involved in handling cars in special train service is that all the cars on the train can be observed by both the head end and rear end crews at practically all times and at practically all locations. This is often not possible, however, with longer, regular trains because of curves, weather conditions and vegetation.

As an operating officer with more than 20 years' experience as a trainmaster and superintendent, I am extremely concerned about the possible effect of a derailment involving a train handling radioactive material. I can foresee the panic that would exist if townspeople were advised that a nuclear incident had occurred in their vicinity. The repercussions created by an overzealous news media could stir the populous of a city or town to such an extent that operations in the future would be very questionable.

For these reasons, it is my firm belief that if we were to handle the material as potentially dangerous as nuclear casks of either initial material or spent material, we must do so in the safest possible manner. This should involve special train service which, in summary, provides the following safety advantages over regular train service:

a. Slower speeds

b. Fewer switching operations

c. Shorter and lighter trains

d. Similar commodities

e. Similar equipment

FURTHER AFFIANT SAYETH NOT.

VERIFICATION

STATE OF ILLINOIS)
) SS.
COUNTY OF COOK)

H. L. Lewis, being first duly sworn, on oath deposes and says that he has read the foregoing statement, knows the contents thereof, and that the same are true as stated.

H. L. Lewis

SUBSCRIBED and SWORN to before me this 25th day of May, 1976.

Notary Public
MY COMMISSION EXPIRES JANUARY 14, 1977

CERTIFICATE OF SERVICE

I, Gary L. Crosby, hereby certify that I served a copy of the above Affidavit of H. L. Lewis on all parties of record in this proceeding by depositing a copy thereof in the United States Mail Box at 80 East Jackson Boulevard, Chicago, Illinois, proper postage prepaid, before 6:00 p.m. on the 25th day of May, 1976.

DOCKET NUMBER
PROPOSED RULE PR-71,73 (41 FR 23768) (90) Ex. 12

VERIFIED STATEMENT

OF

FRED BEALER, JR.

My name is Fred Bealer, Jr., and I am Director of Transportation Operations for Union Pacific Railroad Company, headquartered at 1416 Dodge Street, Omaha, Nebraska, 68179. I have been employed by Union Pacific since 1959. My earlier positions with Union Pacific included Assistant Northwest District Car Distributor, Secretary to Northwest District General Manager, Secretary to Vice President Operations, Safety Agent-Nebraska Division, Trainmaster-Idaho Division, Assistant Superintendent-Kansas Division and Manager-DF Car Utilization.

In my present position as Director Transportation Operations, I have responsibility for general direction of train movement and equipment distribution as well as compliance with governmental regulations concerning equipment movement.

Four years of my railroad career involved traveling the entire Union Pacific system as Secretary to Vice President Operations. My duties included reviewing all accident reports. At no time was there ever an accident involving a special train. During my 17 years with the Union Pacific I have never seen nor heard of an accident involving a special train on my line. I requested that the Union Pacific accident reports in the Office of the Vice President-Operations be checked. There were no reports of accidents involving special trains in those records which go back 13 years.

A special train usually consists of a locomotive, caboose and one or more cars requiring special handling. The speed allowed may vary and depends upon the nature of the handling required.

Special train service does not necessarily mean slower than regular service. In fact, it often provides faster service than regular train service. The reason for this is that special trains, because of their size, move through terminals faster than the longer trains. When they take sidings to meet other trains they can use many sidings which may be too short for regular trains. This feature reduces delays. Trains in special service can also reduce and pick up speed faster than regular trains. I know of instances where special train service was requested when faster than regular service was desired.

In my opinion, special train service is safer than regular train service. For one thing, if a defect in the equipment occurs, such as a hot box, it is more readily apparent to the crew because of the nearness. Also, a short train can stop more quickly than a longer train.

When a special train meets or is passed by a regular train, its speed is usually restricted or it is required to stop. The speed of the opposite or passing train may also be restricted. This greatly reduces the severity of a potential accident.

A regular train usually travels over 50 MPH. Many select regular trains on the Union Pacific are operated at 70 MPH. The number of cars handled in a regular train will vary from 50 to 150 and the length of the trains will be anywhere from one mile to two miles long. The weight of these trains will average between 3000 and 10,000 tons. When a train of 100 cars traveling at 70 miles an hour derails, the combination of the speed and the weight of the train often results in upwards of 30 cars being derailed. The force exerted in the derailment is such that many of the cars frequently are totally demolished and the contents destroyed.

On the Union Pacific between Omaha, Nebraska, and Salt Lake City, Utah, there are two main tracks running side by side. Trains moving eastward use one main track and trains moving westward use the other. We have had accidents involving trains going in opposite directions, both of which were regular trains traveling at a high rate of speed and the results were particularly catastrophic.

As an operating officer, I have been at the scene of many train accidents. I have directed the clearing of wrecks and assisted at others. Some of these incidents have involved hazardous materials such as LPG gas, ammonia and phosphorous. Under these circumstances, it is required that the FRA, AAR, the Bureau of Explosives, Environmental Protection Agency and the appropriate state and local officials be notified. Sometimes the FRA and the AAR will send experts to the wreck to direct.

If cars handling irradiated material were involved in a wreck and were derailed, or damaged, it would present a uniquely difficult problem for the railroad. I, personally, have had no experience in this field, nor do I know any operating railroaders who have. The weight of the empty cask in which the irradiated fuel elements are shipped on DODX cars moving into Scoville, Idaho, is more than 200,000 pounds, and holds 18,000 pounds of irradiated fuel elements. If such a car were derailed, it could present a formidable task in re-railing. I have seen LPG gas cars rolled down an embankment. If this occurred with a DODX car containing irradiated fuel, or even with the empty cask containing residual radioactivity, it would be a time consuming and dangerous situation to clear. There is also the possibility the car could be drailed into a river or lake. Through the State of Nebraska, Highway 30 generally parallels Union Pacific's main line and many portions of the interstate as well as other highways and roads are adjacent to the railroad. At other locations, Union Pacific's tracks run adjacent to tracks of other railroads and sometimes cross them. Union Pacific tracks also are in the proximity of airports such as Stapleton in Denver, and McCarran

Field in Las Vegas. An accident involving a car containing radioactive material at any of these locations could conceivably cause considerable interference with interstate commerce. If the cask should leak as a result of the derailment, there would be the problem of contamination, hazard of deaths and personal injury. I have been at derailments where the forces exerted have caused rails to be torn from the track and thrust through railroad cars. There is always the possibility of a rail impaling an irradiated fuel container. Even if there were no emission of radioactive products, there would be considerable delay in clearing the railroad or highways for operation because of various environmental and regulatory features. What?

I do not know what the full impact would be if there were leakage from a car containing irradiated fuel, or an empty car containing residual radioactivity, but apparently there would be long-term repercussion. For example, Westinghouse receives shipments of irradiated fuel and radioactive waste material at Scoville, Idaho, and is in frequent contact with our Freight Agent nearby at Arco. On August 22, 1975, our Freight Agent received a telephone call from a Westinghouse representative, Mr. Herb Paulson, who advised that a DODX car in the Scoville plant had become contaminated by leakage. He further advised that the car would be unavailable for further use since it was going to be buried.

Described as hearsay by ALJ, first left in

The DODX car was a heavy-duty depressed-center flat car with a permanently attached cask for transportation of spent nuclear fuel cores. The cask and car combined had an empty weight of about 335,000 pounds. The cask alone, when empty, weighed about 225,000 pounds.

The Arco Agent on March 5, 1976, contacted Mr. Paulson to inquire into the cause of this incident but was only informed that the cask and bed of car had been contaminated but that the wheels had not. Mr. Paulson stated that after Westinghouse had received some "inquiries from the East" on the previous day he had been told not to discuss the incident or give out any further information.

In my opinion, handling cars containing irradiated fuel elements, or empty casks which have residual radioactivity, in special train service, would reduce the possibility of an accident, as well as the severity of an accident, if any occurred.

VERIFICATION

STATE OF NEBRASKA)
) SS
COUNTY OF DOUGLAS)

FRED BEALER, JR., being duly sworn, deposes and says that he has read the foregoing statement, knows the contents thereof, and that the same are true as stated.

FRED BEALER, JR.

Subscribed and sworn to before me this 25th day of May

NOTARY PUBLIC

My Commission Expires June 8, 1979

I.C.C. DOCKET NO. 36325
VERIFIED STATEMENT OF HARVEY H. BRADLEY

My name is Harvey H. Bradley. I am Vice President Transportation, Southern Railway Company. I graduated from Virginia Military Institute at Lexington, Virginia, in 1949 with a Bachelor of Science degree in Civil Engineering. I have been employed by Southern Railway since August, 1949, except for two years in the Army during the Korean War. During that time I have held the positions of Student Apprentice; Assistant Supervisor; Track Supervisor; Bridge and Building Supervisor; Assistant Trainmaster; Trainmaster (4 locations), Division Superintendent (3 locations) General Manager Transportation; Assistant Vice President-Safety, Assistant Vice President-Transportation, and Vice President-Transportation.

I understand that this proceeding is concerned with the question of whether or not shipments of irradiated fuel elements and radioactive waste material should be confined to special trains. My knowledge of the commodities involved is rather limited and comes mainly from various government publications. I am advised that the shipping casks may weigh in excess of 100 tons and must be continually cooled. A booklet published by the Energy Research and Development Administration (ERDA), Atoms on the Move: Transporting Nuclear Material (1975) states, on p. 37:

> "If cooling equipment associated with a cask of spent fuel were put out of commission in a highway accident, for instance, the heat of normal radioactive decay would cause the cask's temperature to climb. Calculations show that it might rise to as much as 700°F, in fact, but there would be no danger of melting the cask wall itself."

Another government publication, Environmental Survey of Transportation of Radioactive Materials to and From Nuclear Power Plants. (WASH-1238) prepared by the Atomic Energy Commission in 1972, states, on p. 83:

> "In one design of rail cask now under evaluation (GE, IF-300), complete failure of the external cooling system will cause the cask to overheat over a period of several hours. In that case, under certain adverse but unlikely conditions, the temperature of 50% of the fuel elements would reach 1200°F, which could cause perforation of the cladding on some of the rods if the elements were of the present PWR type."

and on p. 85:

> "Some designs of rail casks have an external mechanical cooling system. An accident may cause moderate damage to the cask such that the mechanical cooling system becomes inoperative. If no corrective action is taken and the ambient temperature is above 100°F, the temperature of the fuel in the cask will increase enough in a few hours to cause an overpressure in the cask cavity, and some of the coolant will be released through the vent system. This also may occur in some cask designs if the cask is involved in a severe fire.
>
> "Venting may occur in a series of releases; one design permits about 5% of the gas in the cask cavity to be released at a time."

In a serious train accident there is frequently compression and telescoping of the train, with a tendency for the cars to pile up and for lighter cars to ride up over heavier cars. In a pileup of mixed freight, a 100 ton cask of irradiated fuel elements would quite likely be at the bottom, with its cooling system out of operation. If the cars on top of it contained inflamable freight, and the cask reached a surface temperature of 700°F (going up toward an interior temperature of 1,200°F) the cask would <u>start</u> a fire.

Since the kindling point of paper is 300°F to 350°F, the placards warning of the radioactive nature of the shipment would burn off before the cask reached a temperature of 700°F.

The concurrent venting of radioactive gases would seriously interfere with efforts to fight the fire and remove the wrecked cars, and it could easily take several days to clear the wreckage, cool down and remove the cask, and clear the railroad right of way.

All this is assuming that no fuel elements were released from the cask in the train wreck. In this regard the AEC publication quoted above states, on page 87:

> "If seven irradiated fuel elements were released from a cask in an unusual accident, the radiation level at 100 feet could be as much as 10^4 r/hr. Assuming the fuel elements remained unshielded for 10 hours, approximately 30,000 persons within a mile radius (based on 10^4 persons/square mile) might receive a cumulative dose of about 1000 man-rem. If a person remained unshielded at an average distance of 100 feet from the fuel elements for 6 minutes, he might receive a dose of as much as 1000 rem. Persons remaining near the exposed fuel for any appreciable length of time may receive large doses of radiation. Someone at a distance of 10 feet from the exposed fuel for about a minute, would receive a dose of 1000 rem. Remote equipment would be required to erect a shield around the fuel elements or to place them in a shielded box or to repackage them.

I am advised that a dose of 500 rem is likely to be fatal.

I have assisted in or supervised clearing the tracks and restoring train service after many accidents, but have never been faced with the conditions that appear likely to result from a serious accident involving a shipment of irradiated fuel elements moving along with other freight of all kinds in general freight train service.

The AEC publication quoted above also stated , on p. 86:

> "The likelihood of a cask remaining unattended after loss of mechanical cooling . . . can be reduced by appropriate administrative controls such as escorts, alarming the mechanical cooling system, inspection of the shipment at regular intervals, and notification of the shipper in case of any failure of mechanical cooling or involvement in an accident."

In this connection the technical description of the General Electric IF-300 irradiated fuel shipping cask states, on page 16:

> "The IF 300 cask is equipped with an audible alarm system. System activation occurs if the cask temperature exceeds a predetermined value. This indicates either the failure of the cooling system or a loss of water from the external water jacket.
>
> "Transportation personnel, railroad or highway, will be given adequate training to respond to this

alarm. A procedures and notification manual will accompany each shipment."

The problem is that, as will be shown hereafter, in a general train of mixed freight no one would ordinarily be available to hear the alarm or to check the cask at regular intervals.

The technical description of the General Electric IF-300 irradiated fuel shipping cask describes four tests that the cask passed. These are the four tests required for all irradiated fuel shipping casks (10 CFR §71.64, Appendix B) and are as follows:

1. A 30-foot free fall onto a flat unyielding surface. This produces a speed on impact of 30 mph. However, in actual train wrecks impact speeds of more than 30 mph are not unusual. In general freight train service speeds of 60 mph are common, and when two 60 mph trains pass, going in opposite directions, the rate of closure is 120 mph. Anything protruding from, or falling off of, one train and striking a cask on the other train would have a speed on impact of 120 mph.

For this reason Southern has operating instructions requiring shipments of irradiated fuel and radioactive waste to be moved at speeds not exceeding 35 mph, and when two trains pass in opposite directions, one train must stop while the other train proceeds at not more than 35 mph. Thus the impact speed in any accident cannot be much greater than the 30 mph for which the casks are tested. However, from an operating standpoint it is not practical to maintain these speed controls unless the shipments are handled in special train service.

2. A 40 inch free fall onto a steel bar 6 inches in diameter. According to the General Electric technical

manual mentioned above, this test is intended to simulate the end of a railroad rail. The intent is good, because accidents in which cars and their freight impale themselves on broken rails are not uncommon. Ordinarily we do not keep separate records of such incidents, but when a broken rail pierces a fuel tank and spills diesel fuel, the resulting pollution problem attracts attention. Therefore I was able to determine that last year we had six fuel spills caused by tanks being punctured by broken rails. However, the 40 inch drop test produces an impact speed of only about 10 mph, and in regular train service a cask of irradiated fuel elements could run up against the end of a broken rail at 50 or 60 mph. A quarter mile long section of rail, spiked in place throughout its length, comes close to being an immovable object.

3. Thirty minutes in a 1,475°F fire. Fires are not uncommon in railroad accidents, and although the temperatures probably seldom exceed 1,475°F, the duration frequently exceeds half an hour. I can recall a three month period during which we had three fires on Southern that lasted more than 24 hours.

4. Immersion under 3 feet of water for 8 hours. If a car carrying a cask of irradiated fuel elements should derail on a bridge or trestle, it is quite likely that the cask would end up under more than 3 feet of water, and considering the weight of the cask and the difficulty of conducting recovery operations from a bridge or a trestle it is most likely that the cask would not be removed from the water within eight hours.

The tests that the casks are required to undergo would be far exceeded by the actual circumstances of many railroad accidents.

Since 1965, as part of my job, I have received daily reports of all train accidents on Southern Railway System. Movements of special trains are very carefully monitored, and any accident involving such a train would of course attract immediate attention. It is my conclusion that special trains simply do not become involved in serious accidents.

Specifically, during the 5-year period 1970-1974 Southern had an average of 357 reportable accidents (involving $750 or more damage) per year and an average of 2,892 accidents per year that were not reportable under the standards set by the Federal Railroad Administration. For 1975 the standards were changed so that accidents involving less than $1,750 were not reportable, and during that year Southern had 273 reportable accidents and 3,489 minor (non-reportable) accidents.

During this entire period of time Southern had only one accident involving a special train. On October 12, 1975 a special [illegible] flatcar carrying an unbalanced load climbed the rail on a curve and derailed at 22 miles per hour, doing minor damage to the track and cars; no damage to the lading and no injuries. This unusual accident was caused by the heavy, unbalanced load, but since it was a special train it was under constant close surveillance and could be stopped quickly.

Regular freight trains are often more than a mile long, so long that on curves a particular car will frequently be out of sight of either the engine or the caboose, and sometimes cars will be out of sight of both. If a car should derail or have some other accident at such a time, no one would know about the accident, or try to stop the train, until some time later. Furthermore, regular freight trains frequently weigh so much that, at a speed of 60 mph, it may take more than half a mile to stop.

On the other hand special trains consist of only a few cars and are so short that every car is under constant surveillance from both the engine and the caboose. This, combined with the slower speeds at which special trains operate and the special care with which they are handled, accounts for the fact that in my experience special trains are never involved in serious accidents and are rarely involved in any accidents at all. Furthermore, if a special train should derail, the slower speed and shorter length (lower total weight of the entire train) would enable the crew to stop the train almost at once, before the cars could turn over or pile up. This would greatly simplify checking the cars for damage. Clearing the track would not be as much of a problem because there would not be a pile of wreckage to clear away.

The slower speed, shorter stopping distance and shorter length of a special train also greatly reduces the likelihood of a crossing accident.

The use of special trains will also give quicker, more dependable service and quicker turn-around time, allowing better utilization of the special casks and cars. Although the irradiated fuel elements would only move at a maximum speed of 35 mph, in a special train the shipment would move right on through from origin to destination. For example, it would take a shipment less than 10 hours to move from the power plant at Newport, S.C. to the reprocessing plant at Barnwell, S.C.

in special train service, and arrangements could be made for the shipment to leave Newport as soon as it was loaded, without waiting for the next outbound train.

On the other hand if the shipment moved in regular train service, it would leave Newport on train 85 at 6:00 p.m. (which might be 23 hours after the cask was loaded and ready to move) and would arrive at Rock Hill, S.C. at 6:30. Then it would leave Rock Hill on train 185 at 2:00 p.m. the following day and would arrive at Columbia, S.C. at 5:00 p.m. The day after that it would leave Columbia at 7:00 a.m. on train 97 and would arrive at Barnwell at 11:00 a.m. and be interchanged to SCL. SCL's local train would pick the car up at Barnwell at 9:00 a.m. the next day and deliver it to the reprocessing plant at 9:45 a.m. That is, if the car left Newport at 6:00 p.m. on Monday it would be scheduled for delivery at Barnwell at 9:45 on Thursday, in regular train service.

VERIFICATION

DISTRICT OF COLUMBIA) ss:

HARVEY H. BRADLEY, being duly sworn, deposes and says that he has read the foregoing statement, knows the contents thereof, and that the same are true as stated.

HARVEY H. BRADLEY

Subscribed and sworn to before me this 24th day of May, 1976.

LAWRENCE A. HUFF
NOTARY PUBLIC
IN AND FOR THE DISTRICT OF COLUMBIA
MY COMMISSION EXPIRES JUNE 30, 1977

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

JUN 30 1976

Mr. Guy A. Arlotto, Director
Division of Engineering Standards
Office of Standards Development
Nuclear Regulatory Commission
Washington, D. C. 20555

DOCKET NUMBER PR-71,73 (40 FR 23768)
PROPOSED RULE
Trans. Radio. Mtle By Air

Dear Mr. Arlotto:

This is in response to your letter of March 24, 1976, inviting the U.S. Energy Research and Development Administration (ERDA) to review and comment on the Nuclear Regulatory Commission's (NRC) Draft Environmental Statement, NUREG-0034, Transportation of Radioactive Materials by Air and Other Modes (March 1976). We have reviewed the statement and have determined that the proposed administrative action will not conflict with known current or future ERDA programs.

We should like to provide you with some general comments for consideration in the preparation of the final statement. Detailed comments are provided in the enclosed staff comments.

This document contains much pertinent information relative to NRC and the Department of Transportation regulations for the shipment of fissile and other radioactive material and reflects considerable work in summarizing information concerning personnel exposure limits and radiological effects. However, it was difficult to verify results presented due to incomplete discussion of the material in the text. Although we are familiar with the subject and the associated technology, we found the organization of the statement somewhat difficult to understand. We would like to suggest that you may wish to revise the organization of the statement for better continuity.

In chapter II (PII-3) where it is stated that ERDA was created by the Energy Reorganization Act of 1974, it would be desirable at this point to describe the role of ERDA in authorizing packaging for use by contractors.

Acknowledged by card 7/12/76

DOCKETED USNRC JUL 12 1976 Office of the Secretary Docketing & Service Section

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

Because of the subject matter of this statement, we would suggest that a glossary be added at the beginning of the statement. Some examples are transport index, half-life, effective half-life, latent cancer fatality, competent authority certification, and others. We feel that such an addition would be quite helpful to all readers. Furthermore, NRC might wish to consider the use of photographs in the statement to also assist the reader.

Our staff also strongly recommends that a more thorough evaluation be given to the need for decontamination after an accident involving rupture of containment. The ingestion pathway discussed in appendix A should be carefully evaluated for the radionuclides which may cause special problems.

We agree with the general conclusion of the statement that the risk from radioactive material shipments is low compared to other societal risks. However, we are concerned that the accident risk analysis overestimates the transportation accident risk and is too simplified to make valid comparisons of the relative risks between the various radioactive materials. The danger in this, is that people might scale the accident risk results in an attempt to determine the shipping level at which the accident risk would become unacceptable. When and if the industry approaches this shipping level at some future time, the overestimation could lead to unwarranted concern over the accident risk. This point is discussed in the enclosed staff comments.

Thank you for the opportunity to review this draft statement and we would like to request that NRC send a minimum of twelve copies of all draft statements for review and comment and four copies of final statements.

Sincerely,

W. H. Pennington, Director
Office of NEPA Coordination

Enclosure:
Staff Comments

cc w/enclosure:
CEQ (5)

DOCKETED USNRC JUL 12 1976 Office of the Secretary Docketing & Service Section

ERDA STAFF COMMENTS
ON THE
NUCLEAR REGULATORY COMMISSION
DRAFT ENVIRONMENTAL STATEMENT, NUREG-0034

1. Page i, Paragraph 3

The first paragraph here gives the person rem per year, but does not give the comparative person rem per year in the U.S. from background radiation. We think it would be appropriate to make this explicit as the conclusion on page v notes the small fraction contributed by the transportation phase. We did not find an explicit number anywhere in the text.

We found no comparison of the excess exposure received by aircraft passengers and crew from cosmic radiation at flight elevation vs. the background radiation they would have received had they stayed on the ground. The comparison of this number with that arising from exposure from packages containing radioactive material carried in the aircraft should be constructive.

2. Page ii, Paragraph 3a

States, ". . . an aircraft carrying a bulk shipment of plutonium oxide. There are presently less than 100 bulk shipments of plutonium per year . . ."

The terminology, "bulk" shipments, may be construed to be loose or unpackaged. We are unaware of any such shipments of plutonium. We suggest that these statements be reevaluated since they may convey a connotation different from that intended in respect to shipment of plutonium.

3. Page iii, Paragraph e

It is not clear in the text, page II-25, whether curve A, B, or C is used. If A has been used in the calculations, then it would be appropriate to state in "e" that no medical precautions are taken.

4. Page iii, Paragraph 4

Another alternative which could be considered is requiring the carrier to survey packages prior to acceptance or loading. If this check and balance had been in effect, we might not have experienced some of the notable exposures in aircraft transportation.

5. Page xxii

What is the basis for the statement "A Factor of twenty decrease in accident risk and consequences seems attainable by this technique (change in physical form) for plutonium shipments."? We agree with the principle but question the technical basis of this factor.

6. Page I-12, Paragraphs 1 and 2

We suggest that these be revised to indicate the following: 1) there are no commercial reprocessing plants presently operating; 2) liquid high level wastes must be solidified within five years of production and 3) an acceptable waste disposal method, not just site approval, is needed before a permanent waste repository will be available.

7. Page I-16 through -18, Table I-1

This table lists shipments which include all nuclear fuel cycle material; however, the statement fails to address U-core, U_3O_8, normal and enriched UF_6, fresh and recycled fuel assemblies, and radioactive wastes. We suggest that these should be addressed in the statement.

We also suggest that the category "Low Level Wastes" shipped from "Fuel Fabricator and Reprocessor" to "Commercial Burial Site" by "Truck or Rail" might be added to this table.

8. Page I-20, Table I-2

We suggest that the category "Fresh Fuel and Radioactive Waste Shipments" be added.

9. Page I-24

What is the basis for the statement that spent fuel shipments represent "a significant transportation risk"? We could find nothing in Reference 7 to support this statement.

10. Page I-24

What is the basis for and meaning of the statement that "a similar risk occurs in the transport of high level radioactive wastes"?

11. Page II-4, Last Paragraph

The statement is made that implies the NRC regulations regarding packaging of radioisotopes are included in 49CFR174-177, clarification of this is in order.

12. Page II-14

In the requirements stated for 49CFR173.395(c)(2), we suggest the wording on the U.S. Atomic Energy Commission be updated.

13. Page III-1, Last Paragraph

The sentence reads as though the range of a "one MeV gamma" is 11 cm in tissue. We suggest that NRC might consider expanding the discussion to correct this impression.

14. Page III-3

The statement and the equation following table III-1 are misleading. Theoretically, the equivalent biological effect can be achieved when the relative biological effectiveness (RBE) of the radiation for each exposure consequence is known. The quality factor is used primarily for radiation protection purposes and in our opinion is not adequate for the purposes of comparing exposure risks from the mixture of sources discussed in this paper.

Furthermore, neither quality factor or relative biological effectiveness are defined; they are not equivalent and should not be used interchangeably, particularly when such diverse effects as acute death and lung cancer are considered. We also suggest that NRC might want to consider expanding the discussion of the rem to rad conversion.

15. Page III-4, First Paragraph

Inhaled naturally-occuring alpha emitters include thoron daughters as well as radon daughters.

16. Page III-9, First Paragraph

We suggest that this paragraph be rewritten since it implies that the MPC (air or water) is a unit of exposure rather than being based on the permissable exposure to critical organs.

17. Page III-12, Table III-6

We suggest that the average or mean effect of radioactive transport be added to compare transport dose effect to background and medical dose effect.

18. Page III-15, Last Paragraph

We suggest that the phrase "specific radionuclide" replace the phrase "radioactive specie" which is used throughout. The latter phrase is confusing since it could refer to animals or plants.

19. Page III-16, Table III-7

For PuO_8 we feel that the biological half-life in liver and bone, as well as in lung must be stated and identified.

For Pu, the biological half-life listed is for the deep lung. The value for bone is 36,000 days. Using the isotopic composition and specific activities found in appendix B, p. B-5 and the dose conversion factors from table III-8, we find the following Pu dose conversion values, in rem/curie inhaled.

Dose commitment over:

	1 y	50 y
Lung	4.2×10^6 rem/ci	1.1×10^7 rem/ci
Bone	1.2×10^5	4.4×10^7

We cannot agree with the value of 2×10^8 listed in table III-7 for PuO_8. Conversion to rem/g yields 50 year dose commitment conversion factor of:

Lung	1.4×10^8 rem/g (inhaled)
Bone	5.4×10^8

These values are closer but still do not agree with that listed in the table. We suggest that the data presented in the table be reevaluated in light of these comments.

20. Page 17, First Paragraph

Is it not the relative risks that are to be compared and not the person-rem?

21. Page III-23, Table III-9

The table has not been correctly copied and adequately referenced. "Whole body" is actually "Total (excluding Thyroid)". Also the table contains those values used in WASH-1400 for external exposure. What was used in this analysis for internal exposure? The risk number shown for the thyroid is surely not a mortality estimate-- morbidity maybe, but not mortality. Finally, if the estimates of table III-9 are based on the absolute model, it should be so noted.

22. Page III-24, First Paragraph and Figure III-2

This figure was taken from p. 9-7 of WASH-1400 appendix VI. However, the referenced figure does not contain a curve for alpha emitters. Any subsequent argument pertaining to acute effects (death) of alpha emitter inhalation is unsupportable without these data and suggest that NRC might wish to include these data.

23. Page IV-13.

Table IV-2 gives population dose to crew and passengers from packages. We suggest that it also include the differential received by same populations as a result.of cosmic radiation at flight altitudes. Such a number would be several times the 1400 for Passengers-1* and many times the Crew-I* numbers.

24. Page IV-20, Table VI-4

There is inconsistency between the PuO_2 shipping distance noted in this table and that noted in table V-10 on p. V-37.

25. Page IV-27

Person rem/yr are calculated on this and following pages. We think it appropriate that background exposure doses also be calculated and presented for comparison. For example, the 5042 person rem/yr is a big number to the layman or the person taking data out of context. However, it becomes small when compared to the population background exposure of 22.5 million person-rem/yr.

26. Page IV-33, Section D.3-2

It is assumed that there will be a two-hour "storage" period associated with time spent in rail yards. Is this a realistic figure, particularly where interline transfer is required, or are these transfers taken into account in arriving at this figure.

27. Page IV-40, Section F.1

We feel that transport index system can be based on dosage from the package or the maximum number of packages considering criticality. Hence, the label does not inform as to which of two potential hazards exists. This could be important in accident recovery.

Likewise, the terms Type A, Type B, or large quantity are meaningless to all but a very few persons. Some improvement might be obtained if the labels provided explicit relevant information. We suggest that NRC may wish to study this suggestion as an "alternative" toward reducing mislabeling and mishandling occurrences.

28. Page IV-41, Section F.3

Since 10% of the incidents that involve release are in the Type A category and that these packagings are relatively inexpensive, it seems reasonable that requiring crush and puncture resistance characteristic of service conditions be explored as an alternative.

29. Page IV-43, Section F.5

Appendix C does not provide a deciphering code. However, some of the more notable incidents have derived from packaging errors. We do not feel that this section discusses this matter in proportion to its importance -- either as to requirements or as to cost-benefit or corrective action. It is implied elsewhere that a preconsignment survey of the package would be beneficial in reducing labeling errors. However, the benefit of a quality assurance over-check as to labeling and proper packaging and closure should be considered as an alternate.

30. Page IV-43, Section G

The subject of this section and that of section D.4 (page IV-34) might well be considered in light of the prospect of using ferry barge shipments to circumnavigate cities or states which embargo nuclear shipments or areas where rail carriers are refusing to haul nuclear shipments. We do not feel that the regulations contemplated the casual public in such proximity to nuclear shipments, particularly spent fuel casks, for the typical time period involved. We feel that this situation lends itself to be analyzed in the draft.

31. Page V-8, Equation (1)

We assume this equation was used to calculate accident risks. We have several questions on the methods used to develop numerical values for input into the equation. A primary concern is the term D_{ij} (estimated release fraction for the type of shipment being considered and for the accident severity class). The method of development of D_{ij} appears to be oversimplified. Release fractions used for each accident severity class are presented in table V-6 (page V-25). Questions are raised for both the values used and the use of the release fraction in the analysis. The statement is made (page V-24) that "Model 1 would be an accurate model if packaging were no better than required by present standards." We disagree that it would be accurate; experience indicates that not all material will get out and become dispersed when a package is breached. We are not sure of the basis for Model II. It was our understanding that the reference testing was under impact conditions. If so, how does one apply the results to, e.g., puncture conditions?

Does a category VII accident in air transport involve the same forces as a category VII accident in truck transport? If not, we would expect different release fractions for different modes (since the same container could be used in any mode).

We would not, in general, expect the same release fraction from an accident involving a category VII impact and one involving a category V impact and a category III fire. According to figure V-6 (Page V-9) the latter is also a category VII accident. Whether or not a category III fire will contribute to a release depends on specific package characteristics and specific contents characteristics.

It is also not clear how the normalized population dose (K_i in Equation (1)) is obtained. We know it involves figure V-11 but there is no reference as to source of figure V-11 nor how the curve was developed.

32. <u>Page V-11, First Paragraph</u>

A fire temperature of 1875^{o}F is referenced. We wonder if it would not be appropriate to discuss the 1475^{o}F used in container (MC 0529, 10 CFR 71 etc.) and the impact of the difference.

33. <u>Page V-15, Section B.2</u>

Crush forces are load dependent. Therefore, if, for example, a shipment is made in a sole use vehicle which contains only a few small radioactive material packages the crush force severity categories (e.g., category VIII, 5% of accidents involve a crush force greater than 500,000 pounds) are likely to be incorrect.

Also it would be appropriate to define the phrase "crush force"

34. Page V-27, Last Sentence

From this statement and the discussion near the top of page III-17, the reader is left with a confused picture. Is the calculation for ^{131}I and ^{137}Cs release consequences based on the milk path or on the inhalation path only? The statements in chapter III imply that only the inhalation was included in which case the consequences for ^{131}I and ^{137}Cs releases are underestimated. This should be clarified in the final statement.

35. Page V-30, Second Paragraph

There is no discussion or reference to explain the model used to calculate the area enclosed by isopleths. When an area as large 10^4 km^2 is involved (see figure VII), the model used for this calculation is very much of interest since this area exceeds by more than four orders of magnitude the areas plotted in Meteorology and Atomic Energy. Also, such a large area would depend more on regional than on local meteorology. The atmospheric stability and wind speed should be mentioned as well as the method by which values of the dispersion parameters σ_y and σ_z are determined.

36. Page V-31, Figure V-10

Figure V-10 is self-explanatory although the normalization dose value of 0.8 rem seems odd and there is no explanation of it in the text. This figure, however, and figure V-11 on page V-38 are inconsistent. From figure V-10 the 10-meter release height curve yields a value of $4x10^6$ m^2 at the 95 percentile. Thus, the area enclosed by the $8x10^{-4}$ rem per g of ^{239}Pu released is $4x10^6$ m^2. In figure V-11, however, the ordinate corresponding to $4x10^6$ m^2 is $9x10^{-3}$ rem/g of ^{239}Pu released. This discrepancy should be corrected.

37. Page V-34, Second Paragraph

In the last sentence a cloud height of 10 meters was assumed; however, we feel that atmospheric stability and wind speed assumption should be made and stated.

38. Page V-38, Figure V-11

We do not understand the shape of this curve. The dose should be proportional to the atmospheric dilution factor, E/Q or x/Q' and the area as a function of x/Q' as plotted in Meteorology and Atomic Energy has a concave shape to it, whereas this one (figure V-11) is convex. Since no model is described or referenced, it is impossible to check. As previously noted, we suggest that the source of this figure and how the curve was developed be referenced.

39. Page V-39, Top Line

A computer code is mentioned. Which code is it? Is it documented? There is an ANSI Standard for computer codes which if followed gives the reader some assurance that the code has been reviewed and checked for accuracy. Has this been done for the codes used in this document?

40. Page V-43, Second Paragraph

We do not feel that taking 20% respirable as a median for 10% and 40% is conservative.

41. Page V-43, Third Paragraph

No support or descriptions are given for either of the two components in the "third factor". The statement "For plutonium this fraction is approximately 11/24" is unsupported as is the statement "ratios of irradiation rates and clearance rates... this factor is approximately unity for plutonium". A geometric standard deviation of 3 (footnote) signifies a very wide range of particle sizes, and a most difficult aerosol from which to derive "irradiation rates". This lack of information renders the entire remainder of this section unsubstantiated and therefore of little value. We strongly suggest that additional information be supplied.

Also, we would like to know what is the significance of 11 and 24 in the fraction 11/24 and is there any reference for these figures.

42. Page V-44, Table V-11

Radionuclide name is missing on first line. We assume this should be ^{239}Pu.

43. Page V-48, Fifth Line

Delete the word "physiological" since it is meaningless as used here.

44. Page V-48, Third Paragraph

We suggest that Equation (1) should be given or referenced.

45. Page VI-49, Table VI-30

Accident LCF reduction in table is by a factor of 23, but the text refers to a 23% LCF reduction. This discrepancy should be corrected.

46. Page V-50, Table V-15

The risk reported in this table of accidents in the shipment of PuO_2 is (for the same annual shipment quantity) at least four orders of magnitude greater than that found in a detailed assessment of the risk of shipping plutonium by truck. (T. I. McSweeney, R. J. Hall, et al. An Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck. BNWL-1846, Battelle, Pacific Northwest Laboratories, Richland, Washington, August 1975.)

We feel that this is extreme conservatism in the accident risk analysis.

47. Page VI-1

One section noticeably missing is a detailed history or "Track Record" of fissile and other radioactive materials during the past 15-20 years and the analysis of that data utilizing the parameters used in this study. This omission is not understood since the first sentence in paragraph 2 on page VI-1 states, "The environmental impact of an alternative in radioactive materials shipments is meaningful only when compared to the impact of the current shipping practice." The evaluation of low consequence events of the past could then be compared to projected consequences of future shipments to assess the method used.

No assessment is made of risks resulting from human error or faulty equipment which could result in dropping or puncturing containers during handling (fork-lifting) operations.

In addition, no mention is made of specialized training for personnel involved in the various facets of fissile and radioative materials shipments and the impact it might have in precluding incidents and accidents.

48. Page VI-2, Table VI-1

We suggest that the annual population dose due to accidents be included.

49. Page VI-10, Table VI-4

Table VI-4 and following give baseline and alternative calculated values then a change usually in percent. Giving this change in percent rather than in absolute value tends to be misleading. This is particularly true when evaluating the sum of LCF for normal and accident. For example, on page VI-22 we find a normal transport LCF increase from 1.166 to 1.195 or 0.029 or 2% while accident LCF decreases 21%. Stopping there it sounds like a substantial overall LCF decrease. But looking farther we see the 21% decrease is from 0.000529 to 0.00044 or 0.000089 decrease off-setting 0.029 increase or a net 0.0289 increase. We recommend showing the change in absolute values throughout this section.

Furthermore, we feel that the text could be strengthened by the addition of narrative which place the differentials between alternate modes in perspective relative to the probable accuracy of the result (i.e., relative to the confidence limits in the data). For example, what is the confidence in, or significance of, the computed 21 percent decrease in latent cancer fatalities due to accidents?

50. Page VI-14, Table VI-6

The annual air cost minus truck cost in dollars for plutonium shipment should be 2.8 x 10^3, not 3.4 x 10^3, based on the information in this table. Also, the footnote for this table is confusing since it is indicated that the plutonium shipping distance is 1200 miles but the cost is given for a 2000 mile trip.

51. Page VI-19, Last Paragraph

States, "additional secondary mode mileage..." This is in conflict with statement on page VI-17, B.1-3 which says, "shorter distance in secondary mode."

52. Page VI-30, Section B.1-6.2

The discussion fails to acknowledge the aggravated logistics and increase in facilities and labor required at a reprocessing plant receiving about 5 metric tons of fuel per day by truck relative to rail. This is important also in light of the added potential for operator error, and dosage to plant operating personnel.

Some mention of the efficient utilization of transport fuels is probably appropriate. A 1000 MWe light water reactor might originate 60 spent fuel cask shipments by year by truck or 10 cask loads by rail. Fuel consumption is typically 670 BTU per ton mile by rail; 2400 BTU per ton mile by truck. Assuming a 1000 mile trip (each way), rail shipments would save over 64,000 gallons of diesel fuel per reactor year.

53. Page VI-41, Paragraph 3

States "Restricting trucks to good weather driving..." A restriction of this type would precipitate confusion as to the definition of "good weather driving" and would prevent the driver from exercising discretion as to whether road conditions are safe or unsafe (he should be in the best position to make that determination).

54. Page VI-43, Section B.2-3.3

This section discusses restriction on truck travel on weekends. Since truck costs are based on miles covered, denial of weekend travel would severely escalate costs of shipments by this restriction. Long haul operations that are currently on the road for greater than five days would be severely affected.

55. Page VI-44, Section B.2-4

In view of recent railroad actions, we feel this section deserves more emphasis and perhaps some expansion. Specifically, is there any basis in statistical data to suggest that the addition of special train units (extra's) operating over trackage otherwise scheduled, but at less than normal freight train speed would increase accident frequency or consequences relative to normal freight service?

56. Page VI-47, Table VI-29

This table shows a factor of 16% increase for one item and 100% decrease for another. We suggest consistency in these tables. Some comment applies to table VI-30, page VI-49.

57. Page VI-49, Line 23

States "...Since accidents involving plutonium shipments are expected to produce 98.6% of the total risk..." If this statement is true, then the packaging requirements for all quantities of plutonium shipments should be upgraded. Perhaps consideration should be given to require all transuranics to have a super classification of containers to be used for all modes of transport.

58. Page VII-1, Third Paragraph

This paragraph indicates, according to the text, that nuclear material is subject to security procedures and safeguards intended to preclude the diversion or theft of nuclear material or sabotage of the nuclear facilities in which it is handled.

This statement in regard to the safeguarding of strategic quantites and types of special nuclear material is misleading and should be revised. There is no option to safeguard special nuclear material in this category. NRC regulations prescribe the safeguarding both at fixed facilities and in transit. Additionally, safeguards and security procedures are not limited to "strategic quantities" but to all special nuclear material.

That part of the paragraph which speaks to radioisotopes, such as cobalt-60 should be eliminated. There are no security and safeguards features in the context within which they are discussed, i.e., to preclude diversion or theft or sabotage, applicable to the handling of radioisotopes by NRC. Mentioning cobalt-60 raises numerous related questions regarding other hazardous radioactive materials not subject to NRC safeguards and security type control (e.g., radium).

59. Page VII-2 B(2) and (3)

Meaning of "Contractors" unclear. Contractors to NRC, U.S. Government, nuclear industry or what?

60. Page VII-5, Second Paragraph

The meaning of "supporting safeguards security systems" requires clarification.

61. Page VII-8, Third Paragraph

We see no reason to specify "escort quards" but would refer to "guards" without the qualification since it is unlikely that guards would be used solely for escort purposes. The same sentence apparently intends to refer to "the transportation mode" rather than "the transportation model."

62. Page B-7, First Paragraph

A portion of material deposited in the tracheobronchial region may also pass directly to blood, depending on initial solubility. The term "reticuloendothelial cells of the alveoli" is ambiguous; it is not clear whether this refers to fixed or mobile pulmonary macrophages.

63. Page B-7, Second Paragraph

"Soluble plutonium" is a thoroughly non-specific term. Translocation half-times and fractions can vary several-fold depending on inhaled particle size, specific chemical form, and isotopes of plutonium. Use of the narrow range "150-200" is misleading and may be dangerous in risk estimates; the unit of time is not even given.

64. Page B-9

This figure is taken directly from publications by J. F. Park and W. J. Bair at Battelle Pacific Northwest Laboratories; reference and credit should be given.

65. Page B-10, First Paragraph

This discussion is not complete; the lethal biological effect of progressive pulmonary fibrosis leading to death by respiratory insufficiency is not even mentioned. We suggest that this section be expanded.

66. Page B-10, First and Second Paragraphs

Terms "high", "low", "lower", and "relatively" should be given values or ranges; "relatively high body burdens (.00007 to .09 microcuries)" spans 3 orders of magnitude. We suggest that ".00007 to .09 microcuries" be changed to "0.005 to 0.420 microcuries". (Reference - WASH-1320, page 25).

67. Page B-11, Fourth Paragraph

It should be pointed out that "increases in urinary excretion in some cases by orders of magnitude" may represent only a decrease of a few percent in long-term lung burden of insoluble plutonium.

68. Page B-12

We suggest that NRC staff may wish to reference Dr. J. N. Stannard's paper "Plutonium Toxicology and Other Toxicology" in The Health Effects of Plutonium and Radium (Jee, W. S. S., ed.). J. W. Press, Salt Lake City, Utah (1976) pp. 363-372 rather than the B. L. Cohen reference. ERDA staff feels the suggested reference to be more current.

69. We are listing the following typo errors to improve the draft:

B-7 - Clearance half-time of 150-200 omitted units.

V-9 - There is a VII just above II and a IIII next to II. Should they not both be III?

V-24 - Last paragraph. Should it not be table V-6?

V-54 - First paragraph, last sentence. Should it not be 0.2 fatalities per year?

70. It has been suggested that the report title be shortened to "The Transportation of Radioactive Materials."

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40FR23?)
Trans. Radioactive Mtl. by Air

22 JUL 1976

Mr. Robert B. Minogue
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Minogue:

Enclosed are the EPA comments from our review of NUREG-0034, the draft environmental statement on the Transportation of Radioactive Materials by Air and Other Modes.

We are concerned with the implication of Table IV-2. It lists maximum and average doses to individuals on aircraft of 340 mrem/year and 60 mrem/year, respectively, and since there is no accompanying discussion of the subject, it implies that NRC finds these doses acceptable. EPA has issued recommendations to FAA which state that doses to individuals at such levels are unacceptable for aircraft passengers since at least one cost effective method can be used to significantly reduce these doses (i.e., increased shielding). Therefore, we do not consider this exposure situation consistent with current Federal guidance which states: (1) that "there should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure" and (2) that "...every effort should be made to encourage the maintenance of radiation doses as far below this guidance as practicable." We believe actions must be taken to reduce doses of this magnitude to aircraft passengers.

In December 1974, EPA issued its recommendations to the Federal Aviation Administration for a dose rate limit of 0.5 mrem/hour at seat level. EPA estimated that this would yield a dose of 42 mrem/year to individuals in the worst assumed case. In the same recommendations, EPA found that there is at least one cost-effective method readily available to maintain dose levels below 0.5 mrem/hour. Obviously NRC has followed neither the FRC guidance nor the EPA recommendations in calculating the doses given in the statement and, further, has chosen to imply these doses are acceptable by failing to discuss them. With the tremendous number of shipments of radioactive materials per year on passenger aircraft, EPA views this matter with grave concern, and believes NRC and FAA should undertake immediate action to correct this unsatisfactory situation.

Acknowledged by card 7/27/76

DOCKETED USNRC
JUL 27 1976
Office of the Secretary Docketing & Service Section

A second major problem with this statement involves the analysis of transportation accidents. While the approach taken to evaluate transportation accidents appears reasonable, there is a lack of supporting information to confirm the results of the analysis and the conclusions which are drawn. Thus, these results and conclusions are based solely on engineering judgment. We believe this fact should be recognized and pointed out in the final statement.

In light of our review and in accordance with EPA procedure, we have rated the proposal as EU (Environmentally Unsatisfactory) and classified the draft statement as Category 2 (Insufficient Information). If you or your staff have any questions concerning our rating or comments, please do not hesitate to call on us.

Sincerely yours,

for Rebecca W. Hanmer
Director
Office of Federal Activities (A-104)

Enclosure

Comments on NUREG-0034
The Draft Environmental Statement on the Transportation of
Radioactive Material by Air and Other Modes

General Comments

1. There is a lack of discussion pertaining to the high individual dose equivalent rates to passengers from normal shipments on aircraft. These dose equivalent rates, which are cited in Table IV-2 as 340 mrem/year maximum and 60 mrem/year average, are large fractions of the Federal Radiation Council guidance and are the most significant impact from normal aircraft shipments. In January 1975, EPA issued recommendations to the Federal Aviation Administration which state that doses to individuals at such levels are unacceptable for aircraft passengers since at least one cost-effective method is readily available to significantly reduce these doses (i.e., increased shielding). The action of shipping radioactive materials as described in this statement is not consistent with current Federal guidance which states: (1) that "there should not be any man-made radiation exposure without the expectation of benefit resulting from such exposure and, (2) that "... every effort should be made to encourage the maintenance of radiation doses as far below this guidance as practicable." We believe actions must be formulated and carried out to reduce doses of the magnitude cited being received by aircraft passengers.

2. In December 1974, EPA issued its recommendations to the Federal Aviation Administration for a dose rate limit of 0.5 mrem/hour at seat level. EPA estimated that this would yield a dose of 42 mrem/year to individuals in the worst assumed case. In the same recommendations, EPA found that there is at least one cost-effective method readily available to maintain dose levels below 0.5 mrem/hour. Obviously, NRC has followed neither the FRC guidance nor the EPA recommendations in calculating the doses given in the statement and, further, has chosen to imply these doses are acceptable by failing to discuss them. With the tremendous number of shipments of radioactive materials per year on passenger aircraft, EPA views this matter with grave concern, and believes NRC and the FAA should undertake immediate action to correct this unsatisfactory situation.

3. We point out that EPA has proposed standards concerned with normal operations in the uranium fuel cycle (40 FR 23420) which include doses received during transportation of radioactive materials. These standards would limit individual doses to 25 mrem to the whole body. EPA believes that this will have little or no effect on the economics or operations of the transportation industry because, as it now exists, the dose equivalent levels appear to be less than 1 mrem

per year, well below 25 mrem per year. The fact that EPA has formally proposed standards which would apply to the transportation of uranium fuel cycle materials and yet is not recognized in the draft statement is an oversight which should be corrected.

4. With regard to transportation accident analysis, the relationship of the shipping package test requirements and the performance of the packaging under various accident categories has not been established to our knowledge. Thus, the information on failure rates and release fractions as presented in Table V and the conclusions drawn are based solely on engineering judgment. This fact should be indicated in the final statement.

5. EPA believes that use of the BEIR report in its unmodified form is the most reasonable model to use to calculate health effects in this statement at this time. Since the debate over the health effects model in WASH-1400 is still continuing, it is premature to base this analysis on WASH-1400 premises.

6. With the exception of weapons-related shipments where the country's security might be compromised, we cannot understand the exclusion of government transportation statistics. Since this group of statistics is surely a large collection, the public release of this information is not only desirable but could certainly aid in the assessment of the environmental impact created by the transportation of radioactive materials.

Specific Comments

1. P. III-2, Last paragraph: It should be noted that the length of time over which energy is absorbed is also critical to creating biological effects.

2. p. III-3: Since there were 5.5 million examinations in 1972 using technetium and the most useful form cited was used a mere 120,000 times, it is not clear what happened with the other 5,380,000 examinations.

3. p. III-9: The statement, "The dose limits proposed by NCRP and adopted by EPA..." is not correct. EPA is currently operating under the 1960 guidelines of the Federal Radiation Council (FRC). The EPA is currently working in an interagency effort to review and update the FRC guidelines; the NCRP dose limits are being consulted in this effort but have not been adopted.

4. p. III-13: We suggest rewriting the sentence beginning "Technetium-99m can be given..." as, "Technetium-99m can be given in relatively large amounts with little radiation exposure." "Relatively" emphasizes comparison with other isotopes and "amounts" eliminates

possible confusion resulting from using the word "dose" which is used in a medical context rather than the radiological context in which it had previously been used.

5. p. IV-12, sec. D. 1-1: It is stated that tiers 6, 7, and 8 in figure IV-3 schematically illustrate the procedure that the FAA employed to arrive at the various dose estimates in their assessment, reference IV-2 in the statement. However, tiers 7 and 8 do not appear in figure IV-3. They should be added in the final statement.

6. p. IV.-34: We feel that the water transport discussion was not thorough enough. The only reason cited for this treatment is a "paucity of information" concerning water transport. However, the discussion in the draft statement on the manufacture of floating nuclear power plants (NUREG 75/113) provides a brief but much more adequate discussion of the subject. If it is believed that a projection to 1985 is too uncertain this is understandable and should be so stated, but a more thorough discussion would be more informative for the public and would not as likely appear to be a sidestepping of the issue. Therefore, further basic discussion of water transport and an explanation for its exclusion in the further analyses is warranted.

7. p. IV-41: In the second paragraph of section F.3, there is no factual basis cited for the statements leading to the 0.5 mrem/year "expected" dose rate. This section needs to be more thoroughly documented to indicate which radionuclides were considered and in what proportions. Further, information on whether certain types of packages are damaged more frequently than others and, if so, which, is certainly of importance to the analysis in this section.

8. pp. IV-42-43: The method of modifying equation 2 to arrive at the given equation is not clear, further elucidation is requested.

If there are records indicating "an average of 5 losses per year over the last 9 years," it seems there might also be records indicating for how long these packages were lost. Such information would eliminate another estimate, i.e., the "7-days lost" figure, to allow a more precise appraisal of possible population doses.

9. p. IV-44: The discussion shows that it is currently possible for workers to exceed 500 mrem/year simply handling shipments. It is clear that if the number of shipments increase as they are projected to do that these workers will routinely exceed 500 mrem/year. Any provisions which have been made to prevent this from occurring should be indicated. Furthermore, if the doses mentioned on p. IV-44 do not include unnecessary doses (e.g., sitting on or standing near radioactive

cargo), which they apparently do not, the problem becomes worse than estimated on p. IV-44. We believe that if unnecessary exposures are indeed a fact of life, they should be included in the environmental impact assessment. Any plans underway to mitigate or eliminate these unnecessary exposures would be of interest also.

10. p. V-13: The scheme of the de-rating of aircraft accidents seems somewhat unrealistic in one sense and quite arbitrary in another. First, airline routes do not blanket the entire country uniformly, especially flights carrying radioactive materials. It would seem much more realistic to determine the proportion of flights carrying radioactive cargo over the various land surfaces and then de-rate the accidents. Second, the reasons for choosing the number of accident severity classes by which accidents are de-rated are not apparent. The arbitrary nature of the statements brings them into immediate question.

11. p. V-24: EPA previously stated and still believes that a technical analysis should be performed relating packaging test requirements to the forces a package may experience in an actual accident environment since primary protection in transportation is currently provided by the packaging itself. Special attention would be given to the probable extent of damage expected to be suffered by the package and the resulting quantity of radioactive materials which may be released to the environment under the various accident conditions. In developing this analysis, it is important to use as much test data as possible rather than relying on unverified engineering models. EPA is encouraged that data is now being gathered from actual tests, however, it appears that insufficient data makes it too early to use "Model II" in Table V-6. In our opinion, Model I should be used as the basis for the risk assessment at this time, with Model II used only as a comparison.

12. p. VI-40, Table VI-25: The discussion on the mitigation of accident consequences which precedes this table in this section indicates a decrease in the "Accident L.C.F." rather than an increase as given in Table VI-25. The reason for this seeming inconsistency should be explained.

13. p. VI-46, B.3-1, 2nd paragraph: Correction of the term "ny" is necessary to clarify the sentence's meaning.

14. Appendix B: The list of references should be more specific where appropriate when only one part of a book or one article in a collection is used. Other references need to give more information to be complete, such as numbers 5 and 12.

On p. B-7, the first paragraph, the movement of particles captured in the mucoid lining is more properly termed transported not sloughed.

In section E, we have several comments. On page B-10, to prevent confusion, a beta particle is not an ion and it is confusing to describe its nature as ionic, its nature is more properly termed that of a charged particle; also, beta particles can travel much further than a few microns in body tissue, in fact into the centimeter range. In the cited case of the Los Alamos personnel, the draft statement indicates that "...none of these people has shown any evidence of radiation injury." It seems this statement is probably too broad and could be optimistic. We doubt that all possible indicators have been checked and even if they have it is quite unlikely that there has been no radiation damage. This statement, if taken literally, would indicate that the NRC has adopted a threshold model for radiation effects. If this is true, the decision should be documented.

In section E.3, first, there are no references cited for the information given; second, there are apparently symbols missing from the amounts of plutonium cited, 0.5 curie Pu-239/gram of lung is the same as 8.2 grams Pu-239/gram of lung.

The discussion in section F on chelating agents does not mention any side-effects of their use, e.g., possible deposition in other organs, rather than excretion, which could create worse problems.

And, finally, the comparisons given on p. B-12 are too simplistic. Nowhere is it stated that the effect of these materials depends on innumerable factors, e.g., exposure time, time between intake and effect, condition of the victim, and how the material acts in a biologic system. This should be corrected in the final statement.

15. Appendix C: The listing of incidents as presented is hard to follow since there are neither dates indicating when incidents occurred nor meanings of the abbreviations used. Such data needs to be included in the final statement.

Editorial Comments

1. p. IV-24: In the "Dose to Crew" equation the "D_c" factor is unnecessary. Its inclusion squares the dose rate.

2. pp. V-9 and V-20: The squares listed for the following figures are apparently mislabeled: Figure V-6: 0-0.5 hour fire, 30-55 mph and, 0.5-1 hour fire, 11-30 mph; Figure V-20: 1-1.5 hour fire, 40-60 mph.

3. p. VI-1: The act referred to as the National Environmental Protection Act is correctly cited as the National Environmental Policy Act of 1969.

4. p. B-7, middle paragraph: The clearance time for soluble plutonium needs to have units added to it.

DOCKET NUMBER PROPOSED RULE PR-71,73 (40FR23768)

Office of Planning and Budget

Executive Department

James T. McIntyre, Jr.
Director

G E O R G I A   S T A T E   C L E A R I N G H O U S E   M E M O R A N D U M

DOCKETED USNRC AUG 5 1976 Office of the Secretary Docketing & Service Section

TO: U.S. Nuclear Regulatory Commission
Office of Standards Development
Washington, D.C. 20545

FROM: Charles H. Badger, Administrator
Georgia State Clearinghouse
Office of Planning and Budget

DATE: July 29, 1976

SUBJECT: RESULTS OF STATE-LEVEL REVIEW

Applicant: U.S. Nuclear Regulatory Commission

Project: The Transportation of Radioactive Material by Air and other Modes

State Clearinghouse Control Number: 76-04-14-05

The State-level review of the above-referenced project has been completed. As a result of that review process, the project is recommended for further development with the following recommendations for strengthening the project:

1. The draft EIS deals with the transportation of all types of radioactive materials, including pharmaceutical as well as spent fuel. It is broad, general, and non-specific. Because of the way it is organized and presented, it is practically impossible to sort out the real issues and impacts associated with an area of prime interest such as the transportation of spent fuel. The NRC should seperate out the issue of spent fuel and do a seperate detailed and factual EIS on its transportation aspects.

2. roughout the document, the dose estimates are related to the average exposure to ulation in man rems. The NRC should also include dose values based on the maximum exposure to individuals.

Acknowledged by card 8/5/76

3. With reference to accident analysis, the EIS seems to look at alternatives in a broad, general context and only related to the average exposure concept. It is questionable as to whether some of these same alternatives would still be valid if the maximum exposure concept were used.

4. In addition to the general considerations of transportation of nuclear materials throughout the United States, specific consideration must also be addressed with regard to large metropolitan areas such as Atlanta, posts of entry, and other large transportation centers. NRC has a definite and specific responsibility in the development and application of proper procedures for the transportation of nuclear materials through such areas in order to insure the complete protection of the citizens of the area. Such procedures must be useable and acceptable by the States that are impacted.

5. In general, the EIS is too general and non-specific to be of much use as a planning tool for specific areas. As was stated in (4) above, NRC has the obligation and responsibility to issue a report that is useable by the States.

The State of Georgia asks that the final environmental impact statement prepared for the project contain a greater degree of specificity when addressing the aforementioned areas of concern.

cc: ...ce Osborn, Executive Department, Office of Planning and Budget
...i Walden
Leonard Ledbetter, Department of Natural Resources
David Tundermann, Council on Environmental Quality
Ray Siewert, Department of Natural Resources

DOCKET NUMBER PROPOSED RULE PR-71,73 (40 FR 23768)

STATE OF NEW YORK
DEPARTMENT OF LAW
TWO WORLD TRADE CENTER
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TELEPHONE: 212-488-7562

LOUIS J. LEFKOWITZ
ATTORNEY GENERAL

PHILIP WEINBERG
ASSISTANT ATTORNEY GENERAL
IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

August 4, 1976

DOCKETED USNRC AUG 17 1976 Office of the Secretary Docketing & Service Section

Director
Office of Standards Development
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Comments on the Nuclear Regulatory Commission's Draft Environmental Impact Statement on the Transportation of Radioactive Materials (NUREG - 0034)

Dear Sir:

Recently it was announced by the U.S. Energy Research and Development Administration ("ERDA") that it will take over the transportation of all strategic amounts of non-weapons special nuclear materials ("SNM") by October 1 of this year. ERDA stated that the takeover was being made because a "higher degree of security is essential." Nuclear News, June 1976, p. 125, copy attached. According to affidavits filed by ERDA and the NRC in the federal case of the State of New York v. NRC, et al., 75 Civ 2121 (WCC) (SDNY), these shipments had been made until now by commercial transport. We are unaware of any action by the NRC to similarly remove from commercial transport SNM shipments by its licensees although it has been stated by the NRC and ERDA that:

> "As a matter of ERDA and NRC policy the control measures imposed on plants and transportation of ERDA license-exempt contractors and of NRC licensees are either the same or comparable." Presidential Report to the Congress Regarding Laws and

Acknowledged by card 8/17/76

Regulations Governing Nuclear Exports and Domestic and International Safeguards, March 31, 1975, prepared by ERDA & NRC.

ERDA's recent finding that a higher degree of security is essential indicates the vulnerability of ERDA and NRC controls on commercial air and related connecting transport to terrorist action as is thoroughly discussed in the comments of this office on the above-referenced environmental impact statement ("EIS") and the prior comments and enclosures dated July 2, 1975 and August 12, 1975, submitted by this office in this administrative docket as originally noticed at 40 Fed. Reg. 23768 (June 2, 1975). (See especially comments of Messrs. Mason and Leamer, submitted by letter dated May 17, 1976, and copies of affidavits of Messrs. Mason and Leamer, dated November 30, 1975 and January 20, 1976, resubmitted by letter, dated August 3, 1976, to J. Corr, NRC Office of General Counsel).

This new development and the anomalous situation which it creates must be publicly addressed by the NRC in a direct and prompt manner.*

The NRC is now once again urged to recognize that the continued commercial transport of SNM runs an unacceptable risk of diversion or loss of SNM. More secure modes of transport must be immediately designed and implemented. As this office has previously stated it is our view that the NRC should require that shipments of plutonium be made by military surface transport and that shipments of uranium**

* Additionally, the Final EIS on transportation should, of course, reflect the NRC response to ERDA's concern over the inferior control measures which are not capable of providing an adequate degree of security for the transport of SNM.

** Other than uranium enriched in the isotope U-233.

be made by military air transport, using military bases as points of shipment and interim storage for all SNM.

It is requested that this letter be docketed and made part of the record of this proceeding.

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
By

JOHN F. SHEA, III
Assistant Attorney General

JFS:rab

APPENDIX "A"

NUCLEAR NEWS / JUNE 1976 p. 125

safeguards

SNM

ERDA to assume shipments by October

Because it says a "higher degree of security is essential," the U.S. Energy Research and Development Administration will take over transportation of all strategic amounts of non-weapons special nuclear material by October 1. These shipments are now being made via private shippers. One of them, Edlow International of Washington, D.C., had objected to ERDA's plan before it was made final.

Following a meeting with Edlow, ERDA reasserted its position. Alfred D. Starbird, a retired Army lieutenant-general and now ERDA's assistant administrator for national security, said, in a letter to the shipper, "Based on our analyses we are convinced that significantly greater security will be provided at an earlier time by expansion of the existing ERDA system" to cover the strategic quantities of SNM.

An ERDA spokesman later emphasized that the agency will continue to study the situation, even as it implements its plan.

October 1 was picked as the deadline after considering the time required to obtain shipping materials and work out security procedures. Contracts with the private shippers will be terminated or adjusted by that date.

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IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

DOCKET NUMBER
PROPOSED RULE PR-71,73(40FR23768)

August 3, 1976

AUG 17 1976

Janice K. Corr
Attorney
Office of the General Counsel
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Comments on the Nuclear Regulatory Commission's Draft Environmental Impact Statement on the Transportation of Radioactive Materials (NUREG-0034)

Dear Ms. Corr:

Judge Conner has ordered that the seal on the affidavits of Messrs. Mason and Learer, dated November 30, 1975 and January 20, 1976, submitted in State of New York v. NRC, et al., 75 Civ. 2121 (WCC) (S.D.N.Y.), be broken.

In accordance with our previous discussions, I enclose copies of those affidavits for submission in conjunction with the other comments of this office which have already been accepted for consideration by the NRC in preparing the final environmental impact statement.

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
By
[signature]
JOHN F. SHEA, III
Assistant Attorney General

JFS:dg
Encl.

Acknowledged by card 8/17/76

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

DOCKETED USNRC AUG 17 1976 Office of the Secretary Docketing & Service Section

-----------------------------------X

THE STATE OF NEW YORK, :

Plaintiff, :

-against- :

THE NUCLEAR REGULATORY COMMISSION, et al., :

Defendants. :

-----------------------------------X

AFFIDAVIT

75 Civ. 2121 (WCC)

STATE OF NEW YORK)
: SS.:
COUNTY OF NEW YORK)

THEODORE T. MASON and ROBERT R. LEANER, being duly sworn, depose and say:

Purpose of the Affidavit

1. This affidavit is submitted in support of plaintiff's motion for a preliminary injunction and motion for summary judgment, and is made with regard to the possibility of terriorist activities directed toward destruction or seizure of special nuclear material or SNM.

2. This affidavit augments and refines the affidavit of 16 June, 1975 submitted by Theodore T. Mason and Robert R. Leaner in support of the position that there is a substantial likelihood that a motivated, trained and equipped group of terrorists could be successful in destroying or seizing SNM in the course of its transportation by commercial air and related connecting ground services. The principal purposes of this affidavit are to address (1) the air transport of uranium as opposed to plutonium, (2) and the vulnerability of commercial air transportation systems currently employed industry-wide as compared to a variety of military assisted air transport systems. Plutonium constitutes a threat as a toxic dispersant and therefore a terrorist might well seek to

destroy a plane transporting it. On the other hand uranium, other than U_{233}, constitutes a threat only as an explosive and requires a terrorist action plan of seizure and escape for later explosive deployment.

4. Each of the following military assisted transportation alternatives for enriched uranium is considered less vulnerable to terrorist action than current commercial practice. The least vulnerable alternative is presented first, the most, last:

(1) long haul military air cargo, leaving from and flying into a military airfield, and connecting with short haul military helicopter service between the airfield and the origin/ultimate destination;

(2) same as (1) but with military surface transport service between the airfield and the origin/ultimate destination;

(3) long haul commercial air cargo, leaving from and flying into a military airfield, and connecting with short haul military helicopter service between the airfield and the origin/ultimate destination;

(4) same as (3) but with military surface transport service between the airfield and the origin/ultimate destination;

(5) long haul commercial air cargo, leaving from and flying into a military airfield, and connecting with commercial surface (truck) service or commercial air (helicopter) service between the airfield and the origin/ultimate destination.

5. Nature of the Threat

Since the terrorist objective will be to seize and escape with the enriched uranium in contemplation of later actual or threatened explosive deployment, he has only limited courses of action:

a. hijack the aircraft;

b. theft at the airport;

c. irception and theft between the airport and the origin/ultimate destination.

The threat of destruction of the long haul aircraft in the air, upon landing, or in parking position is minimal as it is quite unlikely to facilitate a uranium seizure and escape. Complete destruction of short haul transport, either air or surface, is also unlikely for the same reason. The uranium must be seized intact and not destroyed or lost in the process of bringing down the aircraft.

6. Evaulation Criteria

In our affidavit of 16 June, 1975, the earlier planning steps and subsequent destructive employment steps were found to be within the capability of terrorists. Vulnerability of competing transport systems to the threat described in previous paragraphs can be assessed in terms of the relative likelihood of terrorist success in accomplishing steps (5) through (11) under paragraph 8 of our previous affidavit dated 16 June, 1975. These steps are:

(5) acquisition of information on material location, protection and movement;

(6) external penetration of facility (airport);

(7) access to interim storage facility (if applicable);

(8) control of vehicle (aircraft/truck);

(9) access to container (or material);

(10) manipulation of container (or material);

(11) removal of material (from area/authorized control).

7. <u>Assessment of Alternatives</u>

A number of action plans which terrorists might implement to gain their objectives were identified in our affidavit dated 16 June, 1975. A transportation system alternative may be considered vulnerable if implementation of those or similar action plans are likely to allow a terrorist to effect the steps enumerated in paragraph 6 above.

8. A summary vulnerability assessment of each military assisted transportation system alternative described in paragraph (4) above is provided below. The commercial air transport system currently employed industry-wide was found highly vulnerable in our affidavit of 16 June, 1975, and it is not reevaluated herein. Each military assisted transport system considered below is superior to (less vulnerable than) the current commercial system. Varying degrees of military assistance are evaluated in order to show that there is a range of policy options yielding varying degrees of lower vulnerability.

<u>Alternative (1) - All Military with Short Haul by Helicopter</u>

9. Hijacking -- considered remote because the military cargo aircraft would load enriched uranium at and depart from a military airfield. Security at a military base is generally quite rigorous, making access to the base, and the airfield, and then the aircraft, rather difficult. Additionally, military communications can be made very secure, so that terrorist access to critical information on the nature and timing of enriched uranium movement would be quite difficult.

10. Destruction of long haul aircraft--not an appropriate action plan since a terrorist must take physical control of enriched uranium for later use in a bomb.

11. Seizure of enriched uranium at destination military airfield considered remote for following reasons:

--difficulty of accessing military airport;

--military police are armed, motivated and likely to prevent terrorist escape even if a seizure is effected;

--all base personnel can be placed upon immediate alert in the event of an incident;

--military communications are excellent and additional response capability is generally available;

--information on enriched uranium movements can be made extremely difficult to acquire. Secure and controlled communications are central to military operations;

--temporary storage or hold over of enriched uranium at military airports is unlikely since a military helicopter responsible for the short haul leg to a final destination is not likely to be assigned other functions which would delay or conflict with the SNM delivery mission;

--established and tested procedures for secure handling of nuclear weapons have been in use for some time.

12. Seizure of enriched uranium during short haul helicopter transit to or from the ultimate origin or destination -- considered difficult because:

--information on aircraft movement can be made very difficult to acquire;

--the aircraft's route to destination may be made deliberately erratic and such a route clearly is not constricted to available roads as in the case of surface transport;

--it is not appropriate to shoot down the aircraft, since it does not assure the terrorists that they will reach the crash site, find the cargo, and successfully escape before being apprehended (assuming cargo remains intact);

--the aircraft may fly over water in many instances to minimize both the land based ambush opportunities, as well as render difficult unauthorized recovery of enriched uranium if the aircraft went down. Additionally, the potential for crashing in populated areas is minimized;

--aircraft (helicopter) may deliver enriched uranium directly into the destination's secured zone without interim use of even limited surface transport.

<u>Alternative (2)--All Military with Short Haul by Convoy</u>

13. This alternative preserves high security during the long haul transport and at the airport, but sacrifices the extreme flexibility of helicopters for the short haul transport. Relative to commerical surface transport, the military convoy advantages under this alternative are:

--avoidance of population centers associated with large commercial airports;

--information on planned convoys and actual movements are within military structure and hence are highly secure;

--military convoy practices anticipate ambushes and plan accordingly, making use of decoys, advance and rear guard escorts, deliberately erroneous movement information, adequate armed personnel, quick response assistance teams, etc.

<u>Alternative (3)--Commercial Long Haul Cargo Aircraft Using Military Airfields with Military Air Transport for the Short Haul Transit. Alternative (4)--The same as (3) Except Using Military Surface Transport for the Short Haul Transport.</u>

14. These alternatives preserve a measure of security during long haul transport and at the airport, but increase the

possibility that planned movement information will be more widely disseminated and/or that inflight communications will be handled in a less secure manner.

It is anticipated that any commercial aircraft departing fr a military field would be searched for stowaways prior to departure (to avoid hijacking) and would not land at any commercial field before unloading its enriched uranium cargo. Either military air (helicopter) or military convoy would be employed for the short haul transit, each with its attendant security posture.

<u>Alternative (5) Commerical Long Haul Cargo Aircraft Using Military Airfields with Commercial Air on Surface Transport for the Short Haul Transit.</u>

15. This alternative preserves a measure of security during the long haul transport, and at the airport, but greatly increases the possibility of movement information (i.e. air and surface related) being more widely disseminated and/or subject to in-transit monitoring as more commercial interface is necessitated. Also short haul commercial ground or air transit is highly vulnerable for some on all the reasons set forth in our affidavit of 16 June, 1975 and below in paragraph 16.

<u>Concluding Comment</u>

16. Any of the military assisted transportation system alternatives presented are considered more secure than the current commercial practice. The military assisted alternatives to the present commercial air transport cycle for enriched uranium are less vulnerable to terrorist action because of:

(1) less dissemination of movement information, vigorous information control;

(2) more secure in-transit communications;

(3) personnel with security training and clearances;

(4) appropriate selection of weapons and vehicles

(5) superior reaction capability;

(6) physical remoteness of airfields and facilities;

(7) reliable and highly motivated personnel;

(8) psychological deterrent of a U.S. military protective force.

17. Although the entire affidavit thus far has addressed itself to enriched uranium transport, one comment regarding plutonium transport is worth making. A recent report by Ensign Dwight L. Gertz, USN, in Terrorist Weapons and the Terrorist Threat, "U.S. Naval Institute Proceedings," October, 1975, pp. 113, 114, confirms our conclusion expressed in our 16 June, 1975 affidavit that the terrorist motivation and threat to destroy aircraft is real and the weapons are readily available. In a recent instance, five Arabs rented an apartment in Ostia near Rome, 4 miles from Leonardo da Vinci Airport, directly underneath the North-South runway approach, and were only hours away from initiating a planned attack on a commercial airliner. They were equipped with two Russian made Grail missile launchers and a supply of missiles. In a second recent instance, when authorities were informed that terrorists in the Brussels area had been shipped Grail launchers, hundreds of troops were called out to cordon off airports in Brussels and London. The Grail is combat proven and available to Soviet supplied nations and some "neutral" countries. The missile is heat-seeking. The launcher is hand held and simple to use.

In-transit dispersion of plutonium oxide in many instances would be both a highly effective terrorist act and one of far lesser difficulty than seizure and escape. Hence the threat becomes one of destruction of the aircraft in order to breech the plutonium oxide containers and disperse their contents.

THEODORE T. MASON

ROBERT R. LEAMER

Sworn to before me this
30th day of November, 1975

Contents

Terrorist Weapons and the Terrorist Threat

By Ensign Dwight L. Getz, U.S. Navy,
Patrol Squadron Nine

Dozens of airlines and governments operate the big jets which take off from the airport in a steady stream. The departure of each is pinpointed by the roar of engines and the flashing of lights as it roars into the sky. The pilots and passengers can make out only hints of the city that bustles below. Hundreds of thousands of men and women live in the sprawling blocks of apartment buildings underneath the flight path of the ascending aircraft. In one fourth-story apartment, three young men open a closet door and remove something which would remind a movie buff of the bazooka he had seen in a late show war movie. They slide the window open and watch the [illegible] TWA, and [illegible] marked representative of an [illegible] nation. As the marked aircraft arches overhead they take aim at the looming silhouette . . .

The professional naval officer spends a great deal of his time networking among the ships, hardware, and capabilities of his potential enemies. In recent years, this attention has focused, for U.S. naval officers, on the rapidly improving Soviet Navy. In our concern for this massive challenge, we must guard against a tendency to forget that the goals of war are political and that these goals may be achieved by forces other than the regular military establishments of the combatants.

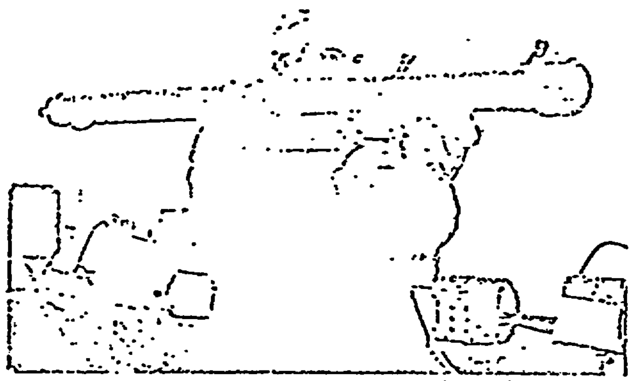
In the gray area between peaceful politics and war live numerous organizations capable of contributing to the achievement of national goals. Although this has never been a secret, it is sometimes forgotten that these organizations are improving their tactics and arms inventories in much the same manner as the world's more conventional mili[illegible]

[illegible] embarrassing loss on an individual company [illegible], or it can be an attack on a [illegible] to the [illegible] alter the political environment in which the [illegible] operates. For this reason, it may be interesting to see what sort of improvements have been made in the terrorist arsenal.

It would not hopelessly threaten plausibility to discuss the possibility of nuclear weapons or other exotic weaponry falling into the hands of a terrorist group. Both the spy thrillers and other military analyses have brought this problem to light. Effective weapons do not have to be exotic, however. The conventional arsenals of the major military powers contain plenty of weapons for the terrorist which do not saddle him with the technical or political burdens inherent in the use of nuclear, chemical, or biological weapons.

One such conventional weapon is the Soviet built SA-7 Grail surface-to-air missile. The Grail's launcher tube, which is about the size of a World War II [illegible], fires a missile which [illegible] the infrared radiation from [illegible] engines. It is considered comparable to the U.S. built Redeye missile which is about four feet long and which [illegible] at supersonic speeds for a considerable distance in pursuit of a low flying airplane.

The simplicity and [illegible] rugged [illegible] of [illegible]



This view demonstrates just how easy it is to take [illegible] with the SA-7.

weapon (ROW) make it a prime candidate for deployment with the armed forces of the Soviet Union in a variety of applications. It can be lugged by foot soldiers, mounted on vehicles, or carried on board naval combatants. The technology involved is simple enough to lend itself to mass production.

One reason for heavy Soviet investment in the Grail is that it is a combat-tested system. Use of the Grail against U.S. aircraft in Vietnam was first reported in the spring of 1972. It downed several aircraft at that time and seriously disrupted reconnaissance and helicopter operations, close air support missions, airborne artillery spotting, and other low altitude aviation operations.[1]

U.S. countermeasures, most notably the use of hot flares to mislead the missile's infrared guidance system, held the casualty rate down but also provided the users of the Grail with a laboratory situation in which to test improvements. The October 1973 Arab-Israeli War offered yet another opportunity to test modifications to the system. As a result, [illegible] improved [illegible] cations to one of the many miniaturized radar systems in production, he can be ready for an enemy aircraft before it even comes into view.

The successful record of the Grail has created a demand for the antiaircraft missile in traditionally Soviet-supplied nations and some "neutral" nations. Several countries already have the Grail system, and as the number of countries increases so do the chances that the link will be created in the chain which will lead to terrorist possession of the deadly missile.

From its Soviet origin, the missile might proceed by any number of circuitous routes on its way to a terrorist organization. The missile might begin as part of an arms shipment to a Soviet-supplied nation such as Syria. Syria, like several of its Arab allies, arms and supports the Palestine Liberation Organization (PLO). This "group" includes several factions, each with varying degrees of loyalty to the central command and differing concepts of the most effective means of obtaining Palestinian goals. It is not too difficult to imagine the possibilities by which a radical faction such as the Black September might obtain weapons from more conservative groups in the PLO by [illegible], theft, defection of personnel or sheer mismanagement.

Another possible pipeline exists in [illegible] missiles [illegible] directly. The Qadhafi regime in Libya, recently the recipient of large quantities of Soviet military hardware, has been suspected as the source of Grail shipments to terrorists on at least two occasions.

In the first case, Italian police apprehended five young Arabs who had rented an apartment in the seaport city of Ostia, near Rome. The apartment was four miles from Leonardo da Vinci Airport and directly underneath the [illegible] pattern for the North-South runway. Cached in their apartment were two Grail launchers and a supply of missiles. The Italian press reported that the terrorists were only hours away from a planned attack on a commercial airliner.

This demonstration of the [illegible] of the Grail threat led to a dramatic reaction by Western European governments when they were informed that Grails had been shipped to terrorists in the Brussels area. Hundreds of troops were required to throw up a special security cordon around airports in Brussels and London. The Grail attack never materialized, but the security measures necessary to protect against it illustrate the type of response required to counter a threat posed by a small group of people equipped with a very small, but effective, weapon.

Different activist groups in nearly every part of the world would undoubtedly like to acquire weapons like the Grail whether they planned to employ them or not. Groups in Ireland, Quebec, Black Africa, Asia, and even the United States have resorted, for political reasons, to tactics which emphasize quick, spectacular actions. Spectacular attacks have become recognized as important facets of numerous successful revolutions or "wars of national liberation." The embryonic revolutionary can look to the histories of Israel, Cyprus, Mozambique, Vietnam, and a host of other countries to see places where terrorism helped spawn either a conventional war, or a political victory without large scale military action.

With the respect generated by these successes, terrorist and guerrilla movements are gaining support daily. With money, influential support, and a feeling of growing power, [illegible] their new weapon [illegible] in existence in the coming months and years.

EDITOR'S NOTE: *The views expressed are those of the author and do not necessarily represent the position of the U.S. Department of Defense or the U.S. Government.*

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

---------------------------------------X

THE STATE OF NEW YORK,

Plaintiff,

-against-

THE NUCLEAR REGULATORY COMMISSION, et al.,

Defendants.

---------------------------------------X

AFFIDAVIT IN FURTHER SUPPORT OF PLAINTIFF'S MOTIONS

STATE OF NEW YORK)
: SS.:
COUNTY OF NEW YORK)

THEODORE T. [illegible] and ROBERT R. [illegible], being duly sworn, depose and say:

Introduction

1. The purpose of the affidavit submitted by ourselves dated 16 June, 1975 was to (1) demonstrate that there is a substantial likelihood that a highly motivated group of terrorists could be successful in destroying, or seizing for destructive use SNM in the course of air transport, or related connecting transport, notwithstanding existing safeguard regulations and/or actual practice, and (2) argue that the military has the current safeguard capability to move SNM by surface transport which is significantly less vulnerable to terrorists than commercial air transport and related connecting transport.

2. The purpose of the affidavit submitted by ourselves dated 30 November, 1975 was to augment and refine the affidavit of 16 June, 1975, [illegible] the question of the transport of uranium as opposed to plutonium and the vulnerability of commercial air transportation systems currently employed industry-wide as compared to a variety of military assisted air transport systems.

Purpose of This Affidavit

3. The purpose of our current affidavit is to restate our positions as outlined in the two above-noted affidavits and, further, to (1) respond to arguments raised in the defendants' answering affidavits insofar as they relate to the vulnerability of transportation alternatives to the threat of terrorist action, (2) provide an assessment of the impact of recent changes in Part 73 of Title 10 of the Code of Federal Regulations, and (3) present recent information contributing to the argument that there exists alternative military SNM transport capability that is less vulnerable to terrorists than the current commercial system.

J. Edlow, Affidavit of January, 1976

4. In paragraph 6. of his affidavit, J. Edlow's reference to "strategic" quantities of SNM misses the point. Apparently Edlow is referring to the fact that CFR Sec. 73.30 sets minimum requirements for NRC licensee shipments of certain amounts of SNM computed by formula, which include 5,000 grams or more of U_{235} enriched to 20 per cent or more, or 2,000 grams or more of plutonium. This regulation fails to cover various significant dangers. For example, any amount of PuO, if used as a dispersant, could cause death and injury. Also, the psychological aspects of SNM seizure are almost equally as real whether the material is low or highly enriched, or in small or large quantities. Any amount of SNM in the hands of a terrorist group would be of great blackmail value and could certainly be used to their advantage. Finally, the factor of multiple thefts must be taken into consideration, with the possible stockpiling of seized SNM.

5. In paragraph 8. Edlow's concurrence with his father's recommendation of "expediting" falls short of accomplishing the task of deterring a determined terrorist group

from successful seizure of SNM. The statement that "[t]his method and this method only will provide early notice that shipment is astray or diverted" is somewhat after the fact and does not preclude the possibility of diversion by seizure or hijacking. The only reaction to the discovery, or "early notice, that a shipment is diverted, is to notify the NRC or "an appropriate law enforcement authority." This is not security in the prevention sense and unless a more secure mode of transport is provided at the same time, seizure is not prevented and potential for recovery may be meager.

6. As we have indicated in our earlier affidavits, one of the weakest links in the current security chain with respect to prevention of successful terrorist action is the wide dissemination of advance shipment information. "Expediting," as described by Edlow, is directed toward loss through misrouting or causual theft. However, such programmed pre-scheduling of times, routes, mode of transport, etc., provides precise information on shipment movement and unless access to such information is strictly limited, may add to a successful terrorist act. According to Peter N. Skinner, affidavit of April 29, 1975, a minimum of 124 people had knowledge of the details of the arrival of a specific shipment of plutonium before it arrived at J.F. Kennedy Airport from Brussels on February 25, 1975. As can be seen, the question of knowledge prior to shipment is one of the greatest short-comings of the civilian transport mode and one of the advantages of the military mode. Mr. Edlow at paragraph 15 of his affidavit stated categorically that "SSNM cannot be lost or diverted under current regulations . . . ." Such an unqualified statement raises questions about his expert objectivity. We would not categorize the current system as failsafe.

J-95-15

7. In paragraph 11, Edlow's reference to the two principal additions to the regulations which "prevents the possibility of loss or misrouting of SSNM while being transported", i.e., "continuous visual surveillance" and "frequent communications," again oversimplifies terrorist and related security problems. Adherence by shippers to these two requirements is intended to provide a degree of protection against misrouting and casual theft, but standing alone, it is inadequate protection against determined terrorist attacks and organized theft.

8. Further, a report prepared for the NRC, released only in December, 1976 (MITRE Technical Report 7022, September, 1975, The Threat To Licensed Nuclear Facilities ["MITRE Report"] para. 3.12.3, page 88) points out the inadequacy of current communications systems, "One weakness in the operation of these private firms involves the communication system and the difficulties incurred during communication blackouts. Vehicles equipped only with a radio-telephone to handle communications to a base station are subject to periodic blackouts due to terrain and atmospheric conditions. Thus, to comply with a necessary two-hour check with headquarters [10 CFR Sec. 73.31] the driver must on occasion leave his vehicle and use a hand-line telephone. During these blackout periods and during the time the driver leaves his truck to use a telephone, the potential for a hijackin or theft is increased."

9. Regarding Edlow's statements (Aff. paras. 12-14) concerning delivery by armored truck with armed guards, one should note that the MITRE Report, para. 3.12.4, page 89, points out:

"It should be noted that armed guards of an interstate shipment have no statutory authority to carry weapons in states other than the one in which they are licensed or across state lines, yet regulations require that they carry weapons in exercising their primary duty of protecting SNM in their custody. These guards are probably often in violation of both state and federal laws."

In other words, the fact that a guard is armed, and in an armored truck, is not necessarily a strong deterrent to terrorist or organized attack; the guard probably knows that he may be in violation of a state or federal statute or law, and, when faced with an armed attack situation, may simply not use the weaponry available for fear of legal, as well as physical, consequences to himself.

10. The MITRE Report confirms and augments the observations and conclusions stated in this and our earlier affidavits regarding the inadequacies of the requirements regarding visual surveillance and communications and armed guards, as outlined by NRC's 10 CFR Part 73, of April, 1975.

Captain James A. Echols, Affidavit of 28 November, 1975

11. Captain James A. Echols' affidavit of 28 November, 1975 recounts numerous terrorist acts occuring aboard commercial aircraft and/or associated with commercial air facilities and installations. The MITRE report itemizes no less than 20 commercial aviation-related terrorist acts in the last 6 years. These findings are consistent with the view expressed in our earlier affidavit that successful terrorist action against

commercial aviation is feasible. We believe that transport of SNM in commercial aircraft provides the terrorist with particularly attractive incentive for action.

Assessment of 10 CFR 73 through 73.36 and 73.72 as Amended

12. At paragraph 56 of our affidavit of 16 June 1975 we stated that the regulations as republished on December 28, 1973 were not adequate to prevent or deter a determined group of terrorists from succeeding with their mission. Those regulations were the regulations in effect on March 4, 1974. A review of 10 CFR 73.1 through 73.36 and 73.72 as amended through December 15, 1975, was made to determine whether amendments after March 4, 1974 would substantially alter our assessment of the vulnerability to terrorist action of SNM carried in commercial transport.

13. Our assessment has not changed. The thrust of these Part 73 regulations remains that of protecting against loss, misrouting and casual commercial theft. Assuming full compliance with the letter and spirit of those sections of Part 73 by all responsible parties (an assumption with which we disagree), the amended regulations do not provide for adequate personnel, equipment or procedures to effectively deter and prevent successful terrorist action or organized theft.

14. The requirements of Part 73 which may give the appearance of providing good security are grossly inadequate. Among the inadequacies are:

(1) shipments of less than 5000 grams of SNM are not covered;

(2) though plans for selecting, qualifying and training guards as well as for specially-designed trucks are called for, neither minimum standards or implementation dates are specified;

(3) the number of guards provided for and their arming is minimal;

(4) communication requirements in terms of the frequency of communication in transit as well as the number and capability of communication channels is inadequate.

15. The Mitre report states: (para. 3.12.5, pp. 89-90)

"a. A wide dispartiy (sic) presently exists in the various screening techniques used in selecting guard personnel and in the training they receive.

b. So long as contact is not always possible with vehicles carrying high security material, the present communication system will contain weaknesses. Response capability suffers accordingly.

c. Armored vehicles used to transport SNM currently vary in construction and in the extent of denial and immobilization features.

d. The present regulations do not provide a sound legal basis for the carrying or emergency use of weapons by guards transporting SNM across state lines.

e. Escort vehicles on overnight and long distance hauls frequently have no sleeping accommodations; thus occupants must rest

16. The Mitre report contains extensive corroboration of numerous points made by us in our current and previous affidavits e.g.:

Terrorists -- 54 pages directed to the history, tactics, capabilities, affiliations, motivations and recent activities of terrorists operating throughout the world. (Mitre Report, pp. 1-55)

Transport Industry -- 10 pages devoted to the extensive role of crime, corruption, employee colusion, and international influences in undermining industry services. (Mitre Report, pp. 55-64)

Weapons -- 6 pages citing types of weapons, their availability and recent employment by terrorists. (Mitre Report, pp. 65-70)

Conclusions reached include "terrorism has become commonplace in the Western World and weapons of large caliber and full-automatic fire can be easily procured," and "a veritable army of criminals and hoodlums in this country is waiting and willing to undertake any activity, including murder, if the profit justifies it."

17. It is apparent that the conditions in the commercial transportation industry described by Sam Edlow in the 1969 speech attached to J. Edlow's affidavit as Exhibit 1 have not substantially improved. Sam Edlow characterized the industry as untrustworthy (Exhibit 1, p. 3) and incompetent (Id. p. 9) and the environment in which the industry operates as one of criminality (Id. p. 6). Indeed he felt that the most that might be accomplished by strengthening requirements within the commercial industry might be early detection and recovery, rather than prevention (Id. pp. 6, 10, 11, 12). As pointed out above in paragraphs 5, 6 and 7 current regulations regarding

What Sam Edlow called "expediting" reflect a goal of detection, rather than prevention, of diversion.

18. As to demonstrating that the commercial air system is potentially unsafe from the terrorist threat viewpoint, the recent bombing of LaGuardia Airport is indicative of a level of vulnerability to terrorist activity which far exceeds the vulnerability of military controlled systems, vehicles and installations.

Recent Information

19. We note that in a January 12, 1976, p. 11, col. 1 New York Times article by David Burnham, the following was reported:

> "The commission [NRC], however, is considering recommending the possibility that an existing Defense Department agency such as the Army's special forces be given training to enable it to react to a situation where a terrorist band seizes and holds a nuclear facility for a relatively long period of time."

Moreover, it was stated in the New York Times, January 18, 1976, News Of The Week in Review, p. 3, col. 2:

> "The Federal Nuclear Regulatory Commission is preparing to recommend that Congress consider, instead of creating a special police force to guard nuclear power plants, training Army units to prepare for attacks on the installations by terrorist groups."

It is clear that even defendant NRC now considers military safeguards against terrorist attack against nuclear facilities and materials to be necessary and desirable.

THEODORE T. TAYLOR

ROBERT R. LEADER

Sworn to before me this
20th day of January, 1976

Assistant Attorney General
of the State of New York

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(96)

DOCKET NUMBER PROPOSED RULE PR-71/73

August 31, 1976

The Hon. Samuel J. Chilk
Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Re: NUREG-0034 - Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, NRC Docket No. PR-71, 73 (40 FR 23768)

Dear Mr. Chilk:

On August 26, 1976, the United States Energy Research and Development Administration transmitted to you for inclusion in the above the evidentiary record to date in Docket No. 36325, Radioactive Materials, Special Train Service, Nationwide, now pending before the Interstate Commerce Commission.

Since August 26th, the shippers other than Federal agencies which are parties to the pending Interstate Commerce Commission proceedings involving the transportation by rail of certain radioactive materials filed comments on a Draft Environmental Impact Statement prepared by the Office of Proceedings of the Interstate Commerce Commission, served July 21, 1976. A copy of those comments is enclosed for consideration by the Nuclear Regulatory Commission in its pending evaluation of the environmental impact of radioactive material shipments.

Very truly yours,

L. Manning Muntzing

Enclosure

Acknowledged by card 9/8/76

Before the

INTERSTATE COMMERCE COMMISSION

Docket Nos. 36307, 36307(Sub. 1),
36307(Sub. 2) and 36307(Sub. 3)

RADIOACTIVE MATERIALS, MISSOURI-KANSAS-TEXAS
RAILROAD COMPANY, ETC.

Docket No. 36312

U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
v.
THE AKRON, CANTON & YOUNGSTOWN RAILROAD COMPANY, ET AL.

Docket No. 36313

ALLIED-GENERAL NUCLEAR SERVICES, ET AL.
v.
THE AKRON, CANTON & YOUNGSTOWN RAILROAD COMPANY, ET AL.

Docket No: 36330

GPU SERVICE CORPORATION, ET AL.
v.
THE AKRON, CANTON & YOUNGSTOWN RAILROAD COMPANY, ET AL.

Docket No. 36335

COMMONWEALTH EDISON COMPANY, ET AL.
v.
THE AKRON, CANTON & YOUNGSTOWN RAILROAD COMPANY, ET AL.

Docket No. 36336

GENERAL ELECTRIC COMPANY
v.
THE AKRON, CANTON & YOUNGSTOWN RAILROAD COMPANY, ET AL.

Docket No. 36325

RADIOACTIVE MATERIALS, SPECIAL TRAIN SERVICE, NATIONWIDE

Comments of Shippers Other Than Federal Agencies on the Draft Environmental Impact Statement by Office of Proceedings.

Comments on the Draft Environmental Impact Statement prepared by the Office of Proceedings of the Interstate Commerce Commission, served July 21, 1976, ("the Draft EIS") hereby are submitted by the following parties to the above-listed proceedings:

Allied-General Nuclear Services
Carolina Power and Light Company
Commonwealth Edison Company
Duke Power Company
Exxon Nuclear Company, Inc.
General Electric Company
GPU Service Corporation
Houston Lighting & Power Company
Kansas City Power and Light Company
Kansas Gas and Electric Company
Niagara Mohawk Power Corporation
NL Industries, Inc.
Northern States Power Company
Pacific Gas and Electric Company
Pennsylvania Power and Light Company
Philadelphia Electric Company
Power Authority of the State of New York
Public Service Company of Indiana, Inc.
Rochester Gas and Electric Corporation
Southern California Edison Company
Union Electric Company
Vermont Yankee Nuclear Power Corporation
Virginia Electric and Power Company

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SUMMARY OF COMMENTS

I. The Draft EIS contains fundamental errors as shown by the following statement:

> This Impact Statement is generic in nature and can be used by the Commission in any proceeding in which the issue is the health and safety aspects associated with special rather than regular train service.

This threshold statement creates problems throughout the entire Draft EIS. First, it mistakenly assumes that all three types of proceedinas currently before the Commission concerning the transportation of radioactive materials involve special versus regular trains when in fact only one of the proceedings involves that issue; and secondly; it states that any action to be taken or not to be taken by the Commission is on the basis of health and safety issues, in spite of the fact that the Congress has given this responsibility to the Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT).

II. The Commission should rely on the expertise of other governmental agencies in areas in which the Commission is not expert in preparing Environmental Impact Statements. However, the manner in which the Commission has relied on the Draft Environmental Statement of the Nuclear Regulatory Commission in this case is inappropriate. That approach tends to obscure the issues in these proceedings and could easily lead to misunderstanding of the impact by persons who are not sufficiently familiar with the subject areas to separate what is relevant from what is irrelevant. The manner in which the NRC document is used is inappropriate because that document is directed primarily to radioactive materials other than spent nuclear fuel and wastes and is concerned primarily with modes of transportation other than rail or highway. Further, the document is in draft form subject to change and the Commission does not really know what the final document will be or the conclusions which it will reach. While we do not believe it to be inappropriate to use such information as a base, the Commission's Environmental Affairs Staff, alone or with assistance from experts in the field such as NRC, should rewrite the Environmental Impact Statement using only the relevant portions of that and other documents, supplementing that information where necessary for these proceedings.

III. The properties of the spent nuclear fuel and radioactive wastes should be explained more fully in the Environmental Impact Statement in order to better assess the consequences of normal and accident conditions. The referenced descriptions which are in the Uniform Freight Classification 12 (I.C.C. 8) are primarily for identification purposes only and do not describe characteristics of the materials essential for evaluating environmental effects.

IV. The containers are designed to meet rigorous standards set by NRC and DOT Regulations for performance under both normal and accident conditions. These regulations are very comprehensive and the containers undergo extensive evaluation to determine that they satisfy the conditions imposed on them. Substantial testimony by Government and other shipper witnesses in these proceedings indicate that these casks can survive any conceivable railroad accident. Conversely, the railroads have made no quantitative analysis of either accident conditions or of the effect of such conditions on these containers.

V. The Draft EIS consideration of alternative modes is inadequate because it does not consider in sufficient detail the impact of those modes of transportation. As described in testimony before the Commission, truck is not a viable mode for spent nuclear fuel and for most wastes because the containers, suited for regular train service, are too heavy to be transported by truck. While small truck casks could be used, they would increase the number of shipments by a factor of seven to ten. This would greatly increase the number of miles traveled, and the number of people involved in handling the cask at the reactor, reprocessing plant, and waste disposal site. It also would require extensive changes to facilities (many already built) to accommodate the smaller casks.

VI. The definition of special-train service relied on by the Environmental Affairs Staff in the Draft EIS is not part of any published tariff nor is it binding in any manner on the railroads. Under the Special Freight Train Service Tariffs, the railroads could handle a shipment in whatever manner might suit their convenience.

VII. The Environmental Affairs Staff has improperly concluded that special trains will add some increment of safety. These is extensive evidence in the record that the risk of transporting radioactive materials in regular trains is no greater than in special trains.

VIII. The treatment of the commitment of future resources in the Draft EIS is inadequate. This commitment of future resources is dismissed as "infinitesimal in relation to total material resource consumption". The waste of natural resources which would be involved in the mandatory use of special trains is substantial today and will increase greatly in the future as additional reactors are put into service.

IX. The Draft EIS is incomplete because it does not include a balancing of the costs of the actions against the benefits allegedly to be derived therefrom. Based on a balancing of the cost of the special-train service against the reduction of risks associated with the shipments, the imposition of mandatory special-train service is not justified even if such special-train service could completely eliminate the risks involved in the shipments, which it cannot do. We believe that a meaningful cost-benefit balance must be included as a part of the Final Environmental Impact Statement.

In order to assist the Environmental Affairs Staff in the preparation of an Environmental Impact Statement, detailed comments have been provided in the following sections.

I. Introduction

A. What is before the Commission

The Draft EIS prepared by the Environmental Affairs Staff of ICC Office of Proceedings ("the Staff") lists in the caption seven proceedings now pending which involve the transportation of radioactive materials by rail. It correctly notes that those proceedings are of three different types but it makes no effort to identify the specific environmental issues in each type of proceeding. On the contrary, it states:

> This impact statement is generic in nature, and can be used by the Commission in any proceeding in which the issue is the health and safety effects associated with special rather than regular train service. (Summary Sheet).

Underlying this threshold statement are two fundamental errors: (1) It incorrectly assumes that the environmental issue in all the pending proceedings (and in unidentified future proceedings) relates to the question of special trains versus regular trains. (2) It identifies as the environmental issue (and the only environmental issue) before the Commission in these cases the "health and safety effects associated with the special rather than regular train service" for the carriage of the radioactive materials involved, which is not an issue on which this Commission can properly pass. Moreover, the issues which are presented by each of the three types of pending proceedings are more complex than the Draft EIS suggests.

One type of pending proceeding ("the Eastern railroads complaint proceedings") involves the refusal of the Eastern railroads to publish tariffs for the carriage of spent nuclear fuel and radioactive waste materials as those materials are defined in Items 80762-A and 80764-A of Uniform Freight Classification 12 (I.C.C. 8).[1] These proceedings (Dockets 36312, 36313, 36330, 36335 and 36336) were commenced when five individual or groups of complainants, including the United States Energy Research and Development

1/ Item 80762-A defines spent nuclear fuel to be: "Fuel elements, nuclear reactor, irradiated and requiring protection shielding, also irradiated parts or constituents, in containers required by I.C.C. regulations, . . . , shipped to Atomic Energy Commission-owned or licensed sites for chemical reprocessing."

Item 80764-A defines radioactive waste to be: "Waste materials having no reclamation value, requiring protection shielding, or requiring radioactive-materials labeling, marking or placarding, in containers required by I.C.C. regulations, . . . , shipped to Atomic Energy Commission-owned sites or to sites operated by contractors or licensees of the Atomic Energy Commission for disposal."

Due to changes in the law, the references to the regulatory authority of the Interstate Commerce Commission and Atomic Energy Commission should be changed to the Department of Transportation and the Nuclear Regulatory Commission, respectively. References to Atomic Energy Commission-owned or contractor operated sites should be to Energy Research and Development Administration-owned or contractor operated sites.

Administration ("ERDA"), filed complaints against the Eastern railroads under Section 13 of the Interstate Commerce Act.2/ The Commission has consolidated these five proceedings, which present the single issue of the Eastern railroads' status as common carriers of spent nuclear fuel and radioactive waste materials.

A second type of proceeding now before the Commission is Docket 36307, Radioactive Materials, Missouri-Kansas-Texas Railroad Company, 36307(Sub. 1), 36307(Sub. 2) and 36307(Sub. 3) ("the M-K-T proceedings").3/ The M-K-T proceedings involve that single railroad's announcements in the form of published tariff "flag-outs" that it would no longer participate as a common carrier in the rail transportation of spent nuclear fuel, radioactive waste materials, and other radioactive

2/ At page 3, the Draft EIS notes that the initial flag-outs were not protested. Most of these flag-outs occurred in 1962 and were not protested at that time because the nuclear reactor industry had not developed, as it has today, to the stage where reliable common carrier railroad service had become essential. The U.S. Government at that time was the only shipper of spent nuclear fuel and wastes, and it had separate arrangements with the railroads under Section 22. The flag-outs of the Chicago, Rock Island and Pacific Railroad Company and the Soo Line Railroad Company occurred more recently, but were not caught by interested shippers at the time. In fact, the Rock Island flag-out occurred on only five days notice.

3/ The Draft EIS does not mention Sub Nos. 1, 2 and 3 of Docket 36307. We assume this was inadvertent and that it was the intention of the Staff to include those sub-numbered proceedings as well. Sub No. 1 is entitled Empty Containers for Radioactive Materials, Missouri-Kansas-Texas Railroad materials and containers therefor on which no other railroad has flagged-out. Similar to the Eastern Railroad complaint proceedings, the M-K-T proceedings present the single issue of the M-K-T's status as a common carrier of the involved radioactive materials and containers therefor.4/

The third type of pending proceeding is Docket 36325, Radioactive Materials, Special Train Service, Nationwide ("the Southern and Western railroads special train proceeding" or "the special train proceeding"). As accurately described in the Draft EIS (at 3), this proceeding involves the investigation of the Southern and Western railroads' proposal to impose a mandatory special train requirement upon

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Company and is the M-K-T's flag-out from empty radioactive materials shipping containers if previously used to ship radioactive materials. (Item 20907 of Supplement 5 of Uniform Freight Classification 12 (I.C.C.8)).

Sub No. 2 is entitled Restricted Usage of Containers and Cars, Non-irradiated Cores and is the M-K-T's flag-out from cores or core assemblies or fuel blanket assemblies, nuclear reactor, not irradiated, with non-irradiated fuel or without fuel, in packages when shipments are made in containers and/or cars which have been used previously to ship radioactive material. (Item 30818 of Supplement 8 of the Uniform Freight Classification 12 (I.C.C. 8)).

Sub No. 3 is entitled Restricted Usage of Cars, Radioactive Materials and is the M-K-T's flag-out from radioactive material shipping cars moving on their own wheels unless such cars are empty and have not been used previously to ship radioactive materials. (Item 81295-C of Supplement 10 of the Uniform Freight Classification 12 (I.C.C. 8)).

4/ The Illinois Terminal Railroad, in Supplement 12 of Uniform Freight Classification 12 (I.C.C.8) has published its flag-out from spent nuclear fuel and radioactive wastes to be effective August 31, 1976. On August 26, 1976, the Suspension and Fourth Section Board voted to investigate this matter and assigned it Docket No. 36307(Sub. 4). A number of protests were filed.

all shippers of spent nuclear fuel and radioactive waste materials. The shippers would be required to request and pay for special train service as provided for by the special freight train service tariffs published by the Southern and Western railroads. As also noted in the Draft EIS, the Southern and Western railroads are not seeking to deny their common carrier status for transporting radioactive materials.

B. What the Commission Must Assess

An environmental impact statement generic to all the pending (and possible) Commission proceedings involving the transportation by rail of radioactive materials must consider a range of effects and alternatives. See 42 U.S.C. § 4332(C)(iii). The Draft EIS (at 3) thus is in error when it states that in the three types of pending proceedings ". . . the same basic question is presented, i.e., whether environmental and safety considerations justify the railroad's (sic) proposed requirement that spent nuclear fuel and radioactive waste materials move in special trains as opposed to regular train service." This basic misconception of the issues pervades the entire Draft EIS.

First of all, the issue of regular train service versus special train service is presented directly only in the Southern and Western railroads special train proceeding.

In that proceeding, the Commission, in assessing the environmental ramifications of mandatory special train versus regular train service, must consider a broad spectrum of impacts. For instance, the Commission must consider the immense added costs and the need for additional railroad equipment and other resources that would be irretrievably committed by the requirement of mandatory special trains. In addition, the availability of alternate transport modes must be considered (especially if costs of rail transportation encourage shippers to change modes). An essential element of this evaluation involves taking notice of compliance with the safety regulations established by the Department of Transportation ("DOT") and the Nuclear Regulatory Commission ("NRC") governing the transport of radioactive materials and the fact that such regulations govern the transport of radioactive materials.5/ Needless to say, through the vehicle of an environmental impact statement, the ICC has not suddenly gained authority which it does not otherwise have to evaluate safety considerations and impose additional regulations.

5/ The correction of deficiencies in such regulations, if there are any, are for the DOT or NRC, the agencies empowered by law with exclusive authority to act in the public interest in the area of safe transportation of radioactive materials. See 10 C.F.R. § 2.802 (1975) and 49 C.F.R. § 170.11 (1975) (providing, respectively, that any person may petition the NRC or the DOT to issue, amend or rescind any regulation).

The M-K-T proceedings and the Eastern railroads complaint proceedings present different issues for the Commission to assess.[6] These two types of proceedings will not decide what should be the characteristics of the respective railroads' operations in transporting any radioactive materials (such as by special train or otherwise), but will determine only whether those railroads have a common carrier duty to perform those operations. The ICC will be presented with the special train issue therein only if it determines in those proceedings that these railroads are common carriers of the involved radioactive materials and then only if these railroads seek to include a provision for mandatory special train service in their published tariffs[7] and only if the Commission were to decide that the flag-out railroads must participate in the presently published tariffs. In these cases, the shippers seek a Commission determination that

6/ When the railroads in the Eastern railroads complaint proceedings filed their pleading in Docket 36313 entitled "Motion to Require the Commission to Prepare an Environmental Impact Statement," that motion was opposed by complainants. While the parties hereto are filing these comments, they have not abandoned their position that the railroads have not demonstrated how the mere resolution of the legal issues presented by both the M-K-T proceedings and the Eastern railroads complaint proceeding will constitute a major Federal action significantly affecting the quality of the human environment requiring the preparation of an environmental impact statement.

7/ If the M-K-T is denied the right to flag-out, it would remain subject to the existing tariffs applicable to the Western railroads (unless it deviated therefrom). If the Commission finds that the M-K-T and/or the Eastern railroads are private carriers and therefore that their flag-outs are lawful, the Commission will lose any power to control what the railroads may then do in connection therewith.

the railroads be required to carry the involved radioactive materials as common carriers. The alternative to be assessed is the denial of that relief, in which case there would be no tariff in effect requiring that these materials be shipped in either regular or special trains. In that case, the railroads could refuse altogether to transport these materials. In these two types of proceedings, the Commission should assess the potential impacts of permitting the respective railroads to refuse to serve as common carriers. The Commission should consider what the results of that alternative would be if shippers turned to truck transportation, which in itself might require basic changes in the entire nuclear fuel cycle. (A possible alternative result could be that shippers, in some cases, could arrange for transportation by the railroads in private carriage under conditions and at costs as to which one can only speculate.)

In assessing the environmental impacts in all three types of cases, the Commission needs to examine the extensive record being developed in the pending proceedings. Examination of this record will enable the Commission to reach more informed judgments about complicated issues which (especially in the nuclear field) may be outside the scope of the Commission's usual experience and expertise. Reference to the record also will serve to avoid inconsistencies.

C. What the Interstate Commerce Commission Lacks Authority to Implement

Regardless of the environmental impacts which may be associated with the instant proceedings, the Interstate Commerce Commission must be mindful of the fact that it lacks statutory authority to establish safety standards or to allow any common carrier (by rail or otherwise) to do so. The Federal regulatory framework governing the safe shipment and carriage of radioactive materials has been prescribed by the Congress, which has vested exclusive control over those activities in the Department of Transportation and the Nuclear Regulatory Commission.[8/] It is those two agencies and not the ICC or individual carriers which have been given authority to establish regulations and criteria to insure the safety of the public, including carriers and carrier personnel, as to the transportation of radioactive materials.[9/]

8/ The Draft EIS (at 6) has incorporated by reference the entirety of Chapter II of the NRC's Draft Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes, NUREG-0034 (March 1976) ("the NRC's DES"). Chapter II of the NRC's DES summarizes the Federal regulations pertaining to the transportation of radioactive materials, and notes that such transportation is regulated by the NRC and the DOT. See NRC DES, pages II-1 to II-2. Some of the undersigned during the course of hearings previously held in the pending proceedings have submitted a memorandum of law which contains a detailed description of the comprehensive safety regulations promulgated by the NRC and the DOT (M-K-T Proceedings Exh. 1; Special Train Service Proceeding Exh. 1).

9/ The memorandum of law referred to, supra, note 8, contains a discussion of the Price-Anderson Act insurance

The railroads' basic position in the three types of proceedings is that, whether or not radioactive materials are tendered to them in compliance with applicable government regulations, they nevertheless may impose their own standards or refuse to transport the materials because they are unwilling to accept whatever risk their transportation might involve. This contention must be put in perspective. Radioactive materials are hazardous and their transportation involves some degree ot risk (as does the transportation of other hazardous and even non-hazardous materials), but the hazards of transportation can be (and have been) reduced to acceptable levels.

The Congress could have determined that the risks involved are unacceptable and could have prohibited the development and use of atomic energy for peacetime purposes. After weighing this question very carefully, the Congress determined that the hazards could be controlled and that the benefits from its peacetime use would outweigh the risks involved in the development of a properly controlled nuclear industry. See 42 U.S.C. §§ 2011 et seq. The policy of the

policies and indemnity agreements whose "omnibus" features protect rail carriers without payment of premiums by the railroads. For the reasons stated in the memorandum, the ICC may not sanction the railroads' actions on the ground that the availability of the Price-Anderson insurance-indemnity system provided for in the Atomic Energy Act of 1954, as amended, together with other available insurance, might not adequately protect the railroads against risk of loss or liability.

Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974 is to encourage the development of atomic energy by (1) providing for the steps necessary to reduce the hazards to an acceptable level and (2) making sure that it will not be burdened, in the name of safety, with restrictions on its use having little or no safety value but imposing a financial burden which would limit its development and use. To accomplish this objective, the Atomic Energy Act established a comprehensive system of licensing by the Atomic Energy Commission (now NRC). E.g., see 42 U.S.C. § 2201 (b).

Congress also understood that, if atomic energy were going to be developed, radioactive materials would need to be transported under regulations designed to accomplish the twin objectives of encouraging its development and reducing the hazards connected therewith to acceptable levels.

Section 834 of Title 18 U.S.C. at one time authorized the ICC to formulate regulations for the safe transportation within the United States of explosives and other dangerous articles, including radioactive materials. The authority conferred by the Transportation of Explosives Act, of which 18 U.S.C. § 834 is a part, has since been transferred to DOT. 49 U.S.C. § 1651 et seq.10/ It is abundantly clear that, since passage of the Department of Transportation Act of 1966, the ICC has had no statutory authority to set transportation safety standards based on the hazardous nature of radioactive materials11/ and that it may not--directly or indirectly--undercut the jurisdiction of the NRC and DOT to establish such standards by allowing common carriers to deviate from the regulations established by those agencies.12/ That is exactly what the railroads would have the ICC do.

10/ The regulatory authority conferred on DOT was expanded and strengthened by the Transportation Safety Act of 1974, 49 U.S.C. § 1801 et seq.

11/ The Interstate Commerce Act, as amended, 49 U.S.C. § 1 et seq. (1970) contains no such authority. It is axiomatic that agency action cannot exceed or extend the scope of its statutory authority. Trenton Chemical Co. v. United States, 201 F.2d 776, 778 (6th Cir. 1953). In other words, the power of an agency "is circumscribed by the authority granted" by Congress. Stark v. Wickard, 321 U.S. 288, 309 (1944). The "authority granted" is determined in turn by the language of the statute and by its "aim and nature." FTC v. Bunte Bros., 312 U.S. 349, 351 (1941).

12/ In Burlington Truck Lines v. United States, 371 U.S. 156 (1962), the Supreme Court warned of the possible dangers when a Commission action intrudes upon another agency's jurisdiction. In examining an ICC case that involved the authority of the National Labor Relations Board, the Court stated:

> Implicit in this analysis is a recognition that if either agency is not careful it may trench upon the other's jurisdiction, and, because of lack of expert competence, contravene the national policy as to transportation or labor relations . . . . the Commission must act with a discriminating awareness of the consequences of its action.

371 U.S. at 173, 174. Because the ICC unjustifiably intruded upon the NLRB's jurisdiction, the Court set aside the order of the Commission there at issue.

Congress has not only made it clear that DOT and the NRC are the sole Federal agencies granted statutory jurisdiction to regulate in this area; in both the Atomic Energy Act and the Transportation Safety Act it has specifically legislated that there are to be no varying or inconsistent regulations. Certainly, the railroads' position is at variance with the DOT and NRC requirements.13/ It would make no sense for Congress to have expressed itself in the fashion it has if it had intended to allow carriers of hazardous materials to engage in regulation of the transportation of such materials.14/ Thus, the ICC lacks authority to allow the railroads to establish their own regulatory framework for the transportation of radioactive materials.

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13/ It should be noted that carriers of hazardous materials have in the past imposed general restrictions on that carriage through the mechanism of a tariff in conformance with DOT requirements. Such restrictions must first be promulgated as regulations by the DOT (or the NRC) before being filed or accepted as tariff material. The nation's railroads have in the past followed this procedure in publising tariffs containing safety requirements. See, e.g., Rule 39 of the Uniform Freight Classification 12 as supplemented: R. M. Graziano's Tariff No. 29, I.C.C. 29. Particular operating restrictions for a limited time period may, of course be imposed in specific circumstances. See 49 C.F.R. § 174.575 and 49 C.F.R. § 1006.1. Cf. Airline Pilots Association, Int'l. v. C.A.B., 516 F.2d 1269, 1275-76 (2d Cir. 1975).

14/ That this is the course which the railroads must follow is pointed out in Kappelmann v. Delta Air Lines, Inc., No. 75-1830 _____ F.2d _____ (D.C. Cir., April 16, 1976). In that

In the following sections, we shall discuss the various matters which the Commission should consider in further assessing the environmental impacts associated with the transportation by rail of radioactive materials. These comments are an attempt to place the issues in focus and to eliminate misconceptions and inaccuracies which may have found their way into the Draft EIS.

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case, the plaintiffs sought an injunction requiring the defendant airline to give warning to prospective passengers on airplanes carrying a significant amount of radioactive materials. After reviewing at some length the legislative history of the Hazardous Materials Transportation Act, the Court sustained the judgment of the District Court which dismissed the complaint, stating:

> In conclusion, we hold that the trial judge properly invoked the doctrine of primary jurisdiction. The need for uniformity and a tribunal of special competence have been shown. It also appears that rulemaking is a more appropriate means of resolving the problems presented than is adjudication. Therefore, we affirm dismissal of the requests for injunctive relief. If appellants in the future desire to impose their suggested regulations upon any interstate common carrier of this limited category of hazardous materials, they must in the first instance request that the Secretary of Transportation or his delegate undertake a rulemaking procedure under section 105 of the Hazardous Materials Transportation Act, 49 U.S.C. § 1804 (1974 Supp.). Slip op. at 16-17.

Even in Delta Air Lines, Inc. v. Civil Aeronautics Board, Nos. 74-1984, et al. __F.2d__ (D.C. Cir. June 22, 1976) where the Court determined that Congress had left in the Civil Aeronautics Board certain residual safety responsibilities, the court stated that the CAB ". . . should defer to the safety expertise of its sister agencies and accept the FAA/DOT position of safety as establishing both an inner and an outer limit in its safety jurisdiction." (Slip op. at 22.)

II. The Draft EIS Has Improperly Relied on a Nuclear Regulatory Commission Draft Environmental Statement Which (1) is Directed Primarily at Radioactive Materials Other than Spent Nuclear Fuel and Wastes and at Transportation Modes Other than Rail, and (2) is Still in Draft Form.

The Draft EIS has incorporated by reference the entirety of Chapters II through VII of the NRC's DES. While some portions of the NRC's draft document are pertinent to the issues before the ICC in these proceedings, most of the material is not pertinent to such issues.

The NRC's DES, which was published in March 1976, originally was prompted by concerns about the air transportation of radioactive materials. Even more to the point, the NRC's DES is addressed to concerns about the transportation through populated areas of radioisotopes and of plutonium and other special nuclear materials.[15/] Most of the calculations in the NRC's DES deal with these particular elements in the form of pure elements in a readily dispersible form. Although these elements are found in small measure in spent nuclear fuel and some wastes, they are tightly bound in the fuel matrix or are otherwise diluted and incorporated in a non-dispersible form. For this reason, neither

15/ The term "special nuclear material" ("SNM") is used to describe plutonium, and uranium enriched in the isotope 233 or in the isotope 235. See 42 U.S.C. §§ 2014aa ard 2071.

the tables reproduced in the Draft EIS nor the related discussion sheds light on the issues now before this Commission.

Wholesale inclusion, without explanation, of material from the NRC's DES, by reference or otherwise, obscures the information related to spent nuclear fuel and radioactive wastes and confuses persons who do not have sufficient background in this subject to recognize the distinctions between the commodities and the issues considered in the NRC's DES and those before the Commission in this proceeding. Therefore, to avoid the confusion which has been created by the incorporation by reference of large portions of the NRC's DES, the ICC should edit the NRC's DES and include only those portions which are pertinent to the radioactive materials involved in these proceedings. Further, editing alone will not suffice without additional work and the rewriting of some portions to provide the necessary framework and background for understanding the results set forth in the remaining portions of the NRC's DES. Moreover, even if the NRC's DES were pertinent, it is not final and is subject to change. For that reason alone, caution should be used whenever parts of it are referred to.

In addition to material in the NRC's DES which is relevant herein, detailed information, findings and conclusions about the rail transportation of spent nuclear fuel and radioactive waste materials are set forth in <u>Environmental</u>

Survey of Transportation of Radioactive Materials to and From Nuclear Power Plants, WASH-1238 (December 1972) (hereinafter "WASH-1238"). This document was prepared after a rulemaking by the former Atomic Energy Commission. It since has been supplemented twice by the NRC.[16/] Much of the material in WASH-1238 and its supplements is directly pertinent herein, so the Commission should consider incorporating it or, for clarity, quoting it in the final EIS.

Listed below are comments on the portions of the NRC's DEC which are germane and applicable to the rail transportation of the involved radioactive materials as well as comments pointing out which portions of the NRC's DES are not relevant or applicable. These comments include specific references to WASH-1238 and its supplements, including further information which should be considered:

1. Chapter II of the NRC's DES, while generic, contains much discussion that is neither relevant nor applicable to the present proceedings. The irrelevant discussions include the discussion of exempt quantities, low specific activity ("LSA") materials, Type A packages, shipment by aircraft, and safeguarding of special nuclear material ("SNM").

16/ WASH-1238 is Exhibit 15 in Docket 36325 and Exhibit 2 in Dockets 36307 et al. The first NRC supplement, NUREG-75/038 (April 1975), is Exhibit 16 in Docket 36325 and Exhibit 3 in Docket 36307 et al. The second NRC Supplement, NUREG-0069 (July 1976), has not been introduced formally in these proceedings at this time.

The Draft EIS should include a discussion of only those portions of the regulations applicable to the commodities covered by these proceedings, i.e., spent nuclear fuel and radioactive wastes, the package types for those commodities, and the modes of transport likely to be used, i.e., rail, highway and possibly water. Any discussion of or reference to Section J of the NRC's DES should be eliminated in its entirety because spent nuclear fuel is exempt from such requirements due to the high radiation levels associated with the unshielded spent fuel (NRC's DES page II-32) and radioactive wastes are not considered to contain sufficient SNM to require safeguarding. Guidance as to appropriate discussion of the regulations pertaining to these shipments can be derived from reference to the verified statements and cross-examination of ERDA and Industry Witnesses R. F. Barker, R. W. Peterson and W. E. Potts in Docket No. 36325.

2. Chapter III of the NRC's DES is also mostly generic but needs substantial revision to eliminate the references to radioisotopes and plutonium and to include the properties of spent nuclear fuel and radioactive wastes, the materials of concern in the proceedings now before the ICC. Specifically Table III-7 as now presented is totally inappropriate as it nowhere even mentions spent nuclear fuel and

radioactive wastes. Also, references to plutonium isotopes on page III-24 and in Figure III-2 (page III-26) of the NRC's DES are not applicable to the present proceedings, and thus should be deleted.

3. Only those portions of Chapter IV of the NRC's DES which are applicable to transport of spent nuclear fuel and radioactive wastes should be included in the Draft EIS and the sections now dealing with rail and highway transport should be rewritten to reflect the differences between the handling of spent nuclear fuel and radioactive wastes and the handling of plutonium and small packages of radioisotopes that now permeate the entire discussion. Specifically, the Introduction except for page IV-7 and portions of page IV-11 are pertinent. Section D-1 should be eliminated. The balance of the Chapter is a good outline if rewritten to reflect realistically the shipment of spent nuclear fuel and radioactive wastes. For example, the analysis should be based on a mid-1980's projection (i.e., 200-1000 MWe reactors), the known geographical locations of the reactors, that at least two reprocessing plants will be operating, and the waste disposal sites presently contemplated by ERDA. In addition, the TI in Table IV-7 (page IV-32) is too high and not representative of spent nuclear fuel and waste shipments by rail.

To the extent that the Draft EIS addresses the truck alternative, the radiation exposure penalty to the public from truck transportation should be quantified.

4. To the extent that Chapter V of the NRC's DES is generic with respect to risk analysis, it may be used. For example pages V-1 through V-8 may be used except that the figures on pages V-5, V-6 and V-7 should be modified or replaced with figures appropriate for the transportation modes of interest in the proceedings now before the Commission. In Section B (pages V-8 through V-26) only the Introduction and Subsections B.2 and B.4 are germane to these proceedings and they should be revised to assure that they properly reflect transportation of spent nuclear fuel and radioactive wastes. Section B.6, while good in theory, is not applicable in actual practice because of the extensive differences between the containers for radioisotopes and special nuclear material and those for spent nuclear fuel and radioactive wastes as well as the differences between the contents of such containers Furthermore, the treatment of probability and consequences of accidents in special train vs. regular train service is totally inadequate for use in these proceedings. The Draft EIS suggests the conclusion that special train service will lead to lower risk. For reasons stated elsewhere in these comments, we believe this is misleading and without soun basis.

In Table V-6 of the NRC's DES (page V-5), Model I release fractions should be deleted from the Draft EIS: Both the spent nuclear fuel and radioactive waste casks referenced in the present proceedings far exceed Model I containment capability assumptions. Furthermore, on page V-26, NRC's DES states that ". . . typical containers are probably better than Model II would indicate." The analysis of consequences of rail accidents in WASH-1238 when updated by Supplement II is a reasonable but conservative estimate (design of the spent fuel casks that have been described in the present proceedings preclude possibility of the accident involving loss of fuel assemblies described on page 87 of WASH-1238). None of the references to other modes of transport and other commodities contained in this Chapter of the NRC's DES should be included in the Draft EIS. Tables V-1, V-2, V-3 and V-5, for example, deal with accidents involving aircraft, trucks, delivery vans and helicopters.

The references to plutonium (pages V-30 through V-53) are irrelevant and misleading in this proceeding. Tables V-16 and V-17 (pages V-52 and V-53) clearly show plutonium to be 98-99+ percent of the total transportation risk with the risk from spent fuel being from negligible to 0.1 percent of the total risk.

The NRC's DES Curie content and dose calculations for spent nuclear fuel in Tables V-8 (page V-35) and V-11 (page V-38) and related latent cancer fatalities (LCF) in Tables V-14 through V-17 (pages V-49 to V-53) appear to have been made prior to the calculations reflected in WASH-1238 Supplement II, which was published in July 1976. Therefore, the calculations in the NRC's DES need to be updated to reflect this later input. Tabulations such as Table V-18 (page V-58) of the NRC's DES should be deleted or revised to reflect spent fuel and wastes only. In general, as stated above, the individual dose calculation in WASH-1238 is more meaningful than the population dose and LCF calculation in the NRC's DES.

5. Applicable portions of the discussion of Alternatives in Chapter VI of the NRC's DES could be included in the ICC statement. Particular attention should be given to the discussion in the NRC's DES of use of special trains for spent nuclear fuel at pages VI-44 to VI-45 which indicates that the use of special trains does not appear to be cost effective for such shipments and that any alleged safety improvement is problematical at best and therefore does not support the ICC Staff's conclusion on special train safety benefits.

Potentially applicable sections of Chapter VI would include Section A Introduction (pages VI-1 through VI-4) provided that numbers are changed to reflect spent nuclear fuel and wastes. In Section B the only applicable parts are B.1-6 (pages VI-27 through VI-30), B.2-3 and B.3-4 (pages VI-41 through VI-45) and B.4 (pages VI-47 through VI-52) and then only if the discussion is limited to those parts applicable to spent nuclear fuel and radioactive wastes. Section C on the radiological effects of the alternatives would need extensive rework to separate the very small effects due to spent nuclear fuel and radioactive wastes from the effects of the other items. For example, only a single line in Table VI-31 through VI-33 is applicable to spent nuclear fuel shipments.

6. Inclusion in the Draft EIS of Chapter VII of the NRC's DES was improper. Security and safeguards requirements are not applicable to spent nuclear fuel and radioactive wastes. The NRC's DES (at page VII-1) specifically notes that there are only two groups of nuclear material that may require safeguarding: (1) certain strategic quantities and types of special nuclear material (SNM) such as highly enriched uranium and plutonium and (2) a few radioisotopes such as cobalt-60. Moreover, spent nuclear fuel is exempt from the safeguarding regulations by 10 C.F.R. 73.6(b), as specifically noted in the NRC's DES at page II-32.

III. A More Complete Description of the Properties and Characteristics of the Radioactive Materials Being Shipped is Needed Than That Provided in the Draft EIS.

The Draft EIS (at 1) references the definition of the principal radioactive materials involved in these proceedings in railroad tariff terminology as set forth in Items 80762-A and 80764-A of the Uniform Freight Classification 12. A more complete technical description is required for a proper assessment of possible environmental effects of both normal transportation and accident conditions.

The principal commodities covered in the proceedings are spent nuclear fuel and four types of radioactive wastes: namely, Low-Level Reactor Wastes, General Trash (GT), Hulls and Non-Fuel-Bearing Components (NFBC) and High-Level Waste (HLW).17/ These materials are described below to assist the ICC in preparing a more complete definition of the commodities before the Commission in these proceedings.

A. Spent Nuclear Fuel

Spent, or irradiated, nuclear fuel as shipped consists of bundles of round zircalloy tubes filled with UO_2

17/ The M-K-T proceedings, as described in greater detail in note 3, supra, also involve both empty containers and cars used previously to ship radioactive materials and cores (cold fuel) or core assemblies. By any reasonable standards, the risk associated with the shipment of these commodities is even less than that associated with spent nuclear fuel or radioactive waste materials.

pellets (fuel pins), which tubes are seal-welded and mechanically bound together into a square assembly. The assemblies range in size from 5 to 9 inches square by 11 to 15 feet long and weigh up to 1,600 pounds. The tubing or fuel pins are retained in the square array by stainless-steel end fittings and intermediate inconel spacer grids.

The UO_2 fuel in the fuel pins consists of pressed and sintered ceramic-like pellets which have a high density (about 10-11 grams/cubic centimeter), high-melting point (about 4,000°F) and which are insoluble in water. The UO_2 is neither flammable nor explosive. Initially, the pellets are enclosed in the fuel-pin tubing in a helium atmosphere; during operation small quantities of fission-product gases such as krypton, iodine and tritium accumulate within the void spaces in the fuel pins. All other fission products remain tightly bound in the fuel pellets. The fuel pins are designed to withstand the external and internal pressures experienced during operation in the reactor. Radiation and heat release from spent nuclear fuel are such that both shielding and heat dissipation are required during handling and shipping.

B. Radioactive Waste Materials

1. Low-Level Reactor Wastes

Low level reactor wastes consist of radioactively contaminated resins and sludges which typically have been solidified at the reactor by the addition of concrete or other materials such as urea formaldehyde and packaged in 55-gallon steel drums. These wastes are the residues left over from handling large volumes of very slightly contaminated water from such sources as reactor coolant, spent fuel storage pool water, and collection from floor drains in areas where potentially contaminated water could leak. The resins' principal function is to demineralize water and consequently to pick up radioactive minerals and contamination as well. The sludges result from evaporation of large volumes of water, thereby reducing the volume of wastes which must be disposed of. As indicated, these reactor wastes are in solid, immobile form packaged in steel drums with low radioactive material concentrations such that heat dissipation is not a significant problem.

2. General Trash (GT)

GT consists of a variety of dry solids which have become contaminated with radioactive materials in nuclear reactor and spent fuel shipping, handling and reprocessing operations. Such materials include metal, wood, paper, glass, plastics, clothing, shoe covers, wiping cloths or paper and air filters. Prior to shipment these materials will be classified and sorted according to subsequent disposition method and destination and enclosed in steel drums. Since radiation levels from these materials are generally very low, most drums will not require shielding. Heat generation will be negligible in these shipment.

3. Hulls and Non-Fuel-Bearing Components (NFBC)

Hulls consist of short pieces of zircalloy fuel tubing remaining after chopping the fuel assembly into a dissolver tank and chemically removing the UO_2 fuel. The stainless-steel end fittings and spacer grids also remain with the hulls along with other non-fuel-bearing reactor components which may be received with the spent nuclear fuel. Occasionally, failed process equipment may also be included with the hulls. These materials are contaminated from reactor operation and are handled and enclosed in stainless-steel containers. While radiation from these materials is sufficient to require shielding, heat release is not a problem.

4. High-Level Waste (HLW)

HLW is the residual elements (fission products) remaining after chemically removing the uranium and plutonium from the spent nuclear fuel. The material is removed in liquid solution, but a special process will solidify the material and fix the elements, most likely in borosilicate glass. This glass will then be encapsulated in stainless-steel canisters for handling, shipping and disposal. The glass is very stable, has a melting point of about 1,800°F and is insoluble in water. The stainless-steel canister provides further containment integrity during handling and shipping. Stainless-steel has a melting point of about 2,600°F). Radiation from the canisters requires shielding and heat release is such that heat dissipation is required during handling and shipping.

IV. Casks Designed to Meet NRC and DOT Regulations Will Withstand Severe Railroad Accidents.

The Draft EIS (at 4) cites the railroads' contention that the stress and accident tests performed on casks for the rail transportation of radioactive materials are not adequate in that the circumstances under which they are tested "do not approach actual railroad operating conditions." This conclusion cannot be supported as testimony in the special train proceeding indicates.[18/]

This section will discuss the regulatory requirements for these casks, the evaluations to which they are subjected, an analysis of how the casks will stand up in a railroad accident environment, and a description of the requirements for operation and maintenance of the casks.

A. The Federal Regulatory Program

1. DOT and NRC Regulations

The regulations of the Nuclear Regulatory Commission (10 CFR Part 71) and the regulations of the Department of Transportation (49 CFR Parts 170-179)[19/] contain stringent standards

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18/ For example, see Exhibits 18-20 and 54-59 and associated testimony in the transcripts in Docket 36325.

19/ An outline of some of the more important DOT regulations is attached as Appendix I.

and requirements designed to assure that the transportation of spend (irradiated) and/or fresh (unirradiated) fuel and radioactive waste from nuclear facilities will be carried out in a safe manner. These regulations, which are applicable to nuclear facility licensees and their carriers, place primary reliance on packaging to assure safety in transport. The regulations rest on the premise that most shipments of radioactive material move in routine commerce on conventional transportation equipment and are subject to the same transportation environment, including accidents, as non-radioactive cargo, and that the conditions of the transportation environment, including the probability of the shipment being involved in an accident, are, for the most part, beyond the shipper's control. The regulations are also premised on the principle that the public is best protected by making certain that only those shipments of radioactive materials which are safe enough to withstand transportation hazards are delivered to a carrier for transport.

The basic objectives of the regulations are to protect employees, transport workers and the public from external radiation in the transport of radioactive material under normal conditions and to assure that the packaging for radioactive materials is designed and constructed so that, under both normal and accident conditions, the radioactive material is unlikely to be released from the packaging, or, if the container is not designed to withstand accidents, the contents are so limited in quantity as to preclude a significant safety problem if released. In accordance with these objectives, the regulations contain stringent standards and requirements to assure that radioactive material packages are designed and constructed to maintain, over their useful lifetime, the necessary design integrity (considering the type, form and quantity of radio-active contents) to prevent a significant loss of radioactive material from a package or a significant increase in radiation levels from a package, to assure nuclear criticality safety and to provide adequate heat removal. The regulations also place limitations on radiation levels on the outside of packages of radioactive material and include stowage and segregation provisions.

Irradiated fuel and nuclear waste must be shipped in Type B packaging, that is packaging which must be designed to withstand normal transport conditions without any impairment of normal operating capability and without loss of contents, increased radiation (levels) or reduction of heat dissipation capability and to suffer not more than the specified loss of contents, or increased radiation levels if subjected to the sequence of severe accident damage test conditions specified in 10 CFR Part 71. Those test conditions make up the design basis accident for Type B packages, i.e., package designs which meet the criteria under these test conditions are considered by the NRC and the DOT to provide completely adequate protection to the public and operating personnel in transportation accidents (as well as under normal operating conditions).

2. Licensing of Packaging

Before these materials can be shipped, a "Certificate of Compliance" (COC) must first be obtained from the NRC on the packaging design and operational plans and then a license must be obtained from the NRC authorizing the user to deliver the material specified in the COC to a carrier for transport in the packaging. The NRC, through its office of Inspection and Enforcement, audits packaging manufacturers and users (licensees) to assure compliance with its regulations and with the specific conditions in the COC covering the packaging.

The COC is obtained only after an extremely rigorous and thorough safety analysis by the Applicant and independently by the NRC to assure that the packaging will withstand both normal and accident conditions in the transportation environment without creating radiological hazards which could cause death, injury, extensive property damage or unacceptable environmental impact. When necessary, analysis is augmented by testing of systems and components to achieve the desired level of confidence in the packaging design. In the case of the packaging to be used for shipping spent nuclear fuel, the safety analysis proceeding between the NRC and the Applicant has taken many years for each packaging design and has resulted in thousands of pages of documentation. This indicates the degree to which the applicant and the NRC consider protection of the carriers and the public in general in transportation of these materials. At present, only six designs of casks have been approved by NRC for shipment of commercial irradiated nuclear fuel. The model numbers of those approved for shipment primarily by rail are the IF 300 (General Electric Company) and NLI 10/24 (NL Industries, Inc.). The packaging for radioactive wastes will undergo the same rigorous safety analysis prior to its approval for use.

There are many detailed requirements in the NRC and DOT regulations on structural integrity and containment. However, the principal requirement is that it must be demonstrated by analysis and/or testing that adequate containment is assured under both normal and accident conditions.

To satisfy normal condition requirements, the packaging must withstand continuous exposure, i.e., equilibrium conditions, to direct sunlight at an ambient temperature of 130°F in still air and continuous exposure to an ambient temperature of -40° in the shade in still air. <u>See</u> 10 CFR Part 71, Appendix A (1975). It must also withstand rough handling which is typified by a one-foot free-fall on an unyielding surface in an attitude that produces maximum damage or other conditions representative of rough handling, and vibrations normally incident to the mode of transport.

Under these normal conditions (which are really fairly severe abnormal conditions) no release of radioactive material or coolant is allowed and shielding effectiveness must not be reduced. In addition, contamination of liquid or gaseous primary coolants must not exceed certain specified low levels.

Accident condition requirements are much more severe. The packaging must withstand very severe impact, puncture, fire and immersion in water test criteria. Impact is defined as a 30 foot free-fall onto an unyielding surface in an attitude that produces maximum damage. Puncture is represented by a 40 inch free-fall onto a 6 inch diameter pin, mounted on an unyielding surface; at an attitude to produce maximum damage. Fire resistance requirements are that the package withstand an exposure to an all-enveloping thermal radiating environment at 1475°F for 30 minutes and no external cooling for 3 hours thereafter. The package must also withstand immersion in water. The regulations require sequential application of the above conditions. The cask must be able to withstand immersion in water after it has been subjected successively to impact, puncture and fire conditions as described above.

Under these accident conditions, no release of radioactive material is allowed except for very small quantities of gases and contaminated coolant with the quantities allowed to be released based on the form and relative biological hazard of each isotope. In addition, shielding effectiveness must be maintained such that radiation levels do not exceed one REM/HR at three feet from the package.

While the packaging and transportation of spent fuel has been treated in great depth by NRC, ERDA and by the industry in the present proceedings, it has not been possible (nor necessary) to treat radioactive wastes in the same manner. This is primarily because detailed primary containment specifications and repository acceptance criteria have not been finalized by ERDA. Accordingly no final packaging designs have been developed and manufactured nor will there be any need to transport these materials for 2-3 years. However, we can nevertheless conclude at this time that the risks related to radioactive waste transportation will be even less than for spent fuel for the following reasons:

1. Fissile content is low.

2. Radiation levels from the wastes are lower because of smaller quantities of radioactive materials and longer delay times in the case of fission products from spent fuel. Accordingly, shielding requirements are less.

3. Heat release from the wastes is lower in the case of HLW and insignificant in the case of HULLS, NFBC and GT.

3. Operations and Maintenance

The NRC requires detailed procedures for initial acceptance testing, loading and unloading, routine testing prior to each shipment and periodic retesting of the packaging. These procedures are designed to assure that the packaging meets performance requirements initially, is loaded and prepared for shipment properly, and is adequately maintained. In particular, the packaging is inspected for any signs of damage, closure seals and valves are inspected, presence of reactivity control materials required in the design is confirmed and leak tightness is checked prior to each shipment. In addition, internal pressure and temperature are measured to assure that design limits are not exceeded and coolant activity and external radiation and contamination levels are measured to assure compliance with regulatory limits prior to each shipment.

B. Analysis of the Casks in a Railroad Accident Environment.

The environment existing during a rail accident is at best complex and one might ask how well the qualification tests contained in 10 CFR Part 71 duplicate those conditions. The tests are not intended to duplicate the environment, but rather to produce damage equivalent to the most extreme and unlikely accidents. Because of unfamiliarity with the behaviour of structures during impact, misconceptions exist about the severity of the 30-foot drop test. It is important to emphasize, in the description of that test, that the cask must impact upon an "essentially unyielding target." An "essentially unyielding target" is defined by the International Atomic Energy Agency in Safety Series No. 6, Para. 708, as a "flat, horizontal surface of such a character that any increase in its resistance to displacement or deformation upon impact by the speciman would not significantly increase the damage to the speciman." In practice that has come to mean a target with a total mass at least ten times that of the object being tested with an upper surface covered by a minimum of 2 inches of armor plate. In addition, the concrete mass must be thick enough to prevent failure of the concrete upon impact. Tests conducted at Sandia Laboratories in New Mexico demonstrate that concrete alone is not an unyielding target and the use of concrete only for a target in contrast to steel covered concrete greatly will reduce the effective damage to the package.

In a test to evaluate the damage to packages which impact on realistic surfaces, as contrasted to the specified test surface, a 16,500 pound cask was dropped 2,000 feet onto undisturbed soil at a location just east of Albuquerque, New Mexico. The soil in this particular locality is predominantly clay that has been undisturbed for a minimum of 25,000 years covered by a thin layer of very fine dust. Attempts to use a shovel on such soil are totally fruitless. The cask that was dropped landed upright on the soil and penetrated a distance of about 4 feet. The result of this test was essentially zero damage to the cask which was still serviceable, although there was some minor compaction of the lead. (Compaction of the lead occurs when the lead deforms to fill numerous small voids between the lead and the steel shells of the cask as the result of the large forces exerted on the lead during impact.) The result of this compaction was that the lead inside the cask moved away from the upper, flat surfaces of the cask by a distance of approximately 1/8 inch.

An identical cask dropped 30 feet onto an unyielding surface at Oak Ridge, Tennessee, showed more damage, including some weld damage, bulging, and lead compaction.[20/] While the cask dropped 30 feet onto an unyielding surface at Oak Ridge was not longer serviceable, it should be noted that the cask itself was not breached. Had it contained radioactive material, no material would have escaped. Had an accident causing damage of this severity occurred in actual use, there would have been no exposure of the source and thus no harmful radiation exposure to those people in the vicinity of this cask.

20/ Note that this was an obsolete cask. Modern designs are stronger.

To understand why the 30-foot drop test is so severe, it is necessary first to understand (1) that what produces damage is peak deceleration and (2) that peak deceleration is a function of both the velocity of the object and the hardness of the target. In the 2,000-foot drop test, the shipping cask hit the ground at a velocity of 325 ft/sec (about 220 MPH) giving it a kinetic energy of about 2.71×10^{7} foot-pounds. In contrast, when the same container was dropped on an "essentially unyielding surface," from a distance of 30 feet the kinetic energy of the cask was only 4.97×10^{5} foot pounds. In other words, the cask dropped 2,000 feet had about 54 times the kinetic energy of the one dropped 30 feet. Since the cask with the lower kinetic energy suffered the most damage, damage must be due to a factor other than kinetic energy. That factor is peak deceleration.

It is difficult, in simple terms, to calculate peak deceleration but we can talk about average deceleration and the two are closely related. The average deceleration of an object impacting a surface in such a way as to absorb all of the kinetic energy involved, is equivalent to the square of the velocity divided by twice the stopping distance. Again, considering the two cask tests, the 2,000-foot drop onto undisturbed soil stopped the cask in about 50 inches while the elastic deformation (and thus the stopping distance) of the "essentially unyielding target" in the second case was estimated to be about 1/10 of an inch. Thus, the calculated average deceleration for the 2,000-foot drop is 12,675 ft/sec^2 while the 30-foot drop resulted in an average deceleration of 116,160 ft/sec^2 or an average deceleration about nine times as great. Since it is the force exerted on the cask to produce the deceleration that causes the damage, there was more damage from a 30-foot drop onto an unyielding target that the 2,000-foot drop onto soil. Equating the 30-foot drop onto an "essentially unyielding surface" to the impact of a cask involved in an 80 mph railroad accident, the average decelerations would be equal only if the stopping distance in the accident case were about one-third of an inch' To stop in such a short distance is obviously incredible.

For realistic targets such as bridge abutments, natural rock outcroppings, etc., the fact that the surfaces of these targets are not flat, but have projections on them, can strongly influence the amount of damage caused. During the impact, these projections are loaded to the point of their failure, thus slowing down the container before its major impact with the surface. Such progressive failure of a target reduces the peak deceleration forces involved and, therefore, reduces the damage experienced by the container. In the railroad environment, there are simply no unyielding surfaces available. Even granite outcroppings do not approach the unyielding nature of the targets used in these tests. Limestones and sandstones are even further from unyielding.

Equally as important is the fact that railroad equipment does not present an "essentially unyielding surface" for the transmission of energy during accident impacts. While it is true that a moving railroad train has enormous kinetic energy, that fact must be put into perspective. The enormous kinetic energy of a train traveling at high speed is absorbed without damage in the normal process of stopping the train by using its brakes. It is only when the forces causing the deceleration exceed the structural strength of the objects involved that damage begins to occur. An impact between a shipping cask and a locomotive will not produce significantly more damage to the fuel shipping cask if the locomotive is trailing a string of cars than if the locomotive alone hits the cask. One reason, for this is that the train is made up of loosely connected units, and not all of that kinetic energy can be brought to bear on a single point. Another reason is that the kinetic energy is dissipated by the crushing of the locomotive structure at the point of impact, by collapse of the column of cars, and by crushing of the softer structures within the train (i.e., railcars and crushable containers).

With respect to puncture or piercing conditions, the force developed in the design condition by the 6 inch diameter steel pin varies from 1.5 to 4 million pounds. Again, there are no objects in the rail transportation environment of such small cross-sectional area and high strength that are so rigidly supported that they would not buckle or otherwise fail rather than inflict significant damage on the cask.

In the case of fire, initial flame temperatures of 2000°F are not uncommon in fires involving flammable liquids or gases and it is conceivable that sufficient quantities of such liquids in the general area of an accident could burn for more than one-half hour. However, the temperatures quickly fall to approximately 1600 degrees Fahrenheit because of the fuel-rich mixture in this type of all-enveloping fire. The overall average temperatures would be approximately 1500 degrees Fahrenheit which is quite close to design requirements. It is hard to conceive of a set of conditions in which the cask would be suspended in and completely enveloped by flames at higher temperatures such that the heat input to the cask would exceed that from the design condition. More realistically, the cask would still be on the car along the right-of-way and there would not be sufficient flammable liquids in the area of the car beneath or around the cask to fully envelop the cask in a fire. Even if the cask did come to rest in a large depressed area filled with a flammable liquid, the fully developed fire would be well above the cask and the area under and around the cask would be relatively cooler.

While the torching condition from a ruptured LPG tank car could create higher localized heat input, the overall effect on the cask would be no more severe than the all-enveloping test required by the regulations.

With respect to closure head and seal design, the NRC regulations, which require no release under normal conditions and allows release of only gases or coolants under accident conditions, results in very high integrity closure designs. In spent nuclear fuel casks, special metal seals are used and bolting arrangements can withstand internal pressure up to 7,000 psi before failure. The force required to fail the bolts and dislodge the closure head in these casks in 4 to 8 million pounds. It is inconveivable that such internal pressures or forces can be developed and cause release of spent nuclear fuel from the cask. Because casks for hulls, non-fuel-bearing components (NFBC), and high-level wastes will be designed to the same requirements, the same degree of containment integrity applies to containers for those wastes also.

The requirement that the containers withstand immersion in at least three feet of water for not less than eight hours following the other accident requirements is intended to assure that fissile material packaging (to which it is limited) would remain subcritical,. even if subjected to immersion in water following the drop, puncture and fire tests. The test is not intended as a requirement that the containers withstand external pressure. As a practical matter, the spent nuclear fuel and most radioactive waste containers have capabilities for withstanding external pressure that far exceed those which would be imposed by the tests because of the materials of construction and other design requirements. For example, spent fuel casks are routinely loaded and unloaded under approximately fifty feet of water. With the design features that are necessary to meet other requirements, the casks will withstand pressures several times those indicated by this test.

Thus it is clear that the casks can withstand any conceivable railroad accident. Because there are no "unyielding surfaces" in the real world, the stress and accident tests subject the casks to greater forces than they would receive in rail accidents. These tests are thus more than adequate to assure safety in transporting these materials.

V. The Diversion of Rail Shipments to Alternate Transport Modes is Impracticable, Would be Inefficient, and Would Involve an Unwise Use of Resources.

While the Draft EIS lists modal shifts as an alternative, it is not covered adequately either in the statement or by reference to the NRC's DES.

A. The Radioactive Materials Involved

1. Spent Nuclear Fuel and High-Level Waste

Due to the size and weight of shipping casks, rail has been recognized as a necessary mode of transportation for spent nuclear fuel and radioactive waste materials. Trucks cannot carry most of the containers required for these materials in the volumes necessary in the near future. Therefore, they must be shipped by rail. To ship the equivalent amount of spent nuclear fuel or high-level wastes contained in one rail cask by truck would require 7 to 10 cask loads. This results in an added expense not only in transportation but also in reactor and reprocessing facility operations. In addition, the overall transportation risk to the public would be increased because of the number of shipments and the increased miles traveled. For these reasons, large spent fuel casks have been developed which can be transported only by rail.

A commercial reprocessing plant is already located in Barnwell, South Carolina, and one is planned for Tennessee. The most cost-beneficial safe means of transportation must be available to move spent fuel from the reactor to these reprocessing plants, and that method in most instances is regular train service.

To design a reactor or reprocessing plant, it is necessary to know well in advance during the conceptual design stage, and certainly at the detail design stage, what containers and shipping casks are to be shipped and/or received and at what rate. This planning concerning transporation is started at least eight to ten years prior to the start-up of a plant. From the beginning, this planning has relied on the availability of economic rail transportation. This is necessary to get the cask and container shipping and receiving rate up to a plant throughput rate that is economically justifiable.

Reprocessing facilities today have been built to receive casks shipped primarily by rail. They cannot handle the additional number of smaller casks that would result from the truck transport. It would require a larger receiving and handling area along with more basins at the reprocessing plant. In fact, the AGNS commercial reprocessing facilitv at Barnwell, South Carolina, was designed and built according to such requirements for shipping spent fuel and high-level wastes primarily by rail and the new, large reprocessing plant under consideration by Exxon Nuclear Company, Inc. for possible construction in Tennessee likewise plans to rely primarily on rail shipments.

A large reprocessing plant, like the Barnwell Plant in South Carolina or the Exxon facility, will have a reprocessing capacity of about 1,500 metric tons per year. They each will provide reprocessing services for services for 50 to 60 light water reactors, distributed over large areas of the United States. The investment to build such a facility would be about $1 billion today.

Insight into the amount of needed transportation can be obtained by considering the number of shipments needed per year for a 1,000 megawatt reactor. The 1,000 megawatt reactor is typical of reactors being built today and is used in calculations to obtain a magnitude of the shipping required per reactor year. At the ratio of 7 to 10 truck shipments to equal one rail shipment, about 60 shipments per year of spent fuel are required if trucks are used and about 6 to 9 shipments per year if rail is used. The ratio would vary slightly depending on the fuel elements shipped.

At a large reprocessing plant, this ratio becomes critical. For illustration, if truck shipments were used exclusively at a plant such as the AGNS Barnwell facility, over 3,000 shipments per year, or 10 a day, of a 25-ton truck cask must be received and a corresponding number of empty casks shipped out. If the larger rail casks are used, those shipments drop to a reasonable number of only about 300 per year or 1 per day.

When waste shipments are added, this aggravates the already substantial logistic problem in moving these materials, adding to the larger cost of transportation containers, facilities and manpower. In addition, denial of rail service for transportation of spent fuel and wastes could jeopardize nuclear energy as a strong energy option for the United States.

Water transportation is an alternative that may be employed in the 1980's in connection with rail service. There are 115 reactors on navigable waters, but present and planned reprocessing plants will require rail service to get from the water to the reprocessing plant. There are isolated cases where neither rail nor water service is available and intermodal (truck-to-rail here) transportation will be required. Again, the rail option must be available for intermodal service. Because of the container size and weight, air transport is not an alternative.

2. Low-Level Waste

The only radioactive waste now moving is low-level waste in steel drums. ERDA's rail shipments of this commodity even now exceed its spent nuclear fuel shipments. Truck transportation of low-level waste possibly could be an alternative. However, the truck alternative may not be as efficient in many cases, and should not be forced on the shipper by the unneeded and costly requirement of special trains for these shipments.

For example, Mr. Davidson of the Tennessee Valley Authority ("TVA") testified in Docket No. 36325 that by 1986, TVA alone could require shipment of 500 train car loads per year of these wastes. If these same wastes were shipped by truck, the number of shipments and the miles traveled would increase by a factor of two to three. Thus it is apparent that while truck shipments can and will be used for some shipments of these materials, there is substantial impact if the nuclear industry and the Nation should have either to rely exclusively on truck transport or to pay an exorbitant premium to use rail shipment. This is especially so when TVA's projections are extrapolated to include the entire Nation's requirements for low-level waste shipments.

B. <u>The Waste of Resources</u>

The use of truck transport rather than regular freight train service would be a waste of our natural resources. If all spent fuel traffic were shifted to truck, the diesel fuel waste compared to regular train service would be 10 million gallons per year. Handling radioactive waste in this manner could be expected to double these estimates of diesel fuel waste. Regardless of the percentage of our total national consumption which these numbers represent, it is an unnecessary waste of energy at a time when energy and fuel supplies need to be conserved. Even in the context of our "total natural resource consumption," this can hardly be dismissed as "infinitesimal." Cf. Draft EIS at p. 19.

VI. The Elements of Special Train Service As Described in the Draft EIS Are Not Contained in Any Tariff.

The Draft EIS (at 4) lists what it finds to be the "major elements" of the special train service which the railroads are demanding as a mandatory requirement for transporting spent nuclear fuel and radioactive wastes. These "major elements" are described as follows:

1. "The carrier provides an engine, crew, and caboose. . . .;
2. "No other type of freight is handled. . .;
3. "Special trains generally operate on a thru-service basis, by-passing freight yards and avoiding normal switching between railroads;
4. "Special train shipments have the flexibility to be routed around major population centers where feasible;
5. "When a train handling one of these shipments passes or is passed by another train, one train must come to a standstill while the other moves past; and
6. "Special train speeds are restricted to 35 miles per hour."

The provision in Supplement 3 of the Uniform Freight Classification 12, which imposed special train service on spent nuclear fuel and radioactive wastes, does not mention these "major elements". All it says is: "NOTE 5. - Ratings are applicable only on shipments moving in special freight train service subject to provisions of applicable Special Freight Train Service Tariffs."21/

From this, it should be expected that the "major elements" of the special train service would be set forth in the Special Freight Train Service Tariffs referred to, but such is not the case. None of the "major elements" of special train service is contained in the railroads' Special Freight Train Service Tariffs, even though these Tariffs state the charges the railroads will exact for providing that service. These Tariffs say only that the railroads will furnish special train service "upon request" and "at their convenience". They define special train service only to mean "a train which is operated on an expedited schedule at a charge in addition to the applicable class or commodity rates".22/

These Tariffs do not articulate or require any of the "major elements" of special train service as described in the Draft EIS. For the Draft EIS to find that these "major

21/ This is Item 80769.5 of Supplement 3 to Uniform Freight Classification 12, ICC 8. It is quoted at Tr. 282-3 of the proceedings in Docket 36325.

22/ Southern Freight Tariff Bureau Tariff S-842-N, ICC S-1155, Item 120, 130; Western Railroads Freight Tariff 1-B, Items 120, 130. These Tariffs are attached to the Verified Statement of Walter E. Potts, which is Exhibit 24 in Docket 36325. Items 120 and 130 of these Tariffs are also quoted at Tr. 281-282 in Docket 36325. It should be mentioned that there is no definition of "expedited schedule" and no penalty if the scheduling is not expedited. Any implied assurance of expedited service is cancelled out by the provision that the trains will be operated at the carrier's convenience.

elements" will characterize the railroads' special train service is to write on sand that may shift in many different directions depending on the railroads' "convenience" in particular situations. Yet, in an effort to save themselves from a violation of Section 6 of the Interstate Commerce Act, the railroads have made clear in Docket 36325 that their special train service for spent nuclear fuel and radioactive wastes will be furnished only under those Tariffs.[23/] In fact, the railroads have sought to characterize such "major elements" as being merely operating practices or rules that normally are not published and that railroads are free to add to, subtract from, or totally ignore based on their sole discretion without any right of the shipper to object thereto.

Thus, those Tariffs are the railroads' mode of fixing the charges the shippers must pay for special trains, but they do not specify the service which the shippers will receive for their money. Shippers must therefore be content with what, in particular circumstances, proves to be at the

23/ This was stated by Counsel Phillips: "Your Honor, this proceeding is only concerned with special trains as defined in the tariff. If a particular road calls something else a special train, they cannot charge under the special train tariff, for it is against the law for any railroad to charge, except what is provided in the tariff. . . ." (Tr. 235).

The trouble is that these Tariffs are evidently designed to accomodate shipper request for special service and carrier and shipper joint agreement on the particulars of that service. The railroads are here putting those Tariffs to a purpose--mandatory, unilaterally defined special train service--for which they obviously were not intended and are not appropriate.

railroads' "convenience" in accordance with those Tariffs. That this is so is demonstrated on the record in Docket 36325 (see the testimony of the railroads' witnesses at Tr. 368 and 472 in that proceeding). That the shippers also are not likely to receive "expedited scheduling"--this being the one characteristic of special train service that is stated in the Tariffs--is also indicated in that record (see e.g., the railroad witnesses' testimony at Tr. 107 and 481 explaining when it will be the "special train" that will stop when it meets another passing train).

Doubt whether the "major elements" of special train service will actually materialize is increased by the ignorance which the railroads' witnesses displayed in Docket 36325 concerning the contents of the Special Freight Train Service Tariffs. Their testimony reveals their appreciation of special trains only in terms of operating practice, instructions to trainment, and the like, not derived from or confined by any tariff specification of the service (see, e.g., Tr. 106, 130-1, 150-1, 233, 302-3, 356, 425, 471).

For these reasons, the Draft EIS should be revised to state that there is no assurance that the described "major elements" of special train service (other than added charges) would in fact be provided in view of their absence from any publication in any tariff.

VII. There is no Substantial Evidence that Special Trains Add Any Increment of Safety.

The Draft EIS concludes that, because the accident probability is so small, the associated environmental impacts are not significant but that speical trains would provide "a small safety dividend" because they have an incrementally lower accident potential. The Draft EIS makes a number of assumptions regarding the nature of special train service and safety advantages of special trains, but no authority is cited for any of these assumptions. Apparently they are based, to a large extent, on the self-serving position paper issued by the Association of American Railroads referred to at footnote 7 of page 6 of the Draft EIS.

The nature of special train service and the relative safety of a cask car being transported in regular and special train service have been the subject of extensive testimony in Docket 36325. The picture there developed differs in essential respects from the unsupported assumptions in the Draft EIS.24/

24/ Reference is made specifically to Exhibits 27, 28, 60 and 61; the cross-examination of witnesses Garrick, Sperry, Eldridge and Power at Tr. 794 et seq., Tr. 1204 et seq., 1241 et seq., and 1131 et seq.; and the portion of the cross-examination of witness German at Tr. 140-152. It is also noted that, in response to a request by the attorney for the Southern Railway Company (Tr. 1138-1143), Westinghouse Electric Corporation has supplied data which shows that accidents have occurred in at least 20 Westinghouse shipments handled in special train service for the period August 1, 1970 to April 30, 1976.

Page 4 of the Draft EIS lists what the authors assume to be "the major elements of special train service". These are listed below, together with our comments:

1. The carrier provides an engine, crew and caboose. The radioactive material is contained in a 100-ton cask loaded on a flat car between the engine and the caboose.

This statement is reasonably accurate. However, where the movement is over more than one line, each carrier provides an engine, caboose and crew. It is possible, moreover, for more than one cask car to be carried in a special train.

2. No other type of freight is handled on these special trains, in order to prevent contamination of other freight being transported with the radioactive material. It is also possible that highly explosive or other hazardous materials, if transported with radioactive materials, might cause additional safety hazards.

It may be true that no other type of freight would be handled on the special trains, but the statement that the purpose is "in order to prevent contamination of other freight being transported with the radioactive material" has no basis ordinarily.[25] The reason that other materials ordinarily would not be handled in the special trains is that there would be no occasion for doing so. If some other material were to

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25/The Special Train Service Tariffs permit the railroads to add cars of other commodities.

be transported from the same origin to the same destination at the same time, there would be no reason for not sending it by the special train. Not even the railroads have argued that the prevention of contamination of other freight is the purpose or effect of using special trains.

The suggestion in the last sentence that special trains are safer because highly explosive or other hazardous materials are not transported in them with the cars of radioactive materials, likewise has no foundation. In regular trains, highly explosive or other hazardous materials are separated from cars of radioactive materials. DOT regulations prohibit the carrying of cars of explosives or other hazardous materials in close proximity to such cars in regular train service.

3. Special trains generally operate on a thru-service basis, by-passing freight yards and avoiding normal switching between railroads.

There is no basis for this statement. Special trains are operated at the convenience of the railroads. They must, moreover, change crews at regular terminal change points and locomotives and cabooses must be serviced where fuel, water, etc., are available. Further, much additional switching of these special trains could be required because of the speed or passing restrictions the railroads have indicated may be imposed on the special trains.

4. Special train shipments have the flexibility to be routed around major population centers where feasible.

Regular trains can be, and frequently are, routed around major population centers to avoid congested terminal areas. There is no reason to assume that special trains would avoid major population centers any more than regular trains do.

5. When a train handling one of these shipments passes or is passed by another train, one train must come to a standstill while the other moves past.

As already noted, there is no such requirement in the special train tariff and this may or may not be done. Even when done, it provides no additional safety, as discussed hereinafter.

6. Special train speeds are restricted to 35 miles per hour.

This requirement, likewise, is not contained in the tariffs and may or may not be observed. It is, moreover, an unnecessary restriction, as hereinafter set out.

Section 2.4 (page 7) of the Draft EIS cites a number of reasons why "institution of special train service may result in a reduction in the severity of accidents." The reasons cited are discussed below.

1. Because of the exclusive nature of the shipments, special trains have the flexibility to be routed around population centers. In the event that a nuclear

incident occurred in transit, the amount of the population exposed to radiation might be significantly less if a special train, rather than a regular train, is involved. Special trains will operate on a thru-train basis and will avoid switching yards where possible. This will eliminate the need for cars carrying nuclear materials to wait at classifications yards or to sit on a siding until a full train is made up. By continuously moving, there will be less likelihood of theft or sabotage. Finally, establishment of thru-trains will decrease the total amount of time required to transport the shipments, thus reducing the statistical probability of accidents.

As already noted, there is no reason to assume that special trains would be routed around population centers any more than regular trains are. Regular trains avoid congested areas to the extent that they can do so feasibly and it must be assumed that special trains would follow the same routes. If the assumption herein is that special trains would be shipped over extremely circuitous routes in order to avoid population centers which trains must pass through when using normal routes, the result would be additional mileage and additional switching, with a concomitant increase in the risk of accident, costs and delays. Also, many of the secondary routings that undoubtedly would be used are not maintained in as good condition and, as indicated in the Draft EIS (p. 9), many accidents occur on such secondary track.

Moreover, the type of accident which occurs in moving through a congested area is generally minor in nature and the risk of a nuclear incident occurring in such an accident is so infinitesimal as to be non-existent for all practical purposes. The more severe accidents occur in the open country, and circuitous routing of a special train would increase not only the risk of accidents but the severity of accidents which might occur.

Special trains might avoid some switching but they require the same crew and locomotive changes as regular trains. Assuming that the special trains operate at slow speeds and stop to permit other trains to pass, the amount of switching to and from sidings could well exceed any amount of other switching avoided by their use.

The suggestion that there is serious danger in having a car of nuclear materials waiting in a classification yard is wholly without merit. Cars requiring special handling receive from railroad police a high degree of protection against theft and sabotage. They also receive a high degree of protection from switching accidents by reason of the careful transportation practices accorded them as set out in the railroads' Book of Rules and Special Instructions, including, for example, no humping, no switching without a locomotive attached, etc.

There is no basis for the conclusion that a car of radioactive materials will be transported more quickly in a special train than in a regular train. Such trains are operated at the convenience of the railroad, and railroads with heavy traffic may encounter very substantial delays as scheduled trains are given priority. Moreover, as the number of spent fuel shipments increases and more and more special trains are required, situations undoubtedly will be encountered where locomotives and crews are not always available as needed.

> 2. As stated previously, special trains will be considerably shorter in terms of length than regular trains. This will enable train crews located in both the engine and the caboose to constantly observe the flat cars containing the radioactive material, something which is not possible on longer regular trains (due to track curvature). Other important factors to be considered are the type of equipment and the mixture of lading. Inasmuch as special trains do not haul different kinds of cargo and different equipment on the same train, there is less likelihood of a derailment or accident. The absence of other kinds of freight eliminates the possibility of radioactive contamination of other commodities. This also prevents the transportation of other hazardous or combustible materials with nuclear materials, which could result in excessively hot and long-lasting fires which might affect the protective casks containing the nuclear material.

Special trains will be shorter than regular trains but this does not mean that cars containing radioactive materials will receive any better surveillance. Such cars are not placed in the middle of long trains. The established practice is to place them immediately before the caboose or with a buffer car between the radioactive car and the caboose. Occasionally such cars would be placed at the front end of the train behind the locomotive. In either case, the car would be subject to surveillance. There would be no necessity to have two crews in a position to observe it.

Whether the risk of derailment is greater on a regular train is speculative. A derailment rarely involves more than 15 or 20 cars and is more likely to occur near the front or middle of a train. If 80 cars pass safely over a section of track, it is unlikely that the 81st car will suffer derailment. It follows that a car at the rear end of a long train is relatively safe from derailment accidents. On the other hand, the possibility of derailments on special trains is increased if these trains are required to enter and leave side tracks frequently in order to permit other trains to pass. 26/

As previously discussed (see note 25, supra, and accompanying text), special trains might carry other material as well. Regulations do not permit radioactive materials to be placed in close proximity to cars containing hazardous or combustible materials. Moreover, the protective casks

26/ The data supplied by Witness Power identified 27 derailments of 17 Westinghouse special trains for period August 1, 1970 to April 30, 1976. One shipment sustained 7 derailments.

are so constructed as to withstand any credible fire, further reducing any conceivable risk due to mixture of lading.

> 3. Many of the main line tracks in the Nation permit train speeds up to 70 mph. It is obvious, however, that a derailment or other accident will be much more serious in terms of damage to the cargo at higher speeds than at lower speeds. It is for this reason that special trains will be restricted to speeds no greater than 35 mph, thus reducing both the theoretical potential for accidents and the resulting damage. Although the vast majority of derailments occur at speeds less than 45 mph, derailments are most closely related to track conditions rather than to train speed (although trains operating over poor track are usually subject to slow orders). Consequently, most derailments occur on light density lines which exhibit poor track conditions.

It is true that accidents are more serious at higher speeds but the cask cars here involved are constructed to withstand the forces involved in a 70 mile per hour accident. Moreover, there is no occasion to ship cars of radioactive materials at such speeds. Most freight trains travel at speeds lower than 70 mph, and there is no reason why cars of radioactive materials cannot be handled in regular service on trains which move at normal speeds.

> 4. Another major cause of rail accidents is collision. Even though special trains will operate on rail lines which handle other trains, the railroads are requiring that when a special train passes or is passed by a regular train, one of the trains must come to a complete halt. The purpose of this precaution is to reduce the potential

for accidents which may occur as a result of train sway, and objects which fall or hang from regular trains.

The risk of damage from collision to a car of radioactive materials is substantially greater in special trains than in regular train service. In special train service, such a car is in a vulnerable position whether the collision is a head-on or a rear-end collision. In regular train service, if the car is at the rear of the train, it is as vulnerable to a rear-end collision as if it were in a special train, but it is protected from the effects of a head-on collision by the cars in front of it. Conversely, if placed at the front of the train, it would be as vulnerable as in a special train in the event of a head-on collision but would be protected from the effects of a rear end collision. In crossing accidents, where a train hits a truck or other object in the crossing, the car at the rear end of a regular train is, of course, protected, whereas it is vulnerable in a special train. If the car is hit from the side in a crossing accident, the type of train makes no difference.

Stopping a special train to permit others to pass is a precaution which is used only where the special train has an excessive width or an excessively high center of gravity. In such cases, there is a danger that train sway could cause a collision. Cars of radioactive materials do not pose such a danger; they are not oversize and they do not have a high center of gravity so the danger in passing a train going in the opposite direction is no greater than for any other equipment.

If the risk of a wreck as a result of "objects which fall or hang from regular trains" had any substance (except where oversize loads are involved), this precaution would be required for most trains, regardless of the nature of the lading. Surely, if the danger from this was real the railroads would not be permitted to have passenger trains and freight trains pass each other at combined speeds of over 150 miles an hour, as they do, since the wreck of a passenger train under such conditions would be catastrophic.

To sum up the foregoing, there is no basis for the unsupported assumption in the Draft EIS that the use of special trains for radioactive materials would provide a "small safety dividend." If <u>all</u> the factors carefully are weighed, the conclusion might well be that transportation of radioactive materials in special trains is less safe than in regular trains.

VIII. The Mandatory Use of Special Trains Will Involve a Large Commitment of Resources in the Future.

The Draft EIS (at 19) notes that use of special trains instead of regular trains is "less efficient," but inappropriately dismisses this as having an "infinitesimal" effect on our total natural resource consumption. Contrary to this unsupported conclusion, two factors need to be considered:

1. Railroad equipment and manpower.
2. Differential fuel consumption via rail.

With respect to utilization of railroad equipment and manpower, which even now is in short supply, special trains will be wasteful. Furthermore, looking to the future, Volume 1 of the Federal Energy Administration's Project Independence Task Force Report entitled "Analysis of Requirements and Constraints on the Transport of Energy Materials" (November 1974) has identified as a critical uncertainty the railroads' capability to handle the necessary increased coal traffic. The FEA Task Force Report makes it clear that the railroads will be called upon to handle about twice the volume of coal by 1985, and it cites the uncertainty in the availability of equipment, manpower, and diesel fuel. It must be concluded, therefore, that the unnecessary and wasteful practices in the transportation of spent nuclear fuel and wastes being proposed by the railroads at the same time they are being called upon to double their capability to handle coal is, to say the least, counterproductive and not in the national interest.

While it is not known exactly what a "special train" would be, the waste of equipment and manpower that such would involve is obvious. It takes the same locomotive, caboose, and crew to handle a special train as a multi-car regular train. The addition of a car of radioactive materials to a regular train would result in only an incremental increase in cost. In most cases, no additional crew or equipment would be required, and very little additional fuel would be consumed. It follows that use of fuel (and other resources) via special trains would be many times greater than in regular freight train service. Regardless of the percentage of our total national consumption which this use would represent, it is an unnecessary waste of energy.

IX. The High Added Costs of Mandatory Special Train Service Cannot be Justified When Compared to the Difference in Risk, if Any, Between Using Special Trains and Regular Trains for the Carriage of Radioactive Materials.

An essential part of an EIS such as that being prepared by the Commission's Environmental Affairs Staff is a balancing of the benefits to be derived from, or claimed for, the proposed action against the costs of implementing the proposed action. Such an analysis should be as objective as is achievable, free of emotion and other biases. In this connection, as quantitative a cost-benefit analysis as possible should be prepared in order to reach an objective decision.

In the instant case, the benefits claimed by the railroads (both of which are disputed by industry) are reduced risks resulting from accidents and expedited service. We have not attempted to quantify any benefit from expedited service since, in our opinion, it is problematical at best that any expedited schedules could be achieved with the restrictions, i.e., speed limits and stopping, that the railroads have stated they intend to impose.

In this section, a quantitative cost-benefit analysis is presented that shows the cost incurred for the shipment of spent fuel from nuclear power plants by special trains as opposed to regular service [27/] and the benefits, measured in reduction of risk, if any, that result from such expenditures. This cost-benefit analysis shows that special trains cannot be justified on the basis of risk reduction.

The risk calculations are based on an assumed average distance of 1,000 miles from a reactor to a reprocessing plant. Using that same 1,000 mile from a reactor to a reprocessing plant. Using that same 1,000 mile shipment, the added cost of the special-train service would be about $20,000 per trip at the current cost of about $20 per mile even if special trains are required only for the loaded movements. This would add millions of dollars per year to utility operating costs. These additional costs, when applied to both spent fuel and radioactive wastes and when escalated to 1986 dollars, could amount to more than $600 million annually by 1986.[28/]

By comparison, using the NRC published value of $1,000 per man rem as the cost of radiation exposure, the total calculated risk using the very conservative values in Table 3 below is less than $1,000 per shipment for regular train shipments. The value of special-train service must then be measured against the reduction of risk, if any, that could be achieved by the

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[27/] In light of the discussion of the differences between spent nuclear fuel and radioactive waste material at pages 29-33, supra, it must be concluded that the potential radiation hazard to the public from the rail shipment of other radioactive materials is substantially less than that from the rail shipment of spent nuclear fuel. This section, therefore, will focus its calculations on spent fuel.

[28/] See testimony of Witness Peterson on July 30, 1976 in Docket 36325 (Tr. 1250).

use of special trains. In our opinion, it is doubtful that the use of special trains would result in any reduction in this risk, but even if special trains could eliminate this risk entirely (which they cannot), use of special trains still would not be justified based on a balancing of the costs to be borne against the alleged benefits to be derived.

A detailed explanation of the derivation numbers follows. In all cases, bases have been used which tend to overestimate the risks and which realistically reflect the costs involved.

Cost of Special-Train Service

The added costs of mandatory special trains contain a number of variables. For example, these variables include special train charges; cask use charges; rail freight tariffs; location of future reprocessing plants, storage facilities, and reactors; round-trip travel times; turnaround time for containers; frequency of container pickup and delivery by the railroad; container utilization; container capacity; and number of cars per shipment.

In order to gauge the economic impact of mandatory special trains, a number of the shippers involved in these proceedings have estimated the added costs that would be incurred.

George P. Rifakes of Commonwealth Edison Company has calculated the cost of shipping by rail all of the fuel to be discharged from 41 reactors during the 10-year period 1977 to 1986, both under the basic freight rates and with the added cost of mandatory special trains. See Exhs. 31 to 33 in Docket 36325. He estimated that in 1976 dollars the basic round-trip freight tariff costs of shipping spent fuel during this period would be $37,944,000 for the fourteen utilities involved. Adding the mandatory special train costs more than trebles this cost of shipping to $131,039,000. One-way shipment of spent fuel from these 14 companies for the same period of time would increase the basic freight costs from $20,176,000 to $66,723,000. By 1986 the annual round-trip added charges for special trains (in 1976 dollars) would be $14,105,000 and for one-way service an added $7,052,000. These figures represent only about one-fourth of all United States reactors planned to be completed by the mid-1980's.

The added costs of special trains even when considered from the perspective of individual utilities close to reprocessing plants are large. Duke Power Company has estimated that its added costs for shipment of spent nuclear fuel by special trains would be $1,527,300 for the period 1980 to 1990. See exh. 34 in Docket 36325. Virginia Electric and Power Company (VEPCO) has calculated that the added costs for shipment of spent nuclear fuel in 1988 when all reactors currently planned are in operation will be $443,000 with freight rates at the 1976 level. Carolina Power and Light Company (CP&L), whose Robinson and Brunswick nuclear units are only 132 and 228 rail miles, respectively, from Barnwell has determined that its additional costs for special train shipments of spent nuclear fuel would be approximately $260,000 per year in 1976 dollars. See Exh. 36 in Docket 36325.

The Tennessee Valley Authority (TVA) has estimated that the requirement for use of special trains for spent nuclear fuel would add about $1,400,000 per year to TVA's transportation costs during the late 1980's. See Exhs. 29 and 30 in Docket 36325. If special trains are required for shipments of radioactive wastes from its nuclear power plants, TVA has estimated that such could result in additional costs to TVA of as much as $1,000,000 per year. When this amount is added to the special train costs for transporting spent nuclear fuel, the total annual additional cost to TVA amounts to $2,400,000.

Allied-General Nuclear Services (AGNS) has evaluated the costs for both spent nuclear fuel and radioactive waste shipments that will be required for its reprocessing plant at Barnwell to operate at its design capacity. See Exh. 24 in Docket 36325. AGNS has estimated that the increased cost of special trains for spent fuel shipments alone will be from some $3,000,000 per year if more than one car per special train is shipped to some $6,100,000 per year if only one car is shipped per train. Special train charges for waste shipments could range from $4,900,000 to $26,800,000 per year depending upon the destinations and the use of single or multiple car special trains.

General Electric Company and a number of its electric utility customers are involved in transactions relating to the transportation of up to 4,200 metric tons (uranium weight) of irradiated nuclear fuel over the next ten years. If all of the material is shipped to storage using the General Electric IF-300 cask, the cost of regular freight service will be about $8,000,000. The use of special trains with one cask per movement would add nearly $21,000,000 to the cost. The stored fuel ultimately will have to be moved again for reprocessing, thus further increasing the transportation costs. The waste generated by 4,200 metric tons of fuel will be transported by rail for disposal. The cost of these waste movements is estimated at $5,000,000 for regular freight service with the cost of special trains estimated at $15,000,000. There is an additional cost to General Electric which is more difficult to estimate, namely that associated with loss of cask lease revenue. Its IF-300 casks are offered to the utility industry for lease service in railroad transportation. Unreasonable restrictions on the use of this equipment, such as mandatory special train service, will cause those potential customers who can do so to shift their business to less efficient but less costly transport modes. At an approximate daily lease charge of $3,000 it is easy to see that a significant amount of lease revenue could be lost. The four existing IF-300 casks at full utilization would bring in about $4,000,000 per year. If the imposition of special trains resulted in a 50 percent reduction in utilization, over a ten-year period this would be a $20,000,000 loss in lease revenue. See Exh. 54 in Docket 36325.

The added costs to the Federal government also must be taken into consideration. The U.S. Energy Research and Development Administration (ERDA) has already stated that its additional costs from transportation of spent nuclear fuel will be significant. ERDA has calculated that its costs will increase as much as five times on shipments in the lower (75,000 to 100,000 pound) weight range. See Exh. 21 in Docket 36325.

All of the costs presented above are in 1976 dollars except as otherwise indicated. The U.S. Department of Labor, Bureau of Labor Statistics Price Indexes for Total Railroad Freight indicate that the cost of shipping goods by rail in the

United States has nearly doubled since 1969. Mr. Reuben Peterson, testifying before the ICC on July 30, 1976, stated that the use of special trains for 200 nuclear reactors in the 1980's would add $600 million annually in transportation charges at escalated dollar value. See Tr. 1250-55 in Docket 36325.

The added expense of special trains can be computed on a per shipment basis or a cost per mile basis. Section B.2-4 of Chapter VI of the NRC DES, which has been incorporated by reference into the ICC DES, estimates the cost of a spent fuel shipment involving seven fuel elements by special train to be $24,000 versus $9,000 by regular freight train. The existing special train tariffs indicate that the normal additional per mile charge is between $18.93 and $20.24 (requiring a 110-mile minimum).

The risk calculations that follow are based upon a 1,000-mile trip. Using the 1,000-mile trip as a standard, the extra charge per shipment would be about $20/mile x 1,000 miles, or $20,000. This cost figure thus provides a convenient basis for comparing cost and benefits.

Calculation of Risk

Based upon railroad statistics developed through the years and analyses prepared by the United States Government, calculations of risk and its reduction by use of special trains has been estimated. The approach to this calculation has been to use conservative or upper-bound assumptions rather than what would be more realistic assumptions in order to eliminate any argument concerning the assumptions. The basis for the calculation is as follows:

(1) Spent fuel shipment mileage -- 10 shipments per reactor year at 1,000 miles each (10,000 miles per reactor year).

(2) Accident rate -- One railroad accident per 1,000,000 miles, or each 1,000 shipments.

(3) Accident rate per reactor year -- Multiplying 10,000 miles per reactor year times one railroad accident per 1,000,000 miles yields a figure of one railroad accident per 100 reactor years.

Following the method of the Environmental Protection Agency study,[29] three categories of accident severity are used: minor, moderate and severe. Based upon the data used in that study, probabilities for each category of severity given an accident are as follows:[30]

P (minor/accident)	=	0.909
P (moderate/accident)	=	0.09
P (sever/accident)	=	0.001

Thus, (for example) one accident in a thousand, or one accident in a hundred thousand reactor years, is severe.

Next, four categories of release of radioactivity are established: none, small, medium, and large. These

29/Transportation Accident Risks in the Nuclear Power Industry, 1975-2000, U.S. Environmental Protection Agency, NSS 8191.1 (November 1974). (Exhibit 28 in Docket 36325.)

30/"P (minor/accident)" is read as follows: The probability, given that an accident has occurred, that the accident is minor.

categories are defined in terms of the amount of radioactivity which might be released, according to the following table:

Table 1

Release Categories

Amount of Radioactivity, in Curies,[31/] Defined to be Released in the Various Release Categories

Radioactive Material Released	Release Category		
	Small	Medium	Large
Kr-85	108	5,400	10,800
I-131	.0014	.070	.14
Other Fission Products	130	6,500	13,000

The more severe the accident, the more likely a large release. This is expressed in the following table of c conditional probability of release category given an accident of a certain severity:

Table 2

Conditional Probability of Release Category Given Accident Severity Category

Release Category	Accident Severity		
	Minor	Moderate	Severe
None	.988	.986	.982
Small	.0092	.01	.013
Medium	.0023	.0027	.0034
Large	.00097	.00011	.00015

31/"A unit quantity of any radioactive nuclide in which 3.7×10^{10} disintegrations occur per second.

Combining Table 2 with the probabilities of accident, the conditional probabilities or release given an accident may be estimated as follows:

P (none/accident) = 0.988

(Example: .988 x .909 + .986 x .09 + .982 x .001 = .898 + .089 + .001 = .988)

P (small/accident) = 0.0093
P (medium/accident) = 0.0023
P (large/accident) = 9.8×10^{-5}

Or, in round numbers:

probability of no release given an accident = 99%

probability of small release given an accident = 1%

probability of medium release given an accident = 0.2%

probability of large release given an accident = 0.01%

Thus, one out of 100 accidents will result in a small release of radioactivity, one in 500 in a moderate release, and one in 10,000 in a large release.

If there were a release of radioactivity, the consequences would depend upon the number of people in the vicinity, the wind speed at the time, etc. The net effect

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Continuation of footnote 31.

which 3.7×10^{10} disintegrations occur per second.

of these variables has been computed in WASH-1238 and has been presented in an appendix of WASH-1238. Table 3 herein, which is a summary of the probability of a given number of people receiving a given dose from an accident for each trip, is derived by using the results in that appendix of WASH-1238, and especially Table 7 and Figure 5 therein, and combining those results with the release definitions of Table 1 herein, and with the release probabilities stated above.

Table 3[32/]

Probability, in a 1,000-Mile Train Shipment of Spent Nuclear Fuel, That N or More Persons Will Receive D or More Dose to the Whole Body From Gross Fission Products Which are Released in an Accident During This Shipment and Which Deposit (I.e., Fallout) on the Ground[33/]

Number of People	Dose, Millirems						
N	1	10	10^2	10^3	10^4	10^5	10^6
1	$1x10^{-5}$	$1x10^{-5}$	$1x10^{-5}$	$1x10^{-5}$	$9x10^{-6}$	$4x10^{-6}$	$1x10^{-6}$
10	$1x10^{-5}$	$1x10^{-5}$	$1x10^{-5}$	$9x10^{-6}$	$4x10^{-6}$	$2x10^{-6}$	$5x10^{-7}$
10^2	$1x10^{-5}$	$1x10^{-5}$	$8x10^{-6}$	$5x10^{-6}$	$2x10^{-6}$	$1x10^{-6}$	$9x10^{-8}$
10^3	$1x10^{-5}$	$9x10^{-6}$	$6x10^{-6}$	$2x10^{-6}$	$7x10^{-7}$	$1x10^{-7}$	$4x10^{-9}$
10^4	$1x10^{-5}$	$7x10^{-6}$	$4x10^{-6}$	$1x10^{-6}$	$2x10^{-7}$	$1x10^{-9}$	
10^5	$9x10^{-6}$	$6x10^{-6}$	$2x10^{-6}$	$4x10^{-7}$	$1x10^{-7}$	$6x10^{-10}$	

32/ Based upon Table 7, in WASH-1238.

33/ Exposed persons are assumed to remain in the contaminated area for one year and it is assumed that there is no loss or cleanup of radioactivity from the ground. [illegible]0 percent of the dose is to the skin.

Table 3 is essentially a calculation of the risk surface[34/] in tabular form for regular train service. Thus, it says, for example, that in a 1,000-mile shipment, the probability that there will be an accident which will result in 100 (10^2) or more people receiving a dose of 1 rem (10^3 millirem) or more as a result of fission product fallout is 5×10^{-6}, i.e., one chance in 200,000 shipments of spent fuel.

The numbers in Table 3 may be put into context by comparison. For example, a typical medical x-ray is of the order of 10^2 to 10^3 millirems. The threshold for observable effects from whole body radiation is 50 rems, or 50,000 millirems. Therefore, the millirem doses in Table 3, which are doses resulting from an accident, become biologically significant only somewhere between the 10^5 and 10^6 column.

The curve for special train service must be computed so that the difference between the two curves, which is risk reduction, can be measured against the cost of the reduction. However, the risk surface for special trains cannot be calculated in a definitive way, since no statistical data have been presented on accident rates for special trains. There are only some

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34/ See Appendix II. More accurately, Table 3 represents an upper bound to the risk surface. It assumes, in a "large" release, a release of radioactivity 100 times greater than that assumed in WASH-1238, Table 7. Table 3, moreover, assumes no evacuation or cleanup or natural dispersion for a period of one year. Moreover, since 80 percent of the dose in Table 3 is to the skin, and the threshold for biological effects is 50 rem, the doses in Table 3 become biologically significant only between the last and next-to-last columns (10^5 and 10^6 millirems).

opinions by railroad personnel to the effect that these rates are lower. Cask cars on special trains are more vulnerable to collision damage than on regular trains and it may be that the risk for special trains is actually higher than for regular trains.

Thus, a definitive risk curve for special train service cannot be calculated, and a convincing argument cannot be made that this curve is lower than the regular curve. Thus, it cannot be said that there is in fact a reduction in risk.

However, the maximum possible reduction in risk would be to eliminate the risk entirely. Even if the risk in special trains were absolutely zero, the maximum reduction in risk is the risk that exists in regular trains, i.e., Table 3. The maximum possible reduction in risk in such an unlikely situation then would be the difference between the probabilities presented in Table 3 and zero. It is infinitely more likely that the difference in risk between special and regular trains is much less than the difference between the probabilities presented in Table 3 and zero. Because elimination of even this gross upper bound risk reduction is not worth the price of special trains, the actual risk reduction is, *a fortiori*, not worth it.

Conclusion

We may now ask: Suppose the reduction in risk is all of that shown in Table 3; would that be worth $20,000 per shipment?

The number $1,000 per man-rem is currently being used by the Nuclear Regulatory Commission as a measure of the detrimental value of radiation.[35/] It should be noted that the use of this figure is conservative, because another distinguished study estimated the figure at $12-$120 per man-rem.[36/] Based upon the use of $1,000 per man-rem, Table 3 would imply an expected detriment of less than $1,000, far below the $20,000 per shipment cost.

Thus, Table 3 illustrates that the expected detriment per shipment is extremely low. These figures illustrate the point that the railroads are proposing protection against risk which exceeds any possible loss that might result.

There is, of course, no assurance that special trains decrease risk -- their use may in fact increase it. Special trains should not be used, of course, unless it can be persuasively shown that their use decreases risk. But even if it is assumed that the use of special trains does decrease risk, they should not be used unless that benefit (decrease in risk) exceeds their cost. We have, however, demonstrated that costs exceed any possible benefit to be derived from the use of special trains. Thus, the conclusion is inescapable, in light of the above cost/risk/benefit analysis, that special trains are an unjustified and unreasonable alternative.

35/ 10 C.F.R. 50, Appendix I, Sec. II D (1976).

36/ "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", Report of the Advisory Committee on the Biological Effects of Ionizing Radiation, National Academy of Sciences (1972), p. 70.

Respectfully submitted,

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CERTIFICATE OF SERVICE

We hereby certify that on this 30th day of August, 1976, we served copies of the foregoing Comments on the Draft Environmental Impact Statement upon all parties of record in Docket Nos. 36307, 36307 (Sub 1), 36307 (Sub 2), 36307 (Sub 3), 36312, 36313, 36330, 36335, 36336 and 36325, and upon other persons known to be interested, by mailing copies of the same to them, postage prepaid, in accordance with the General Rules of Practice of the Interstate Commerce Commission.

JAMES F. BROMLEY — JOHN F. DONELAN

OMER F. BROWN, II — JOHN K. MASER III

APPENDIX I

Outline of Department of Transportation (DOT) Regulations

The DOT regulations deal primarily with shipper and carrier responsibilities in preparation of the package for shipment; external temperature, radiation and contamination limits, labeling and placarding, and certification; and with transportation requirements, restrictions, and emergency notifications during shipment. The DOT, in keeping with the Memorandum of Understanding with NRC, accepts the adequacy of packaging for which NRC has issued a COC. Some of the more important DOT regulations are:

Temperature [49 CFR 173.393 (e)2]	For sole-use rail cars, the maximum allowable temperature of accessible surfaces is specified.
Radiation - [49 CFR 173.393 (j) and 173.29(e)]	For sole-use rail cars loaded, the maximum allowable radiation levels around the car are specified. Empty packaging is limited to 0.5 mrem/hr on contact.
Contamination - [49 CFR 173.393 (h), 173.29(e) and 174.566(d)]	No "significant" removable surface contamination on the exterior of the package. Significant is rigorously defined in the regulations. Also, limits on rail car contamination are specified.

Loading and Testing - [49 CFR 173.393 (m)]

Reiterates and reemphasizes NRC requirements on proper loading and testing prior to shipment.

Labeling and Placarding - [49 CFR 173.399 173.402(a), 173.416 and 174.541(b)]

The package must be labeled according to its contents and the vehicle must also bé placarded to make persons aware of the contents of the shipment.

Certifications - [49 CFR 173.427, 173.430 and 174.510-511

The Bill of Lading given to the Carrier must include the information specified regarding the contents and packaging and certification that the contents have been properly classified, described, packaged, marked, labeled and are in proper condition for transportation according to DOT regulations.

Mixing and Handling Radioactive Materials with Other Hazardous Materials - [49 CFR 174.527, 532(j), 538, 586(h), 589(m)]

Controls are placed on the Carrier to avoid the presence of explosives or flammable materials in close proximity to radioactive materials both in a train and while standing in a terminal. The primary intent of these controls is to minimize the possibility of explosion or fire caused by other materials in the train in close proximity to radioactive materials.

Routing and Movement - [49 CFR 174.582]

Carriers are required to assure that shipments go forward promptly.

Accidents - [49 CFR 171.15-16 and 174.588(c)]

Carriers are required to notify DOT and the Shipper immediately in event of serious accident or fire, breakage, spillage or suspected contamination involving radioactive materials and are advised to notify the AAR and ERDA for assistance, if needed. Both ERDA and Shippers are prepared to make available promptly any assistance that is requested.

Appendix II

Decision Theory and Its Application To the Special Trains Case

Outline of Decision Theory

A concise, yet quite general, presentation of the ideas of decision theory is contained in the diagram of Figure 1 which shows the anatomy, or structure, of a general decision problem. At the point of decision we have various "indications" or items of information. With this information we are faced with choosing between the various decision options A, B, C, . . . etc.

If we knew what the outcomes of the various options would be, we would have little trouble making a choice. What makes the problem interesting is that there are a number of possible outcomes, or ultimate results, from each decision option. So at this point the diagram represents the range of possible outcomes coming from each decision option and indicates the probability (likelihood) of each such outcome. Thus, if option A is chosen, the probability is p(A1) that the outcome will be A1, p(A2) that it will be A2, and so on.

Each outcome, if it occurs, does not have just a single effect; it usually has a number of effects -- effects on people, property, environment, costs, etc. In general then, one can make a list of all these effects or impacts. This list is what we call the impact "vector"

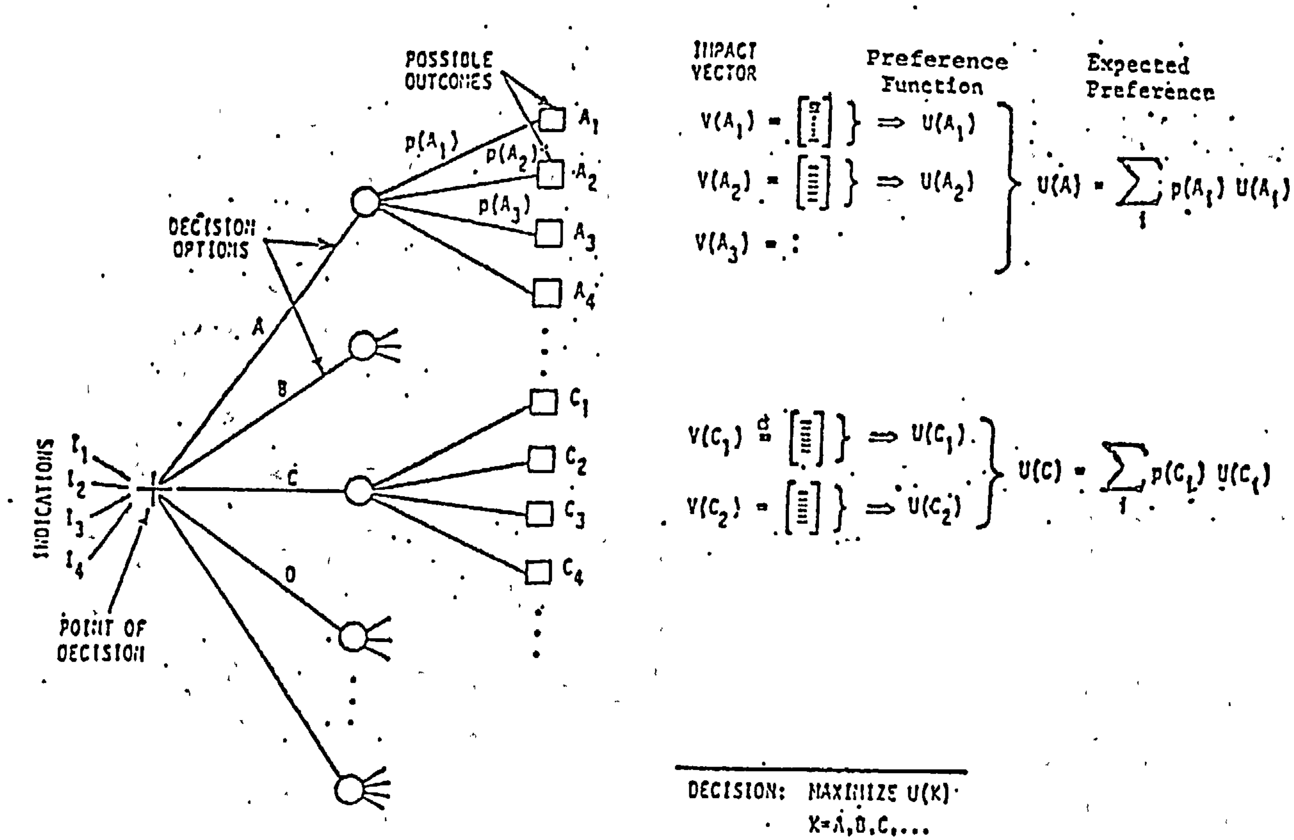

FIGURE 1. ANATOMY OF A DECISION

where the word vector connotes, as usual, that we are talking about a multiple valued, rather than a single valued, quantity.

In general, certain of the impacts, i.e., the individual items in the list, will be desirable, and some will be undesirable. Yet they come all together as a set in the impact vector. The set as a whole then may be desirable or undesirable and any given set may be more or less desirable than any other set. Thus, with respect to the collection of impact vectors we will have in our minds a notion of "ranking" or "preference". That is, we will prefer one set of impacts to another. We could express this preference by assigning a numerical value to each impact vector. This numerical value is often called the "utility function". So each impact vector has a "utility" associated with it which expresses our degree of preference for that set of impacts.

Each possible outcome of the decision thus also has a "utility" value assigned to it. And the "expected utility", then, for any decision option is the sum over all possible outcomes of that option, of the probability of the outcome times the utility of the outcome.

The "optimal" decision then is that option which has the largest expected utility. Note that within this general framework we regard no decision as just another decision option -- it has its own outcomes and impacts.

Application to the Special Train Question

In order to place the special train question within the general forumlation of the last subsection, let us imagine that we have a specific shipment of spent fuel to make. At the point of decision then, we have a choice of sending this shipment by special train or regular train.

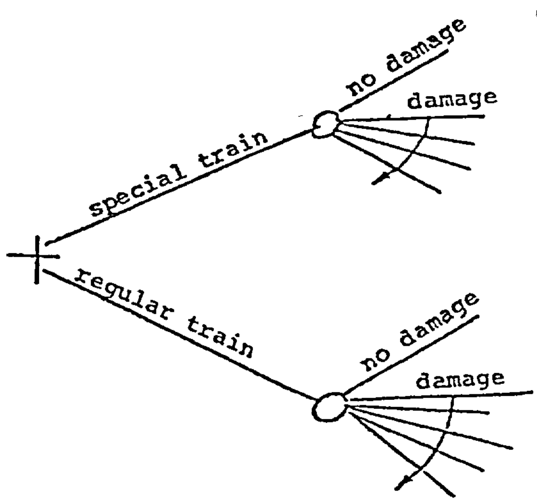

FIGURE 2. SPECIAL TRAIN DECISION TREE

The outcome or consequence of most interest to us is the degree of damage to people as a result of possible release of radioactivity to the environment. Either there will be a release during the shipment or there will not. If there is, it may be of varying quantities at various locations with various consequences, etc. Thus, in concept there is an infinity, a whole continuum, of possible "bands" of outcome possibilities. Likewise in concept there exist probability density functions erected over the bands of outcomes. The question we wish to resolve is what are these probability functions and how do they differ on the special and regular train branches of the decision tree shown in Figure 2.

These probability functions may be visualized in graphical form as a risk curve, Figure 3.

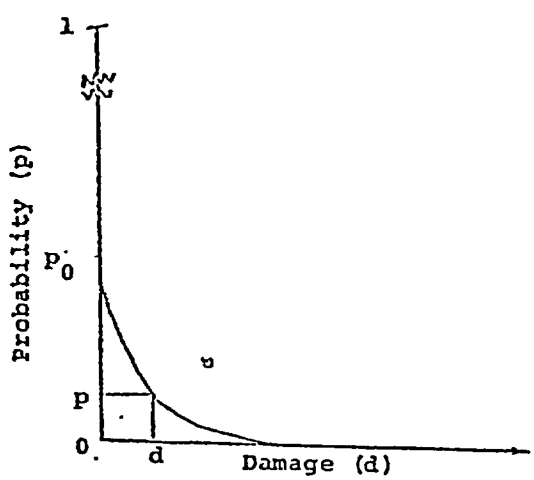

FIGURE 3. RISK CURVE

The ordinate, p, of this curve at any point d on the abscissa expresses the probability that as a result of this shipment we will have damage to the public of amount d, or greater. This curve thus tells the total risk story in far more complete fashion than one can by speaking in terms of "mean" or "expected" values. Observe that the curve starts at a value p_o, much smaller than one. The difference 1 - p_o in fact is the probability that there will be no damage at all to the public in this shipment.

Data are not available from which to plot a risk curve for special trains. The Draft EIS assumes that the risk is less for special trains. The contrary may well be true. But, if a risk curve could be plotted for special trains and if it was lower than the risk curve for regular trains, the difference between the two curves would represent what would be gained by going to special trains.

The other impact of importance is the costs, ultimately to the public, of going to special trains. This must be included in the impact vector for if there were no extra costs, we would of course opt for the lower curve regardless of how low the curves are or how small the difference between the curves. On the other hand, if there is extra cost, and if the probability p_o and the possible damage values are sufficiently small, then it would not be worth going to special trains even if the special train curve were reduced to absolute zero.

The impact vector therefore consists of two components: cost and damage. The damage must be expressed probabilistically for the two options; the cost can be expressed deterministically from the rates for special and regular trains. The decision then rests on the utility function applied to the impact vectors, which is to say whether the reduction in risk, if there is one, is worth the extra cost.

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DEPARTMENT OF LAW

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PHILIP WEINBERG
ASSISTANT ATTORNEY GENERAL
IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

97.

August 25, 1976

Director
Office of Standards Development
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Re: Comments on the Nuclear Regulatory Commission's Draft Environmental Impact Statement on the Transportation of Radioactive Materials (NUREG- 0034)

Dear Sir:

The New York State Attorney General has submitted a series of comments to you on certain portions of the above-referenced document.

Further consideration of this document has illuminated several other deficiences in the presentation which have been numbered according to the prior Resnikoff-Skinner comments.

48. Your analyses have considered impacts of transportation accidents in terms of population dose only. Careful consideration must be made in the final document of the clean-up costs of all postulated accidents as well as a qualitative description of the inconveniences suffered by residents adjacent to and within accident contamination zones.

49. Your analyses should contain reviews of typical accidents which have already occurred and the costs and difficulties of clean-up at each. These reviews should include plutonium clean-up operations at Thule, Greenland and Palomares, Spain.

50. No discussion appears in the alternatives section concerning the impact of facility location on the severity of accidents and the probability of their occurance.

51. Many accident modes within each transportation pathway have been overlooked. Such likely occurences as fork lift puncture and container leakage are not treated in each pathway.

52. No discussion in the Draft Impact Statement can be found relating to errors in record-keeping, radiation monitor errors, container maintenance hazards, and other miscellaneous causes of inadvertant over exposure to the public during transportation.

We hope these comments will further assist you in preparation of a thorough Final Environmental Impact Statement on Transportation of Radioactive Materials.

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
By

PETER N. SKINNER P.E.
Environmental Engineer

JANET WILLEN
Environmental Investigator

PNS:FC

ASSOCIATION OF
AMERICAN RAILROADS
LAW DEPARTMENT
AMERICAN RAILROADS BUILDING · WASHINGTON, D.C. 20036 · 202/293-4096-97

HARRY J. BREITHAUPT, JR.
Vice President and General Counsel

DOCKET NUMBER
PROPOSED RULE PR-71,73

(98)

DOCKETED USNRC SEP 17 1976 Office of the Secretary Docketing & Service Section

September 14, 1976

Mr. Samuel J. Chilk, Secretary
Nuclear Regulatory Commission
Washington, D. C. 20555

Re: NUREG 0034 - Draft Environmental Statement on the Transportation of Radioactive Materials by Air and Other Modes

Dear Mr. Chilk:

I have received a copy of the letter dated August 26, 1976, addressed to you by Mr. Joseph DiStefano, Attorney for the Energy Research and Development Administration, in which he questions the credibility of certain conclusions contained in the five Verified Statements furnished to me by member railroads and enclosed with my letter to you of June 25, 1976. Since the AAR is not a party to ICC Docket No. 36325, Radioactive Materials, Special Train Service, Nationwide, or related proceedings, I have not had access to any of the data referred to in Mr. DiStefano's letter and cannot determine the credibility of that data.

My purpose in writing to you initially was to advise your Commission that experienced railroad officers in the ICC proceedings had expressed conclusions on special train service which were contrary to the conclusions stated in the Draft Environmental Statement. As I understand, the evidentiary record in the ICC proceedings is not closed as yet, but I feel confident that when all of the facts are made known, the railroad officers' conclusions will be fully supported and verified by such facts. The ICC proceedings will be very informative on special train service, so I would hope that the Nuclear Regulatory Commission would not

Acknowledged by card 9/17/76 ...

make a statement concerning special train service in its final Environmental Statement until all of the facts are developed in those pending proceedings.

Very truly yours,

cc: Mr. Joseph DiStefano, Attorney
U. S. Energy Research and
Development Administration
Washington, D. C. 20545

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
WASHINGTON, D.C. 20545

AUG 26 1976

(99)

DOCKET NUMBER
PROPOSED RULE PR-71,73 (40FR23768)

DOCKETED USNRC DEC 9 1976 Office of the Secretary Docketing & Service Section

Mr. Samuel J. Chilk
Secretary
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Chilk:

NUREG 0034, DRAFT ENVIRONMENTAL STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIALS BY AIR AND OTHER MODES

We recently received a copy of a letter dated June 25, 1976, to you from Mr. Harry J. Breithaupt, Jr., General Counsel, Association of American Railroads. He enclosed copies of certain verified statements of the railroads in Docket No. 36325, Radioactive Materials, Special Train Service, Nationwide, now pending before the Interstate Commerce Commission. He apparently did not enclose the verified statements of the other parties, nor the transcript containing cross-examination of any of the witnesses. In order that you will be assured of having the complete ICC record for your files, we are transmitting herewith a copy of the entire evidentiary record to date in Docket No. 36325 as well as a copy of ERDA's brief in Docket No. 36307, another ICC proceeding involving the transportation of radioactive materials. We have omitted the following exhibits from the copy of the record in Docket No. 36325:

> Exhibits No. 15, WASH 1238; No. 16, NUREG 75/038; No. 20, film; No. 26, NUREG 0034; No. 55, photograph; No. 56, photograph; and No. 57, photograph.

We do not have additional copies of Exhibits 20, 55, 56, 57, which, however, can be made available to you upon request on a loan basis; and, of course, Exhibits 15, 16, and 26 are readily available to you.

Mr. Breithaupt criticizes NUREG 0034 in his letter for its alleged failure to take into account the "special service" that would be afforded by the special trains that the railroads would force the shippers of spent fuel and radioactive waste to use. Mr. Breithaupt claims that the special handling connected with special trains "virtually eliminates accidents," based on the statements of five railroads that in their experience there had never been an accident of any sort involving a special train operation.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

First, our information is quite different. There is evidence that there have been special train accidents (e.g. Tr. 1203, 1229-31); and it is the opinion of a respected witness with 40 years of operating experience on the railroads that a special train is no safer than a regular train (Tr. 1226).

Second, the comparative safety of special trains is essentially beside the point, because the transportation of spent fuel and radioactive waste in regular trains entails such a very low risk. In this connection, we refer you to the testimony and cross-examination of Robert F. Barker of the NRC staff, and of B. John Garrick.

The very high cost of special train service is described in the testimony of Murray Chais for ERDA and that of several other witnesses for the industry. Accordingly, the statement in NUREG 0034 that "the use of dedicated trains does not appear to be cost-effective," is fully supported by the ICC record, and indeed understates the waste of resources that would flow from the mandatory use of special trains for the transportation of all spent fuel and radioactive waste.

Sincerely,

Joseph DiStefano

Joseph DiStefano
Attorney
Office of the General Counsel

Enclosures:
As stated

cc: Mr. Breithaupt, AAR
Attorneys of Record in
ICC Docket 36325

Due to its bulk the evidentiary record was not reproduced. It has been reviewed by Standards Development and will be on file in the Docketing and Service Branch.

APPENDIX K

COMMENTS ON THE DRAFT FINAL ENVIRONMENTAL STATEMENT

DATED FEBRUARY 1977

Comments on NUREG-0170

by

Karl Z. Morgan
February 25, 1977

RECEIVED
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U.S. NRC ... COMM.
ADVISORY ... ON
REACTOR SAFEGUARDS

1. When Dr. C. Siess announced and Dr. D. Hopkins confirmed at the Atlanta meeting that NUREG-0170 in its present form was essentially the final manuscript for the NRC Impact Statement on Shipping, some of the persons attending this meeting—and especially some of the consultants—had the feeling that maybe we had wasted our time reading this material and attending the meeting. Perhaps there is a compelling reason why this material must be rushed into print, but it is a shame that the published report cannot be modified in such a way as to benefit from the numerous constructive criticisms expressed at this Atlanta meeting. Although, in many respects NUREG-0170 is more carefully prepared than many other NRC documents I have reviewed, it is far from a polished publication; it fails to answer satisfactorily several questions raised at the meeting, and in some cases lacks clarity and makes it possible for the reader to arrive at wrong and unintended conclusions.

2. The final drafts of the papers under review did not reach the hands of the consultants and many of others who might have input to the meeting. Usually, I like to check equations and verify a few of the calculations by spot checks, but, because of the shortness of time, no one could do a good job of this. This is especially true for busy persons who cannot drop everything else a few days before the meetings.

3. My general impression of NUREG-0170 is that it is not an attempt to assess the effects on health and the risks of surreptitious diversion of fissile or radioactive materials during shipping, but rather an attempt to prove the effects on health and the risk of surreptitious diversion are completely negligible. Sometimes there is only a shade of difference in these two styles of writing, but the effect of one is concurrence and acceptance of the public and the result of the other is a challenge to the public to show the NRC is wrong. The job of the NRC would be easier if the public were made to believe NRC was simply stating the true facts and

explaining their meaning. Nuclear energy could sell itself better sometimes without the aid of a salesman.

4. I do not believe this report treats adequately the long term problems of wide spread contamination of a city by plutonium and transplutonium following a major shipping accident. In Rocky Flats, Colorado, we have many square miles contaminated with plutonium above the 2.2 dpm level and this contaminated desert land is resulting in serious immediate and long-term problems. Not many persons would care to live in a building or make their home in a city that is badly contaminated with plutonium.

5. I think a poor case is made for shipping plutonium and transplutonium material by air.

6. The cost comparisons for shipment via air, truck, train and barge are biased because of transhipments at each end. What would be the cost (in man-rem) were barge or train terminals located at all nuclear facilities? In a proper comparison, I believe the man-rem cost by rail would be about 1/10 that by truck and the cost by barge would be about 1/100 that by truck.

7. I would like to see the estimated saving in costs (in man-rem) were we to completely change our future nuclear power program and do the following:

a. Discontinue the LMFBR program for the present.

b. Establish large reactor parks over suitable bedded salt formations such that:
   1) High level waste would not have to be shipped
   2) Build converter (Pu+ ^{232}Th + ^{233}U) reactors at the parks
   3) Denature the ^{233}U with ^{238}U when it is shipped outside the park to reduce the risk of hijacking and diversion.
   4) Have proper isolation of these parks
   5) Several studies at Georgia Tech suggest Th-breeders are possible which would have a negative void coefficient in the coolant, and would have a doubling time much less than that of the LMFBR.
   6) Pu and trans-Pu elements would not be produced
   7) The problems of ^{232}U and ^{234}U production in the Th cycle are minor compared with the Pu problems.
   8) Of course, the parks would have fuel reprocessing and fabrication plants as well as power reactors (convertors and breeders).

8. I think NUREG-0170 should have given more attention to the recommendation of the Special Panel to Study Transportation of Nuclear Materials and its report to the JCAE of Congress (December 17, 1974).

9. It was indicated by Mr. Hoppins in answer to my question that some of the shipping containers that were improperly designed and approved by the AEC (now NRC) are still in use under the grandfather clause. This presumably includes the C-10 industrial source shipping container which occasioned the serious accident into Atlanta in which I became involved a few years ago. It was indicated that NRC places reliance on administrative control rather than upon safe design in these cases. I think this is a very serious situation because unless the operator is careful about what he is doing, the source will be pushed outside the C-10 shipping container where no shielding protection is provided. I think NRC must share responsibility for any accidents that result during the term of the grandfather clause because it (or the AEC) is responsible for this ridiculous design in the first place.

RECEIVED

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Battelle

Pacific Northwest Laboratories
Battelle Boulevard
Richland, Washington [illegible]
Telephone (509) 946-2222
Telex 32 6345

March 1, 1977

[illegible] ADVISORY [illegible] REACTOR SAFEGUARDS

Mr. G. R. Quittschreiber
Senior Staff Engineer
Advisory Committee on Reactor Safeguards
Nuclear Regulatory Commission :
Washington, D. C. 20555

Dear Mr. Quittschreiber,

At the conclusion of the Working Group Meeting on Transportation, Atlanta, Georgia, February 24, 1977, Chairman Siess invited the consultants to submit comments on the review of NuReg-0170. We understand that the Working Group is not proposing to advise NRC on this topic at this time.

Therefore, the following comments are intended solely to document my personal concerns.

I am disappointed to discover that it is proposed to publish NuReg-0170 in essentially the form discussed on February 24. Despite the evident care that has gone into this preparation, I believe that the end-product is far less useful than it could have been. I understand that it started in support of proposed rule-making concerning air transportation of radioactive materials (Federal Register June 2, 1975). Such a study would have considered alternatives to air transport but only for such packages as a reasonable person would have contemplated sending by air as one option. That vital distinction has not been observed so that one immediately becomes involved with the whole gamut of transportation scenarios.

The new lists of package types for standard shipments are impressive in two ways:

1. They are so different from the earlier NuReg-0034 versions in number and activity that one wonders whether a third look would bear any resemblance to either -0034 or -0170 tallies.

2. They contain packages whose "hazard properties" are polar extremes. For example, a typical radiopharmaceutical source

is a short-lived gamma emitter requiring some heavy material shielding for normal transport. If it is either misplaced or damaged in transit, it is not likely to be very hazardous. At worst, the effect is gone in a relatively short time. At the other extreme is the long-lived alpha emitter. In this case the hazard in normal transport is essentially zero. In an accident capable of releasing the product, one has the long-term risk of contamination.

In NuReg-0170 the so-called alternatives group all these classes together so that real differences between modes tend to cancel each other out.

The quoted differences in health effects for the various scenarios, are in my opinion below the uncertainty level of any of the calculations of risk and cost-effectiveness.

I, for one, believe that air shipments should be limited to cases where speed is of the essence*--in practice, to the radiopharmaceutical case, where the public does accept a compensating social benefit. If that analysis had been made separately it would at once have been clear that innovative alternatives have not been included. As examples, let it be assumed that estimated doses from air shipments are too high. Then, at the source of the transportation web, one must analyze the merits of radiopharmaceutical preparation at more and better chosen locations. Upon loading on planes, one must consider packaging with one thick shielding face under the passengers instead of conventional equal shielding on all sides.

At the natural terminals, usually large cities with clustered hospitals, one must examine the possibility of underground tube delivery, and so on.

For other modes of transportation, one should make the alternatives for <u>each generic type</u> of shipment--not for all taken together.

The above steps seem to be necessary to develop an environmental statement of adequate sensitivity. There are many minor points to be raised of which the following are examples.

a. The above scenario was predicated on the assumption that dose from air shipments was too high. Table IV-19 (p.IV-55) displays an annual individual dose to an airline passenger of 108 mrem, which translates the issue from assumption

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* These comments are a more simplified exercise than the detailed rule-making. For example, I could accept the reasonableness of helicoptering survey sources to otherwise inaccessible locations, where special circumstances other than speed prevail.

to fact. In view of the NRC's efforts to get reactor fencepost doses down to the range of 10 mrem/yr, casual acceptance of 108 mrem/yr for an unsuspecting passenger is incredible. Surely the ALARA principle calls for reduction by about one order of magnitude.

b. It is somewhat difficult to fault the authors in their attempt to use numerical health effects such as a Latent Cancer Fatality Index. The plain truth is that whatever figure is used, vociferous objectors will appear quoting studies of their choice with different results, not a single one of which is definitive in 1977, nor likely to become so in the 20th Century. Yet the -0170 approach must be faulted on two counts:

   1. Genetic effects are excluded on the grounds of scarcity of information. Curiously, this is one area in which there is essential agreement on a dose and dose-rate effect. There is no real way to add genetic effects and cancer fatalities on a common scale, but some arbitrary allowance has to be shown.

   2. There is much more scarcity of information on the somatic side than is reflected by an LCF Index of 121.6 per 10^6 person-rem. The implied precision for a number that may be 12 (or even zero) on the one side or perhaps 600 on the other side is entirely out of place. The best efforts of NRC to set dollar indices such as $1000 per person rem, or $8 million per LCF simply cannot be accepted.

c. Some of the basic dosimetry equations need better support. Even the point source formulation

$$\frac{Ke^{-\mu D}B(D)}{D^2}$$

where μ is some formal absorption coefficient and B(D) is a Berger build-up factor is arbitrary. The relevant absorption factor is rarely well known and the build-up factor is both empirical and terrain-variable. What is known is the total energy emitted from any well described source. Then, the integration of energy absorption over all space would demonstrate the appropriateness of the combinations of μ and B(d) used.

In the integration of dose at a point from a source moving uniformly in a straight line, we have mathematically the same issue as dose at a point from a uniform line source, the familiar Sievert equations published in Acta Radiologica in 1928. Formal demonstration of this equivalence would have improved confidence in the result.

In the second stage of double integration as in Fig. D-2 of p. D-4, the same result should be obtained by integrating the dose from an infinite disc of radioactive material (also a familiar Sievert equation) as the receptor moves uniformly across a diameter.

Sincerely yours,

H M Parker

H. M. Parker
Consultant

Copies to: Dade Moeller
J. W. Healy
K. Z. Morgan

SAFE ENERGY
ENVIRONMENTALISTS INC.
FOUNDED 1972

TO: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

FROM: ENVIRONMENTALISTS, INC., a non-profit South Carolina Corporation

SUBJECT: NUREG -0170

DATE: FEBRUARY 24, 1977

Environmentalists, Inc., is a non-profit public education organization existing in South Carolina. This group has a strong interest in potential existing problems surrounding shipment of radioactive materials. In addition to studying nuclear fuel reprocessing for five (5) years, the organization is officially intervening in the licensing proceedings for both the Barnwell Nuclear Fuel Plant and the Barnwell Fuel Receiving and Storage Station. Obviously, the transportation of radioactive materials by any mode will have a significant environmental impact. Environmentalists, Inc., recognizes the importance of having a well-documented and realistic estimate of such impact. On behalf of Environmentalists, Inc., this statement is submitted to ACRS for its consideration.

We know of no report which adequately assesses the outcomes of transportation of radioactive materials. Estimates of the radiation doses to the public from the shipment of radioactive materials presented in the Draft Environmental Impact Statement on the Transportation of Radioactive Materials by Air and Other Modes, NUREG-0034, are based on incomplete and incorrect information. The following examples are among the numerous deficiencies:

1. The impact of transporting radioactive nuclear materials associated with nuclear weapons is excluded.

Continued . . .

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2. Accidental releases are not among the factors included in the models used to calculate radiation dose predictions.

a) The long-term detrimental environmental impact from a major transportation accident, such as an unplanned release of radioactive materials, is not included in the models used to calculate radiation dose predictions. The pathways by which such radioactive releases might continue to increase the public's exposure to radiation are not considered.

b) The cumulative impact from frequent small leaks, the escaping of radioactive materials due to such human error as not fastening an opening securely, failures of gaskets and other equipment, highway, rail, air, and barge incidents that may not be reported are among the exposure increases which have been excluded.

3. The increase of radiation exposure to the public and to workers at those points where delays in shipment occur are not included as part of the model calculations, i.e. on highways, in rail, air, and barge transport, during switch operations in freight yards, and at transfer points.

4. The failure to calculate radiation exposures with consideration for the converging of transportation routes to one central point is conspicuous.

5. The study fails to include an estimate for the releases that might result during hijacking, theft, and other terrorist activities.

6. There is an absence of any evaluation of genetic damage resulting directly from transportation activities or indirect damage to the gene pool from such activities.

Continued . . .

7. The study fails to reveal whether or not the "No Threshold/Linear Hypothesis" is utilized in assessing the impact on public health. Any amount of man-made radiation is damaging and is an added harm over and above the harm done by natural radiation.

8. The study fails to prepare a number of models which would be relevant to special areas. Many vicinities will be receiving radiation exposure from a number of sources: nuclear power plants, waste handling facilities, weapons operations, etc.

9. The study fails to take into account the varying qualities of rail points in existence on the various routes proposed.

The defects in calculating and assessing the effects of radiation exposure due to the transport of radioactive materials make the existing report practically useless. Environmentalists, Inc., is most concerned about transportation activities associated with the various Barnwell facilities. The Barnwell area will be the terminal of many transportation routes. The population will be exposed to radiation not only from numerous shipments, but will be exposed to accidental and normal releases from the Savannah River Plant, BNFP, converging transportation routes, Chem Nuclear waste handling, nuclear submarine base, nuclear power plants --- including leaks to the drinking water. NUREG-0170 will be of small value in assessing the environmental impact of the Barnwell operations.

We question the use of taxpayers' money for a report which appears to have little if any use. The report does not follow the provisions of NEPA. The alternative section does not include discussion of the possibility of not transporting nuclear materials nor the alternative of halting the use of nuclear energy.

Continued . . .

The cost-benefit analysis fails to quantify many of the transportation costs and some are not even listed.

Environmentalists, Inc., regrets not having had the opportunity to make initial comments on NUREG-0034. However, since NUREG-0170 appears to have such little merit, we anticipate a redundant study for the purposes of licensing the Barnwell facilities.

G P I R G

Georgia Public Interest Research Group, Inc.
201 Washington Street SW
Atlanta, GA 30303
(404) 659-7082

G-PIRG COMMENTS CONCERNING NUREG-0170 FINAL ENVIRONMENTAL STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY AIR AND OTHER MODES

The Georgia Public Interest Research Group (G-PIRG) is a private, non-profit organization concerned with consumer and environmental issues in the state of Georgia. We would like to thank the Advisory Council for the opportunity to present these comments.

Before commenting, we would like to express our concern of the adequacy of notice for this meeting. There has been no notice that NUREG-0170, a lengthy and complex document, was schedule for release. The most recent notice in the Federal Register announced an ACRS meeting "to review public comments on NUREG-0034 'Draft Environmental Statement on Transportation of Radioactive Materials by Air and Other Modes'." There was no mention of comments on the Final Draft NUREG-0170. Finally, NRC's Regional Office did not receive verification of this meeting until fourteen days prior to date.

In light of these facts, and because of the inability of G-PIRG and other interested parties to adequately review the document under consideration, we strongly urge that the Advisory Council schedule an additional public meeting with 60-days notice to each agency or group represented here today.

G-Pirg's chief concern with the Final Draft Environmental Statement is with the adequacy of treatment accorded coordination between State and Federal Authories. There are twenty Federal and State agencies that could be called upon to act in the event of an incident. The instant document does not adequately deal with this problem.

The New York Department of Law asked similar questions in a letter to NRC dated May 17, 1976. The NRC failed to sufficiently address the issue. For example, there are no regulations or plans for communication equipment or frequent contact between local law enforcement agencies along truck routes (see VII-10). Nor does NRC's answer deal with distances, transportation, or communications between airports (see VII-11) or with regulations concerning "airport security personal" as stated in VII-11, or airplane security personal.

G-PIRG also feels that the FES should have focussed more attention on the issue of financial responsibility in the event of an incident. Will the costs be borne by the agencies involved or by the carrier? If by the former, how would the liabilities be apportioned?

G-PIRG also feels compelled to ask who is responsible for the planning and approving of routes and times of travel and for the notification of checkpoints. These activities are vital in the effort to reduce the risk of incidents. Again, these questions are not sufficiently dealt with in the FES.

Finally, G-PIRG cites the NRC for not confronting the potential problem of non-compliance. It is naive to assume that the regulations will be followed merely because they exist. We are mindful of the Brown's Ferry incident. G-PIRG also submits that it is extremely unwise to accept "industry practices" as assurances of compliance.

In conclusion, we feel that the potential dangers of transport of radioactive materials are great enough to warrant an unhurried and careful consideration of all the issues and ramifications. These risks are particularly acute to Atlanta and to Georgia because of their location at the crossroads of America's transport links and because of their proximity to the Barnwell Nuclear Reprocessing Plant. In light of t is, G-PIRG urges more thorough attention to the issues addressed in this paper and to the convening of another public meeting in Atlanta concerning NUREG-0170 with proper advance notice to all interested parties.

- Sharon Collings,
  Project Coordinator

- Larry Katzman,
  G-PIRG Executive Director

The Georgia Conservancy

3110 MAPLE DR., SUITE 407 ATLANTA, GEORGIA 30305 TELEPHONE: 404/262-1967

THE GEORGIA CONSERVANCY
COMMENTS GIVEN FEBRUARY 24, 1977
BEFORE THE ADVISORY COUNCIL FOR
REACTOR SAFEGUARDS ON
NUREG - 0170

FINAL ENVIRONMENTAL STATEMENT ON THE
TRANSPORTATION OF RADIOACTIVE MATERIAL
BY AIR AND OTHER MODES

Docket N PR - 71,73 (40 FR 23768)
February, 1977

Before making specific comment on various issues contained in the Statement, we first wish to express our vigorous disapproval and criticism of the lack of notice to interested parties, and the inadequate time interval between publication and availability of the material on which comment was solicited and the date set for the public hearing. The impossibly short time period between availability and the date set for comment evidences on the part of the NRC either a lack of competence in establishing and meeting reasonable time schedules or a lack of sufficient consideration for the schedules of those for whom the hearing is held.

Whether due to incompetence or unconcern, the result is burdensome to public participation and lowers the quality and value of the hearing. We deeply resent such a cavalier approach by a Federal Agency created to serve the public interest.

It is self evident that a generic statement such as this is inadequate to meet the needs of specific areas of the Nation where a concentration of nuclear facilities or a convergence of transportation routes to such facilities create circumstances demanding independent and detailed treatment. This is particularly true of Georgia, where the presence of the Savannah River Plant, Chem-Nuclear low level waste storage facility, Barnwell Nuclear Fuel Reprocessing Plant, together with the proposed Posiedon Base at Kings Bay, nuclear reactors, weapons systems and weapon components within the State, medical radio-pharmaceutical, industry, etc. will funnel a disproportionate shore of hazardous nuclear materials through Georgia's rails, highways, waterways, and airways. A separate Environmental Impact Statement incorporating the aggregate and cumulative effect of such activities is a minimal requirement for the understanding and protection of those asked to accept and support their existence. We need a comprehensive study of precisely what is moving through and to our State now, and a projection for 1985 and beyond.

(1) The cost for land reclamation of a radiation accident site is stated to "exceed $200 million" in the Summary and Conclusions. However, table V-14 shows the cost of decontamination being as high as $8.21 billion which is 40 times as much cost. We therefore find it materially misleading to include only the lower figure in the summary statement.

(2) As seen by the above comment, the possible costs resulting from a radiation transport accident are enormous. It appears that insufficient attention has been given to the question of who will be responsible for absorbing these costs and their financial ability to pay. It is questionable that the shipper would be able to cover such costs and the State of Georgia should certainly not be required to bear the responsibility for reclamation and decontamination.

What provisions have been made for assurances that these costs are paid?

Will the Federal Government be prepared to cover such costs? Through what mechanism?

(3) It's apparent that the accident risks and health effects due to a given accident are directly tied to the frequency of shipments and routes of transport. The full impact of radioactive transport on the State of Georgia or communities in the State cannot be fully assessed without adequate information on these factors.

Is information on the projected frequency and routes of shipments available to the State of Georgia and concerned citizens?

It is imperative that the State be provided with advance notice of radioactive shipments and that the State be given the option of prescribing acceptable routes and times of transport.

It is our understanding that the State of Florida is already pursuing this option.

Is there provision for Georgia to exercise this right?

(4) The magnitude of health effects following a radioactive transport accident will obviously depend to a large degree on what immediate action is taken at the accident site to minimize these effects.

Has an established procedure been developed for handling such an event and have responsibilities for specific activities been fully defined?

For example, who will be responsible for radioactive monitoring, for evacuation of adjacent areas, for retaining contaminated people at the site, for decontamination of the accident site?

We question whether there are even adequate medical and personnel decontamination facilities in Georgia to handle victims of such incidents.

(5) We question whether all reasonable alternatives have been considered to reduce the environmental effects of radioactive transport. For example, the alternative of limiting the amount of radioactive material transported should be addressed. This would include limiting the number of nuclear power plants in the country to those now in operation or under construction. This would significantly reduce the risk of adverse environmental effects due to transport, and particularly in Georgia, it would help to minimize the amount of nuclear materials transported across the State to and from the Barnwell, South Carolina Reprocessing Plant.

(6) Spent fuel shipments are specifically exempted from physical protection requirements of 10CFR Part 73. No discussion of special precaution or less rigorous methods of protection proportionate to the risk are discussed. The rupture of a cask is a stated possibility, resulting in a total of 244 predicted deaths (page VII-2). A consequence of this magnitude (or worse, should the cask fall in a water supply for example) merits more serious consideration of escorts or other appropriate types of safety precautions.

The final conclusion of Section VII dealing with special nuclear materials, states that "alternative means of protection --- are neither necessary nor desirable for the protection of privately owned materials." Apart from the highly debatable merit of this conclusion, a more profound question which should be addressed is "What are materials such as these (which have the potential for cataclysmic harm to society in a variety of ways) doing in private ownership to begin with?"

It seems to us that there is a substantial question as to whether bomb grade material should be introduced into the general stream of commercial traffic.

(7) Table VI - 2 sets forth the economics of rail and truck shipments of spent fuel. Do the "costs" include the costs to the State for road damage and maintenance (particularly for overweight shipments), bridge strengthening where needed, increased police coverage and special equipment, if necessary?

Who bears these costs? Sec. 168 of the AEC Act of 1954, as amended, and Sec. 91 of the Atomic Energy Community Act, of 1955, as amended, provide a specific statutory mechanism for the evaluation and determination of the need for financial assistance to local entities which may be affected by ERDA activities.

Would these or similar costs imposed by any of the various modes of transport contemplated by this statement qualify for relief under these provisions?

(8) On Page XXV of the Detailed Summary as one of the long term positive results from the shipment of radioactive materials the assertion is made that the use of nuclear fuels in reactors allows production of electricity for society with lower costs than is possible by more conventional methods of generating electricity.

Statements like the above have for far too long accompanied cost benefit assessments. To state it now, without qualification or supporting data, in the light of increasing numbers of critical analyses which arrive at contrary conclusions, is simply inexcusable.

This is particularly true when it is characterized as a "long term" benefit, implying either (1) an adequate supply of uranium for the indefinite future, (2) the acceptability of plutonium recycle, (3) and/or the economic and environmental viability of a breeder reactor, none of which has or can be demonstrated at the present time.

Cecil R. Phillips
Executive Director
The Georgia Conservancy

The Georgia Conservancy

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3110 MAPLE DR., SUITE 407 ATLANTA, GEORGIA 30305 TELEPHONE: 404/262 1967

ADDITIONAL COMMENTS ON THE FINAL ENVIRONMENTAL STATEMENT ON THE TRANSPORTATION OF RADIOACTIVE MATERIAL BY AIR AND OTHER MODES, NUREG-0170
Docket N. PR-71, 73 (40 FR 23768), February 1977

March 4, 1977

We are pleased to accept the invitation of the Chairman to offer further comment to become a part of the record of this Proceeding. While our additional remarks will be confined to two principal matters, we would like it to be clearly understood that our silence in regard to a variety of other issues is not to be construed as consent or acquiescence, but simply reflects the limitations of available resources to adequately address them in a restricted period of time.

I. We recognize that this meeting was not intended as a "public hearing" in the usual connotation of that term, with the opportunity for full participation. There was, however, a clear expectation that members of the public and other interested parties would attend and contribute to the substance of the meeting by comment.

As a part of the written comment furnished prior to the meeting we expressed our disappointment and indignation at the lack of adequate time between the date when the Final Environmental Statement first became available and the date set for the meeting. We now learn from NRC's Mr. Hopkins that the sole reason for such haste was to meet the exigencies of a lawsuit against the NRC by the State of New York, an admission of an outrageous unilateral decision which passed without a single comment or critical observation on the part of the Ad Hoc Committee.

A further abuse of the rulemaking process, to our understanding of the purpose of the meeting, and to the assembled consultants and members of the Committee, was that, as far as the NRC was concerned, the document was in final form. They intended it to be printed substantially as it now exists, apparently without regard to what may have transpired at the meeting.

II. Among the final matters dealt with by the Committee was the question of what consequences might reasonably be expected as a result of a successful "diversion of special nuclear materials," a question wholly omitted in the Statement itself.

Let us first comment the Committee Chairman for directing the NRC Staff to initiate a study of this question. And now we would like to talk about it for a while.

First we would suggest that euphemistic terms like "special nuclear materials" and "diversion" be deleted entirely from any communication which is intended to enlighten or edify. "Special nuclear material" means bomb grade material and "diversion" means theft. It does not change the nature of a substance or an act to call it something else. The literature of this industry and the agencies governing it is replete with similar efforts to obscure reality. Please stop it. Learn to tell the truth in a fashion that can be understood and dealt with.

In the NRC spokesman's formal presentation on the threat of "diversion," in the following sequence we understood him to say first that "it is impossible to quantify the threat" and later on to state that "any mode of transportation can be protected against any level of threat." Those two statements are totally inconsistent. More importantly, they reveal an attitude, a "way of thinking" as the Chairman expressed it, which in our opinion has characterized the Government's role in the nuclear industry from its inception, and accounts in large part for the growing mistrust and resistance on the part of the public to continued or increased reliance on nuclear power as the sine qua non of our economic existence.

Some years ago Dr. Edward Teller, an outspoken advocate of nuclear power, presented the question of reactor safety as an interesting mathematical problem - "What is the product of zero times infinity?" It is indeed interesting, because the survival of our nation as we know it may depend upon the answers to a number of such questions inherent in the use of nuclear materials as an everyday article of commerce.

The specific question addressed briefly in this proceeding were the probabilities and consequences of theft of bomb grade material. We suggest for your consideration that history supports the view that any human endeavor whose success depends upon achieving "zero defects" is doomed to failure. Recent examples in the realm of technology are the Apollo and SNAPS programs. A similar failure in the field of "anthropology" is exemplified by the actions of Mr. Nixon's staff.

We further suggest that any serious effort to achieve zero probability of failure, whether technological or anthropological, will, in itself, incur unprecedented costs to our society. Financially, power companies are already chafing under the escalating capital costs of nuclear facilities which knowledgeable critics proclaim to be still not safe enough. Societally, you gentlemen calmly discussed the introduction of guards armed with automatic weapons to traverse America's expressways - a profound "environmental impact" upon our society, we should say. We urge you to reflect upon it.

Nuclear power generation has already distorted our judicial system in a variety of ways. Most notably, the ancient doctrine of tort law creating liability to innocent third parties for harm done them by a negligent act has been laid aside to accomodate the growth of this particular industry, and for none other.

Less obviously, but perhaps even more importantly, scientific dissent is quelled, not encouraged, as it properly should be in the search for truth. William Rowe, a ranking official of the Environmental Protection Agency, recently responded to a question on this topic by stating that no effort was made to discourage dissent "except, of course, when it is contrary to departmental policy."

Examples abound. The price already paid or incurred to generate electricity in this way is far greater than that which appears in any cost-benefit analysis. The more we seek to attain zero defects the more the price will rise.

And we have no choice but to seek it, for the consequences of a major failure, whether it be a transportation accident, a successful theft, or any other mode, though not infinite would surely be intolerable. With costs in the billions, and fear of repetition rampant, regardless of who pays what to whom, what do you think would happen? Do you think it would end there? Would a new Rasmussen study placate the public?

And suppose it happens when 20% - 40% of the electrical power of the United States is generated by nuclear fission and you are the President? What do you do?

This EIS is inadequate in failing to consider the above questions. They are being discussed in other forums. As a presidential candidate addressing the Washington Press Club, Mr. Carter predicted that a major reactor accident would mean the end of the nuclear power industry. Dr. Lynn Weaver head of Georgia Tech's nuclear Engineering Department has expressed the same opinion. Countless others share this view. Clearly, it is a credible consequence of any major nuclear disaster, including theft or transportation accident, and should be included in any responsible overall assessment of acceptability.

It seems to us, as it has for a long time now, that, in dealing with the nuclear questions we will remain torn between intolerable risk and intolerable cost.

In summary, then, we ask that these specific matters be addressed:

1. Adequate notice and availability of subject matter to all interested parties in timely fashion.

2. A clarification of language using plain english rather than terminology which tends to obscure fact or meaning.

3. The <u>ultimate</u> consequence of a successful theft of bomb grade materials, or any major credible catastrophe which might occur anywhere in the commercial fuel cycle. Such an assessment should address not just the immediate economic or biological effects of such an occurance as this statement does, but the predictable events which are likely to ensue, including the possible shutdown of the industry and the attendant disruption in our economy and other major effects (on our foreign policy for example). Alternatively, if the plants are not closed, what effect on public and worker morale? And to production costs if more stringent safety features were demanded?

4. A more comprehensive review of the societal effects of efforts to shield from error, accident, or misuse ultra-hazardous materials in huge quantities as a day-to-day commercial enterprise. We have identified a few examples:

(a) Civilian guards armed with automatic weapons. What effects, subtle or overt, on travelers sharing the expressways and the general public? What specific instruction to the guards as to their response in a wide range of potential encounters, both real, or as they may be perceived by the guards in a sudden and unexpected confrontation? What quality of individual is contemplated to be recruited and entrusted to bear these weapons? What program of indemnification and financial responsibility on whose part for error in selection, training, supervision or performance?

(b) What surveillance systems are specified and in place to identify and monitor potential threats to transportation of nuclear materials? The statement was made that there are no known groups who have the motivation and capability to successfully divert bomb grade materials. Who made that determination? The FBI? The CIA? The NRC? Is the dollar cost of acquiring and maintaining such information charged to the public generally, or is it internalized and accounted for in the cost-benefit analysis? Apart from financial cost, what loss of freedoms is likely to occur to individual citizens? Will there be increased numbers of phone taps and similar encroachments on privacy deemed necessary to adequately protect these materials? Will the need to protect them result in the successful passage of legislation such as that proposed in the State of Virginia to grant to the Virginia Electric and Power Co. a variety of police powers?

(c) What additional effects can be expected in our judicial and political systems to protect and encourage nuclear power generation? We have identified the abandonment of tort liability, the repression of dissenting opinion, and the extension of police powers to private firms. Will the states be preempted by the Federal Government from a voice in nuclear plant siting and the regulation of nuclear materials transported within their borders? Is that good or bad? Who decides? These are not frivolous questions and they are not adequately considered (if addressed at all) in the Final Environmental Impact Statement. We think they should be.

James T. Mills
Chairman, Energy Sources Committee

Cecil R. Phillips
Executive Director
The Georgia Conservancy

J. LEFKOWITZ
RNEY GENERAL

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PHILIP WEINBERG
ASSISTANT ATTORNEY GENERAL
IN CHARGE OF
ENVIRONMENTAL PROTECTION
BUREAU

April 29, 1977

Director
Office of Standards Development
United States Nuclear Regulatory
Commission
Washington, D.C. 20555

Re: The Nuclear Regulatory Commission's Environmental Statement on the Transportation of Radioactive Materials (Draft: NUREG-0034, Final: NUREG-0170)

Dear Sir:

Pursuant to the Notice of Availability of the above-referenced Draft Environmental Impact Statement ("DES") published at 41 Fed. Reg. 12937 and the solicitation of comments on that DES as contained in the Notice of Availability, the New York State Attorney General submitted a series of comments on the DES. It was noted in the Attorney General's filing of May 17, 1976 that the DES did not address the issues set forth in the materials previously submitted by the office to the NRC in the course of this administrative proceeding on transportation of nuclear materials as originally noticed in the Federal Register. 40 Fed. Reg. 23768 (June 2, 1975). More specifically the DES did not address the materials submitted by way of this office's letter, dated July 2, 1975, which letter and materials are apparently on file in the Commission's public docket room.

It has been brought to our attention that, as with the DES, the unreleased final environmental impact statement ("FES") ignores the above described materials and, in part, subsequent filings. In addition, we have been informed that certain comments are dismissed as being based on "unconfirmed analysis." Such a response to the comments, calculations and estimates of this office is meaningless and displays a failure by staff to resolve factual disputes. All the comments and supporting materials filed by this office must be responded to in a thorough manner in order for the Commission to comply with the Guidelines of the Council on Environmental Quality under the National Environmental Policy Act, 42 U.S.C. § 4321 et seq. It is particularly appropriate for the Commission to attend to this matter now in view of its recent decision to have the FES redrafted.

For your convenience, the filings by this office which have been incorporated into its comments include

letter and enclosures dated July 2, 1975
letter and enclosures dated August 12, 1975
letter and enclosures dated February 23, 1976
letter and enclosures dated May 17, 1976
letter (from John F. Shea, III) and enclosures (comments By Dr. Marvin Resnikoff and Peter N. Skinner, P.E.) undated
letter and enclosures dated August 3, 1976
letter and attachment dated August 4, 1976
letter dated August 25, 1976

We hope this letter will further assist you in preparing a thorough FES on the transportation of radioactive materials.

Very truly yours,

LOUIS J. LEFKOWITZ
Attorney General
By [signature]

JOHN F. SHEA, III
Assistant Attorney General

JFS:rab