EUR 112.e, f

EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING

VOL. 2

1966

Euratom/United States Agreement for Cooperation

Report prepared by Stanray Corporation, Chicago, Ill. USA

Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF

LEGAL NOTICE

This report is on sale at the addresses listed on cover page 4

at the price of FF 25,—	FB 250,—	DM 20,—	Lit. 3 120	Fl. 18,—

When ordering, please quote the EUR number and the title, which are indicated on the cover of each report.

Printed by Guyot, s.a.
Brussels, April 1966

EUR 112.e, f

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING
Vol. 2

European Atomic Energy Community - EURATOM
Euratom/United States Agreement for Cooperation
Report prepared by Stanray Corporation, Chicago, Ill. (USA)
(AEC Contract No. AT (11.1) - 963)
Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF
Brussels, April 1966 - 192 pages - FB 250

On November 8, 1958 the European Energy Community (Euratom) and the United States of America signed an Agreement for Cooperation to develop the peaceful applications of atomic energy. This Agreement provides for the construction in Europe of a certain number of power reactors intended for producing electric energy of nuclear origin.

The first of these reactors, designed by General Electric, belongs to SENN (Società Elettronucleare Nazionale) and is located in Italy, near Naples, on the banks of the river Garigliano.

EUR 112.e, f

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING
Vol. 2

European Atomic Energy Community - EURATOM
Euratom/United States Agreement for Cooperation
Report prepared by Stanray Corporation, Chicago, Ill. (USA)
(AEC Contract No. AT (11.1) - 963)
Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF
Brussels, April 1966 - 192 pages - FB 250

On November 8, 1958 the European Energy Community (Euratom) and the United States of America signed an Agreement for Cooperation to develop the peaceful applications of atomic energy. This Agreement provides for the construction in Europe of a certain number of power reactors intended for producing electric energy of nuclear origin.

The first of these reactors, designed by General Electric, belongs to SENN (Società Elettronucleare Nazionale) and is located in Italy, near Naples, on the banks of the river Garigliano.

EUR 112.e, f

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING
Vol. 2

European Atomic Energy Community - EURATOM
Euratom/United States Agreement for Cooperation
Report prepared by Stanray Corporation, Chicago, Ill. (USA)
(AEC Contract No. AT (11.1) - 963)
Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF
Brussels, April 1966 - 192 pages - FB 250

On November 8, 1958 the European Energy Community (Euratom) and the United States of America signed an Agreement for Cooperation to develop the peaceful applications of atomic energy. This Agreement provides for the construction in Europe of a certain number of power reactors intended for producing electric energy of nuclear origin.

The first of these reactors, designed by General Electric, belongs to SENN (Società Elettronucleare Nazionale) and is located in Italy, near Naples, on the banks of the river Garigliano.

On sale at
PRESSES ACADEMIQUES EUROPEENNES
98, Chaussée de Charleroi, Bruxelles 6

EUR 112.e, f

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING
Vol. 2

European Atomic Energy Community - EURATOM
Euratom/United States Agreement for Cooperation
Report prepared by Stanray Corporation, Chicago, Ill. (USA)
(AEC Contract No. AT (11.1) - 963)
Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF
Brussels, April 1966 - 192 pages - FB 250

On November 8, 1958 the European Energy Community (Euratom) and the United States of America signed an Agreement for Cooperation to develop the peaceful applications of atomic energy. This Agreement provides for the construction in Europe of a certain number of power reactors intended for producing electric energy of nuclear origin.

The first of these reactors, designed by General Electric, belongs to SENN (Società Elettronucleare Nazionale) and is located in Italy, near Naples, on the banks of the river Garigliano.

The second, designed by Westinghouse, belongs to SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is found in France, near Givet in the Ardennes, on the banks of the river Meuse.

The Euratom/United States Agreement for Cooperation provides for a joint research and development program mainly intended for lowering the costs of the fuel cycle in these reactors.

The present study was undertaken within the compass of this program. It concerns transportation from Europe to the United States of fuels irradiated in these reactors.

The object of the study is, first, to arrive at an evaluation of the problems resulting from the transports envisaged, then to examine such problems, from a general viewpoint and in the light of concrete studies undertaken in the two particular cases of SENN and SENA, and, finally, to point out which direction may be followed in searching for the best transportation.

The second, designed by Westinghouse, belongs to SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is found in France, near Givet in the Ardennes, on the banks of the river Meuse.

The Euratom/United States Agreement for Cooperation provides for a joint research and development program mainly intended for lowering the costs of the fuel cycle in these reactors.

The present study was undertaken within the compass of this program. It concerns transportation from Europe to the United States of fuels irradiated in these reactors.

The object of the study is, first, to arrive at an evaluation of the problems resulting from the transports envisaged, then to examine such problems, from a general viewpoint and in the light of concrete studies undertaken in the two particular cases of SENN and SENA, and, finally, to point out which direction may be followed in searching for the best transportation.

The second, designed by Westinghouse, belongs to SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is found in France, near Givet in the Ardennes, on the banks of the river Meuse.

The Euratom/United States Agreement for Cooperation provides for a joint research and development program mainly intended for lowering the costs of the fuel cycle in these reactors.

The present study was undertaken within the compass of this program. It concerns transportation from Europe to the United States of fuels irradiated in these reactors.

The object of the study is, first, to arrive at an evaluation of the problems resulting from the transports envisaged, then to examine such problems, from a general viewpoint and in the light of concrete studies undertaken in the two particular cases of SENN and SENA, and, finally, to point out which direction may be followed in searching for the best transportation.

The second, designed by Westinghouse, belongs to SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is found in France, near Givet in the Ardennes, on the banks of the river Meuse.

The Euratom/United States Agreement for Cooperation provides for a joint research and development program mainly intended for lowering the costs of the fuel cycle in these reactors.

The present study was undertaken within the compass of this program. It concerns transportation from Europe to the United States of fuels irradiated in these reactors.

The object of the study is, first, to arrive at an evaluation of the problems resulting from the transports envisaged, then to examine such problems, from a general viewpoint and in the light of concrete studies undertaken in the two particular cases of SENN and SENA, and, finally, to point out which direction may be followed in searching for the best transportation.

EUR 112.e, f

EUROPEAN ATOMIC ENERGY COMMUNITY - EURATOM

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING

VOL. 2

1966

Euratom/United States Agreement for Cooperation

Report prepared by Stanray Corporation, Chicago, Ill. USA

Contract Euratom/Lebon-Sogei, Paris No. 043-61-2 RDF

CONTENTS

CHAPTER III — THE IRRADIATED FUEL AND ITS PROCESSING

CHAPTER IV — THE CASK

CHAPTER V — TRANSPORTATION IN USA

SUMMARY

On November 8, 1958 the European Energy Community (Euratom) and the United States of America signed an Agreement for Cooperation to develop the peaceful applications of atomic energy. This Agreement provides for the construction in Europe of a certain number of power reactors intended for producing electric energy of nuclear origin.

The first of these reactors, designed by General Electric, belongs to SENN (Società Elettronucleare Nazionale) and is located in Italy, near Naples, on the banks of the river Garigliano.

The second, designed by Westinghouse, belongs to SENA (Société d'Energie Nucléaire Franco-Belge des Ardennes) and is found in France, near Givet in the Ardennes, on the banks of the river Meuse.

The Euratom/United States Agreement for Cooperation provides for a joint research and development program mainly intended for lowering the costs of the fuel cycle in these reactors.

The present study was undertaken within the compass of this program. It concerns transportation from Europe to the United States of fuels irradiated in these reactors.

The object of the study is, first, to arrive at an evaluation of the problems resulting from the transports envisaged, then to examine such problems, from a general viewpoint and in the light of concrete studies undertaken in the two particular cases of SENN and SENA, and, finally, to point out which direction may be followed in searching for the best transportation.

The kind cooperation and assistance of the following persons and groups is gratefully acknowledged.

1.	Mr. Frank M. Covey, Jr.	Legal Consultant McDermott, Will and Emery Chicago, Illinois
2.	Mr. T. C. George and Mr. L. C. White	Bureau of Explosives New York, New York
3.	Capt. J. J. Hutson, Jr. and LCDR John Flynn	U. S. Coast Guard Washington, D. C.
4.	M . C. W. Taylor and Mr. Victor E. Haninger	Interstate Commerce Commission Washington, D. C.
5.	The Atlantic Coast Line Railroad	Chicago, Illinois and Jacksonville, Florida
6.	Gulf Associated Freight Conf.	New Orleans , Louisiana
7.	Lykes Brothers Steamship Co.	Chicago, Illinois and New Orleans, Louisiana
8.	Nuclear Energy Liability Insurance Association	New York, New York
9.	Nuclear Energy Property Insurance Association	Hartford, Connecticut
10.	Marsh & McLennan Insurance Brokers	Chicago, Illinois and New York, New York
11.	The Savannah District Authority	Port of Savannah Georgia
12.	South Carolina State Ports Authority	Chicago, Illinois and Charleston, South Carolina
13.	Waterman Steamship Corp.	Chicago, Illinois and Mobile, Alabama

CHAPTER III - THE IRRADIATED FUEL AND ITS PROCESSING

INDEX

A. Abstract

B. Reprocessing Agreement

C. Financial Protection at the Savannah River Plant

1. Personal injury
2. Property damage

D. Fuel Properties

1. Fresh fuel
2. Irradiated fuel

E. Reprocessing Costs

1. Processing costs
2. Processing losses
3. Conversion costs
4. Conversion losses
5. Total cost of reprocessing
6. Resale value
7. Valuation for insurance purposes

APPENDIX A Bibliography

INTRODUCTION (°)

The United States and the European Atomic Energy Community (EURATOM), on May 29 and June 18, 1958 signed an agreement which provides a basis for cooperation in programs for the advancement of the peaceful applications of atomic energy. This agreement, in part, provides for the establishment of a Joint U.S. - Euratom research and development program which is aimed at reactors to be constructed in Europe under the Joint Program.

The work described in this report represents the Joint U.S. - Euratom effort which is in keeping with the spirit of cooperation in contributing to the common good by the sharing of scientific and technical information and minimizing the duplication of effort by the limited pool of technical talent available in Western Europe and the United States.

(°) Manuscript received on February 16, 1966

A. ABSTRACT

The United States Atomic Energy Commission announced in October of 1957 that it would, for only an interim period, make its chemical reprocessing plants available for the purpose of processing and converting spent fuel from privately owned power and research reactors. This decision was made only after it was determined that the chemical industry was not yet ready to undertake this job on a purely commercial basis.

The Commission indicated at that time, and still intends, that as soon as privately owned reprocessing facilities become available to all at a fair and reasonable price, spent fuel from private reactors will no longer be processed at government facilities.

In February of 1962, the Davison Chemical Company of Baltimore, Maryland filed a letter of intent with the U. S. Atomic Energy Commission. This letter set forth Davison's intention of filing an application with the Division of Licensing and Regulation for a license to design, construct and operate a spent fuel reprocessing facility. The proposed plant would be operated by a newly formed subsidiary known as Nuclear Fuel Services, Inc.

Present plans call for the Davison plant to be completed and ready for operation by 1965 and have the capability of reprocessing all the currently designed types of reactor fuel. The site of the plant has yet to be decided.

Since the conditions under which the proposed Davison plant would process fuel are not available, the following discussion of reprocessing is based on information available prior to Davison's decision to enter the field.

The U. S. Atomic Energy Commission has designated two locations as plants to be used for the reprocessing of spent fuel. The Idaho Chemical Processing Plant near Idaho Falls, Idaho has been assigned the task of reprocessing highly enriched and intermediate enriched uranium-aluminum spent fuel, and the Savannah River Plant near Augusta, Georgia has been assigned low enriched and intermediate enriched (other than U-Al) fuels.

Fuel from the SENN reactor would be destined for the Savannah River Plant.

The Savannah River Plant does not have a typical or standard contract available as yet, therefor, the following discussions are based on the contract available from the Idaho Chemical Processing Plant.

The following discussions are not intended to act as a substitute for or an interpretation of the actual contract but merely to serve as an illustration of what types of clauses and information are to be found in the reprocessing agreement.

1. USAEC - Proposed Part 72 (cont.)

The complete shipping procedures and operating procedures must be set forth in detail, including procedures to be used to test the cask and make measurements to prove the shipment satisfies the various regulations applicable.

An application may, for the purpose of eliminating duplication of effort, refer to any information contained in previous applications.

The Proposed Part 72 requires that the construction of the interior components along with the cask as a whole be capable of withstanding a free fall of the loaded cask through a distance of 15 feet onto an unyielding surface, without exceeding the ultimate strength of the material or deforming the cask to such an extent that the radiation level one meter from the cask surface exceeds one roentgen per hour. The conditions considered to be equivalent to this free fall are spelled out in the regulations.

The lid and lid closing mechanism is required to withstand a force in any direction equal to 15 times the weight of the loaded cask.

The exterior attachments of the cask are required to withstand various forces dependent on the use and kind of attachment. These requirements are clear except for that of section 72.34 (d) which states that any device that may be used to tie the cask down during transport must be capable of withstanding a static force having a vertical component of 2 times the loaded weight of the cask and a horizontal component of 10 times the loaded weight of the cask without exceeding the yield strength of the material in the device.

For purposes of our design we have assumed that the tie down system as a whole must withstand these forces.

Certain types of casks must be equipped with pressure relief devices which are in turn protected by particulate filters of extremely high efficiency.

The Commission (U.S.AEC) requires that they be notified every three months of the amount of material removed from the reactor within that three month period, which is intended for reprocessing. The Commission must also be notified, at least ninety days in advance of the agreed upon delivery date, of the size of the batch to be delivered.

The delivery of each processing batch must be completed within sixty days of the date on which the first portion of the batch arrives at the processing plant. No charge for storage is made during the sixty day period and the Commission may extend this free storage period at its discretion.

The processing batch may not contain more material on which no use-charge is assessed, than would normally be discharged from the reactor in any twelve month period. This limitation on batch size is applicable to leased fuel. The conditions under which purchased fuel will be handled are still unknown, and we are, therefor, assuming the above limitation applies to the case under study.

The shipper shall not be held responsible for damage to Government owned property as a result of handling or processing of specification material, which has been delivered in accordance with the terms of the contract.

The shipper warrants, however, that the cask contains specification material and in the event of a breach of this warranty all costs that may arise, as a result of such breach of warranty, shall be borne by the shipper. A limitation of $500,000 however, is placed on these costs.

If the casks used to carry spent fuel become contaminated in the normal course of operations at the reprocessing facility, the shipper is not charged for decontamination, if the shipment contained specification material and met the acceptance criteria of the plant, which is attached to and made a part of the contract. The acceptance criteria also specifies that to be eligible for free decontamination the exterior surface of the cask must be constructed of 300 series stainless steel.

Decontamination of vehicles or unloading areas will be performed free of charge if the contamination was caused by a condition other than delivery of casks which fail to meet the acceptance criteria.

If contamination of any sort is attributable to failure to meet the acceptance criteria or failure to deliver specification material, then the full cost of decontamination will be charged to the shipper.

Casks furnished by the shipper and damaged during normal operations at the reprocessing facility will be repaired or paid for by the Commission only in the event the damage is caused by the negligence of the Commission.

B. REPROCESSING AGREEMENT

The reprocessing agreement, or contract, for the purpose of utilizing the chemical processing and conversion services of the U. S. Atomic Energy Commission is a matter for negotiation between the fuel owner and the U.S.A.E.C.

Two plants have been designated by the A.E.C. as authorized reprocessing facilities. These are the Idaho Chemical Processing Plant, for high enrichment types of fuel, over 20% U-235 content, and the Savannah River Reprocessing Plant, for low enrichment types of fuel, less than 20% U-235 content.

To date, there have been no contracts signed for the reprocessing of fuel at the Savannah River Plant. The A.E.C. has a model reprocessing contract for services at the Savannah River Plant.

Reprocessing agreements between licensed reactor operators and the A.E.C. has been signed for services to be performed at the Idaho Chemical Processing Plant. The spent fuels involved are of high enrichment and unlike the common power reactor types of fuel.

The Idaho Chemical Processing Plant has a basic agreement which is used as the basis for all agreements entered into by the I.C.P.P. This is the agreement which will be discussed here. The difference between the I.C.P.P. contract and the one expected to be applicable to the S.R.P. is expected to be slight.

The contract for processing and conversion services specifies the conditions for delivery of the spent fuel at the reprocessing facility, including methods for determining the charges applicable and for settling disputes that may arise with regard to the contract.

The terms of the contract apply specifically to "specification material". "Specification material" is material which meets the physical and chemical description outlined in an appendix attached to and made a part of the contract.

Material delivered to the reprocessing facility and determined by the reprocessing facility to be non-specification material is handled in accordance with the paragraphs of the contract that apply to non-specification material.

The Commission (U.S.AEC) requires that they be notified every three months of the amount of material removed from the reactor within that three month period, which is intended for reprocessing. The Commission must also be notified, at least ninety days in advance of the agreed upon delivery date, of the size of the batch to be delivered.

The delivery of each processing batch must be completed within sixty days of the date on which the first portion of the batch arrives at the processing plant. No charge for storage is made during the sixty day period and the Commission may extend this free storage period at its discretion.

The processing batch may not contain more material on which no use-charge is assessed, than would normally be discharged from the reactor in any twelve month period. This limitation on batch size is applicable to leased fuel. The conditions under which purchased fuel will be handled are still unknown, and we are, therefor, assuming the above limitation applies to the case under study.

The shipper shall not be held responsible for damage to Government owned property as a result of handling or processing of specification material, which has been delivered in accordance with the terms of the contract.

The shipper warrants, however, that the cask contains specification material and in the event of a breach of this warranty all costs that may arise, as a result of such breach of warranty, shall be borne by the shipper. A limitation of $500,000 however, is placed on these costs.

If the casks used to carry spent fuel become contaminated in the normal course of operations at the reprocessing facility, the shipper is not charged for decontamination, if the shipment contained specification material and met the acceptance criteria of the plant, which is attached to and made a part of the contract. The acceptance criteria also specifies that to be eligible for free decontamination the exterior surface of the cask must be constructed of 300 series stainless steel.

Decontamination of vehicles or unloading areas will be performed free of charge if the contamination was caused by a condition other than delivery of casks which fail to meet the acceptance criteria.

If contamination of any sort is attributable to failure to meet the acceptance criteria or failure to deliver specification material, then the full cost of decontamination will be charged to the shipper.

Casks furnished by the shipper and damaged during normal operations at the reprocessing facility will be repaired or paid for by the Commission only in the event the damage is caused by the negligence of the Commission.

The Commission is not obligated to reprocess the material immediately or at all, if it desires not to. The contract spells out the method of arriving at a financial settlement in these cases.

If commercial facilities for reprocessing become available and the Commission feels that these services are available at a reasonable price, they may terminate the entire contract or any part of the contract. Such termination will be made only after twelve months notice has been given to the shipper.

The shipper also has the right to terminate the contract but is liable for any costs incurred prior to the date of termination or costs which the Commission became liable for because of the termination.

Reports relative to the material to be delivered as specification material will be of such form and detail as the parties to the contract may agree.

In the event fuel, of a different nature than described in the appendix describing specification material, is intended for use and eventual reprocessing, the Commission shall be informed of the exact nature of the material and shall then rule on whether the proposed new material may be considered specification material under the existing contract.

Under certain conditions, approved by the Commission, the shipper may combine his material with other shippers in the formation of a processing batch.

The reprocessing contract also has many clauses of a general nature including one setting forth the procedure for handling disputes and clauses setting forth charges to be made for the services rendered. The clauses relative to charges for services are discussed in Part E - Reprocessing Costs.

Non-specification material shall be handled in the manner prescribed by the applicable clauses which are negotiated for each contract. These clauses will state alternatives which are applicable to any given situation.

The contract can contain as many appendices as required. There are two, however, which will always be included. These are a "Description of Specification Material" and an acceptance criteria.

The "Description of Specification Material" includes drawings of the fuel units, description of weight and size, and a description of the composition, weight and size of certain specified components. Information with regard to the expected post irradiation composition of the fuel is also included.

The acceptance criteria is a summary of the conditions that the cask must meet so that the shipment may be handled safely and efficiently at the reprocessing facility. Included are specifications applying to radioactive contamination, cooling medium properties, physical handling abilities of the plant, and specific features that must be included in the cask design so that it can be properly and safely unloaded.

C. FINANCIAL PROTECTION AT THE SAVANNAH RIVER PLANT

The financial risks that a shipper may be exposed to while his material and equipment are at the Savannah River Plant spring from the reprocessing contract and the ordinary principles of legal liability imposed by law.

1. Personal Injury

Injury to any person at the Savannah River Plant as a result of the nuclear energy hazard, regardless of fault, is covered by the indemnity agreement entered into between the Savannah River Plant and the U. S. Atomic Energy Commission.

The Domestic Supplier's and Transporter's Policy, available from the NELIA and MAELU insurance pools can be made to apply by including one of their available endorsements. A complete discussion of this policy can be found in the chapter entitled "Transportation in U.S.A."

2. Property Damage

a. Damage to Property of Shipper

In the event of damage to property belonging to the shipper which results from fault on the part of the shipper, there is no insurance presently available to reimburse the shipper for the loss. If, however, the damage results from the fault of others, the shipper has recourse to legal action based on the ordinary principles of tort liability.

Article VII -B of the reprocessing contract specifies that the Commission is responsible for damages to the shippers equipment only in the event the damage is due to negligence on the part of the Commission. The word "Commission" is defined to include any authorized representative of the Commission.

b. Damage to Government Property

In the event that damage to government property occurs during the normal handling and reprocessing of specification material, Article V-A of the reprocessing contract specifically states that the shipper shall not be held responsible for the damage.

b. Damage to Government Property (cont.)

If non-specification material is delivered and damage occurs before the Commission determines that it is non-specification material, then a breach of the warranty contained in Article VI-B of the reprocessing contract shall have occurred. In this case, the shipper by the terms of Article VI-B agrees to hold the United States harmless for any costs, as a result of such breach of warranty, subject to a limitation of $500,000.

The standard Domestic Supplier's and Transporter's Policy specifically excludes coverage for property located at the site of a "nuclear facility".

c. Damage to Property of Third Persons

There is no insurance presently available which would cover the shippers' liabilities in the event the property of third persons was damaged, while at the reprocessing site, and which results from the fault of the shipper.

Coverage is afforded, however, for vehicles not used in the operation of the reprocessing facility, by the standard Domestic Supplier's and Transporter's Policy.

D. FUEL PROPERTIES

Information concerning the fuel properties before irradiation and the expected fuel properties after irradiation were furnished by the General Electric Company, designers of the SENN reactor.

1. Fresh Fuel

a.	Type of Fuel	UO_2 pellets
b.	Enrichment	Variable: 2.1% to 1.6%
c.	Total Weight of UO_2 per Assembly	560 lbs.
d.	Weight of U-235 per Assembly	10 lbs.
e.	Total Weight of Assembly	770 lbs.
f.	Type of cladding	Zircalloy -2
g.	Reloading schedule of Reactor	42 assemblies every 9 months

2. Irradiated Fuel

a.	Weight of U-235 per Assembly	4.9 lbs.
b.	Weight of Plutonium per Assembly	2.5 lbs.
c.	Weight of UO_2 per Assembly	552.4 lbs.

E. REPROCESSING COSTS

The costs associated with the processing and conversion of spent fuel into the form necessary for sale to the Atomic Energy Commission will in all cases be clearly stated in the reprocessing agreement. Also listed will be the charges associated with the various supplementary services available at the reprocessing plant.

The processing charges at the present time are based upon an assumed processing plant and cycle. This conceptual plant is outlined in the document entitled "Summary Report: AEC Reference Fuel Processing Plant (WASH-743)", dated October 1957.

The following cost analysis will be based on the contract which is presently in effect for commission services at the Idaho Chemical Processing Plant and the various notices which have amended the conditions under which these services are made available.

In all cases, only the charges associated with the processing and conversion of specification material are considered. Each delivery of non-specification material will be handled on an individual basis, within the provisions of the contract, and additional costs will be incurred.

1. Processing Costs

The charge for basic processing costs is determined by the following formula:

$$C = D\left[\frac{W}{R} + T\right]$$

C = processing charges in dollars

D = $15,300, subject to escalation

W = Weight in Kilograms of the total amount of uranium contained in the processing batch.

R = daily processing rate in Kilograms of total uranium.

T = $\frac{W}{R}$ (to be no less than 2 or more than 8 days)

1. Processing Costs (cont.)

The quantity "D" is made up of two separate values; that representing the daily depreciation charge and that representing the daily operating and overhead charges. In both cases the charge was based on prices and costs as of July 1956. The contract provides for the increase or reduction of the daily processing charge on the basis of changes in the Official Monthly Construction Cost Indexes and the Wholesale Price and Price Indexes.

Based on the average of the Monthly Price Indexes for the last six months of 1961 the quantity "D" is increased from $15,300 to $17,400.

The provisions of existing documents limit the batch size, for fuel on which no use charge is paid, to a maximum equal to the amount that is normally discharged from the reactor core in one year. In the case of the SENN reactor this means 42 fuel assemblies since one-fifth of the core is removed every nine months.

The daily processing rate for low enrichment uranium-zircalloy clad fuel elements has not been published by the A.E.C. Various papers written on the economics of fuel reprocessing seem to agree that this type of fuel will probably be processed at a rate of approximately 1000 Kg per day. This figure has been adopted for item "R" in our cost analysis.

Based on the above assumptions, the processing cost per batch of 42 SENN fuel assemblies is:

$$C = D \left[\frac{W}{R} + T \right]$$

$$C = \$17,400 \left[\frac{9284.94}{1000} + 8 \right]$$

$$C = \$17,400\ (17.3) = \$301,020 \text{ per batch}$$

2. Processing Losses

Processing is the converting of the irradiated fuel element into nitrate salts, namely, uranyl nitrate and plutonium nitrate. The losses which are expected to occur during processing have been

2. Processing Losses (cont.)

estimated by the AEC at 1% of the contained material.

The specific loses would be:

Plutonium: (47.67) (.01) = .48 Kg/batch
Uranium: (9284.94) (.01) = 92.8 kg/batch

3. Conversion Costs

Conversion is the changing of uranyl nitrate into uranium hexaflouride and plutonium nitrate into plutonium metal buttons. These two final forms are the only forms in which the U.S.A.E.C. will accept the material.

The quoted conversion charges are $5.60 per Kg. of uranium and $1.50 per gram of plutonium.

These charges amount to:

Uranium: (9284.9 - 92.8) (5.60) = $51,475.76
Plutonium: (47.67 - 0.48) (1000) (1.50) = $70,785.

4. Conversion Losses

The U. S. Atomic Energy Commission has stated that the losses which are expected to be incurred during conversion are 0.3 of one per cent of the uranyl nitrate, and one per cent of plutonium nitrate.

Therefor, the following amounts will be lost during conversion:

Uranyl nitrate: (9192) (.003) = 27.58 Kg. of U/batch
Plutonium nitrate: (47.19) (.01) = .47 Kg. of Pu/batch

Based on the previous sections the amount of material available per batch for resale after processing and conversion is 9164.4 kilograms of U in UF_6 and 46.72 kilograms of plutonium metal.

5. Total Cost of Reprocessing

The cost of reprocessing per batch (42 fuel elements to a batch) is as follows:

Processing Costs:	=	$ 301,020.00
Conversion Costs:	=	
Uranium	=	51,475.76
Plutonium	=	70,785.00
Total		$ 423,280.76

Other charges can be incurred but these are not available at this time. These additional charges would be nominal and could be for the following services: decontamination of exterior surfaces of shipping equipment, storage charges (in the event the 60 days free storage is exceeded while awaiting the arrival of a full batch), and rental charges for cylinders in which to ship the UF_6 to the receiving point.

6. Resale Value

The "buy back" prices established by the U. S. Atomic Energy Commission are identical to the published base charges. The base charge is the value placed by the A.E.C. on the material. At the present time the A.E.C. has guaranteed specific base charges up to June 30, 1963. Shipments from the SENN reactor will take place after this time but since we are not in a position to predict the base charges that may be in effect we will assume current values.

The value of uranium enriched in the isotope U-235 is based on the percent of enrichment of the uranium. Based on the information, relative to fuel properties, which is listed earlier in the report, we can calculate the percent enrichment of the uranium as 1.00%. This corresponds to a "buy back" value of $47.70 per kilogram of uranium.

The current "buy back" price for plutonium produced in reactors outside the United States is $12.00 per gram of plutonium. We are again assuming that this value will be applicable when the SENN fuel is ready for reprocessing.

6. Resale Value (cont.)

The material in each batch, therefor, has the following resale value.

Uranium: (9164.4) $47.70	=	$437,141.88
Plutonium: (46.72) (1000) (12.00)	=	$560,640.00
Total per batch	=	$997,781.88
Total per fuel assembly	=	$ 23,756.71

7. Valuation for Insurance Purposes

The value to be assigned to the fuel for the purpose of determining the amount of property insurance necessary will depend on whether the fuel is purchased or leased from the U.S.A.E.C.

If the material is purchased from the A.E.C. then, in the event the material is completely lost, the only real loss to the fuel owner will be the resale value of the spent fuel minus the costs of reprocessing.

This value is:

$997,781.88 - $423,280.76 = $ 574,501.12 per batch
or = $ 13,678.60 per fuel assembly

In the event the material has been provided under a lease agreement, the lessee is obligated to pay to the Commission an amount equal to the value of the contained material. It would, therefor, be wise to insure the shipment for the maximum amount possible.

The maximum value would be based on the uranium and plutonium content prior to reprocessing. This value is:

Uranium: (9284.94) $47.70	=	$ 442,891.64
Plutonium: (47.67) (1000) ($12.00)	=	$ 572,040.00
Total Value per Batch	=	$1,014,931.64
Total Value per Fuel Assembly	=	$ 24,165.04

APPENDIX A

BIBLIOGRAPHY

1. U. S. Atomic Energy Commission Notice of March 12, 1957 (22 F.R. 1591)

2. U. S. Atomic Energy Commission Release No. 1205 October 28, 1957

3. U. S. Atomic Energy Commission Notice of March 3, 1958

4. U. S. Atomic Energy Commission Notice of March 12, 1958 (23 F.R. 1707)

5. U.S. Atomic Energy Commission Notice of December 16, 1959 (24 F.R. 10165)

6. U. S. Atomic Energy Commission Notice of May 23, 1961 (26 F.R. 4435)

7. U. S. Atomic Energy Commission Release No. D-138 of May 29, 1961

8. "Materials/Services and Facilities Available From the United States Atomic Energy Commission", TID-4559 (2nd Rev.) January, 1958.

9. F. L. Culler, "General Economics of Chemical Reprocessing for Solvent Extraction Processing", Symposium on the Reprocessing of Irradiated Fuels, May 20-25, 1957, Brussels, Book 3 Session V

10. M. B. Kratzer, "Atomic Energy Commission Charges for Chemical Reprocessing Services", Symposium on the Reprocessing of Irradiated Fuels, May 20-25, 1957, Brussels Book 3, Session V

11. A. M. Poindexter, "Minimizing Fuel-Processing Costs", Nucleonics, November 1959

12. J. W. Ullmann and E. D. Arnold, "Choosing Storage Time To Minimize Processing Costs", Nucleonics, June 1957

13. "United States Atomic Energy Commission Contract for Chemical Processing and Conversion Services" Contract No. AT (10 - 1) Idaho Chemical Processing Plant

CHAPTER IV - THE CASK

INDEX

A. Abstract

B. Regulations and Approvals

1. United States Atomic Energy Commission
   Proposed Part 72

2. Bureau of Explosives of the Association of American
   Railroads

3. International Atomic Energy Agency - Regulations for the
   Safe Transport of Radioactive Materials.

4. Savannah River Plant - Cask Acceptance Criteria

C. Physical Quantities Governing Design

1. Fuel Properties

2. Reactor Handling Facilities

3. Transportation Facilities

4. Reprocessing Plant Facilities

D. Physical Design

E. Heat Dissipation Design

F. Radiation Shielding

G. Auxiliary Equipment

H. Cost Estimate

Figure IV-1	Decay Heat Per Assembly
Figure IV-2	Decay of Hard Gamma-Ray Power After Shutdown for Various Irradiation Periods.
Figure IV-3	Effective Energy of Gamma Rays After 750 Days Irradiation
Figure IV-4	Mass Absorption Coefficient for Aluminum
Figure IV-5	Linear Absorption Coefficient
Figure IV-6	Effective Self-Absorption Distance
Figure IV-7	Dose Buildup Factor in Lead For a Plane Monodirectional Source
Figure IV-8	Conversion Factors
Figure IV-9	Attenuation Factors
Figure IV-10	Conceptual Cask Design SENN Reactor
Figure IV-11	Temperature Distribution 9 Assembly Cask
Figure IV-12	Cask Lifting Yoke
Figure IV-13	Ship Board Skid
Appendix A	Regulations for the Safe Transport of Radioactive Materials, International Atomic Energy Agency- Vienna, 1961.
Appendix B	References and Acknowledgements

A. ABSTRACT

In general, a cask for the shipment of spent fuel should be as large as physically possible. An examination of various cask sizes and designs points out that the increase in the weight of the over-all package is not directly proportional to the increase in the weight of the contained fuel.

Minimizing the ratio of pounds of cask to each pound of fuel leads to the most economical solution to the shipping problem, by minimizing freight costs and in some instances cask costs.

Transporting the maximum number of fuel assemblies possible per cask reduces the number of cask trips necessary, with an attendant reduction in clerical work, and insurance costs. A reduction in the number of cask trips also reduces the probability of an incident occurring.

The cask design discussed in this chapter was made for the sole purpose of determining the suitability of the various facilities and as an aid in estimating cost factors. Details of the design are not considered necessary in determining these matters.

The cask design as it is presented in this chapter meets the basic provisions of the applicable criteria. Additions or alterations to the design for the purpose of meeting other more specific provisions of the criteria are expected to leave the size and weight of the cask basically unaltered.

B. REGULATION AND APPROVAL

1. United States Atomic Energy Commission - Proposed Part 72

On the 23rd of September, 1961, the United States Atomic Energy Commission published the most recent version of Proposed Part 72 of Title 10 Code of Federal Regulations. The regulations in Proposed Part 72 are entitled "Protection Against Radiation in the Shipment of Irradiated Fuel Elements."

These proposed rules have been under discussion by various commercial companies and regulating agencies for many months, and have been revised and rewritten a number of times.

The prime purpose of the regulations is to set forth procedures and criteria for the safe transport of large radioactive sources in the form of solid irradiated reactor fuel. The proposed Part 72 deals primarily with the technical criteria applicable to cask design and construction.

Although the rules of Part 72 are expressly stated to apply to persons licensed pursuant to Part 70, the rules by administrative decision have been made applicable to import shipments of spent fuel.

It is specifically stated that approval under Part 72 shall be indicated by the issuance of a license or amendment to a license. Again, by administrative decision, no license will be issued to indicate approval in the case of import shipments. The AEC will issue a letter to the applicant to indicate approval of the cask and shipping procedures.

Any person or group wishing to make a shipment of spent fuel in the United States must apply for approval to the Division of Licensing and Regulation of the United States Atomic Energy Commission.

This application for approval must contain the information listed in section 72.21 of Part 72. The required information briefly consists of an evaluation of the cask's ability to contain the spent fuel safely. This evaluation must include drawings and calculations relative to the structural integrity, radiation shielding, decay heat removal, and criticality safeguards of the cask, both during normal and emergency conditions.

1. USAEC - Proposed Part 72 (cont.)

The complete shipping procedures and operating procedures must be set forth in detail, including procedures to be used to test the cask and make measurements to prove the shipment satisfies the various regulations applicable.

An application may, for the purpose of eliminating duplication of effort, refer to any information contained in previous applications.

The Proposed Part 72 requires that the construction of the interior components along with the cask as a whole be capable of withstanding a free fall of the loaded cask through a distance of 15 feet onto an unyielding surface, without exceeding the ultimate strength of the material or deforming the cask to such an extent that the radiation level one meter from the cask surface exceeds one roentgen per hour. The conditions considered to be equivalent to this free fall are spelled out in the regulations.

The lid and lid closing mechanism is required to withstand a force in any direction equal to 15 times the weight of the loaded cask.

The exterior attachments of the cask are required to withstand various forces dependent on the use and kind of attachment. These requirements are clear except for that of section 72.34 (d) which states that any device that may be used to tie the cask down during transport must be capable of withstanding a static force having a vertical component of 2 times the loaded weight of the cask and a horizontal component of 10 times the loaded weight of the cask without exceeding the yield strength of the material in the device.

For purposes of our design we have assumed that the tie down system as a whole must withstand these forces.

Certain types of casks must be equipped with pressure relief devices which are in turn protected by particulate filters of extremely high efficiency.

1. U.S. AEC - Proposed Part 72 (cont.)

Section 72.34 (o) requires that an iodine gas removal device be included in the pressure relief system if the amount of Iodine-131 which would be released from the fuel, in the event emergency conditions existed, exceeds 10 curies; or the amount of Iodine-129 under the same conditions exceeds one curie.

Since it is extremely difficult to predict the amount of iodine that could reasonably be expected to be released from the fuel, and also quite difficult to provide a reliable gas removal filter; the simplest solution appears to be to cool the fuel long enough so that the total contained iodine is beneath the allowed levels.

The radiation shielding must be fixed in relation to the cask structure and must provide sufficient shielding to reduce the radiation to 200 milliroentgens per hour at the surface and ten milliroentgens per hour at three meters from the surface. In the event, the cask does not have the exclusive use of the vehicle the level of radiation must not exceed 200 milliroentgens per hour at the surface or ten milliroentgens per hour at one meter from the surface.

Criticality within the cask is controlled in two ways:

(1) by limiting the number of fuel assemblies within the cask, and

(2) by calculating the effective neutron multiplication constant, taking into account poison material which may be present.

If the number of fuel assemblies in a cask does not exceed 75 percent of the number necessary to attain criticality it shall be considered safe.

If the effective neutron multiplication constant, $k_{eff,}$ does not exceed 0.9 the shipment will be considered critically safe.

In both of the above cases the fuel and the cask must be assumed to be in the condition which would promote maximum reactivity.

The ability of the cask to dissipate heat shall be sufficient so that the following values will not be exceeded;

1. USAEC - Proposed Part 72 (cont.)

(1) Accessible cask surface temperature of 180°F

(2) Primary coolant 20° F less than its boiling point

(3) The maximum surface temperature of fuel to be no greater than 300° F below the failure temperature of the irradiated fuel.

In all cases the primary coolant may not be circulated outside the cask; the coolant must be protected against freezing; in the event of mechanical coolant circulation a standby system may be required; all calculations must be made with an ambient temperature of 100° F and a no wind condition.

Ruptured fuel elements must be enclosed in a container prior to loading in the cask and ruptured or defective casks are not to be used.

Prior to using a cask for the first time heat transfer and shielding calculations shall be experimentally verified.

Prior to each shipment the following tests shall be made:

(1) External radiation levels within allowable limits

(2) Surface contamination of alpha particles less than 500 disintegration per minute per 100 square centimeters and beta-gamma radiation of less than 4000 disintegrations per minute per 100 square centimeters.

(3) The loaded cask shall be tested for leak tightness with an internal pressure of no less than five pounds per square inch.

(4) A sample of the primary coolant shall be drained from the cask and the following limits of activity shall not be exceeded:

(a) Beta-Gamma activity - 10^{-5} curies per milliliter
(b) Alpha activity - 10^{-7} curies per milliliter

1. USAEC - Proposed Part 72 (cont.)

The maintenance of certain records relative to the irradiation history of each fuel element is required along with detailed results of tests made on each shipment.

The foregoing is a brief general summary of the requirements to be found in the Proposed Part 72. It is not intended to be, nor is it complete enough to be, used as a substitute for the regulations as printed by the USAEC.

The regulations as they currently exist present no serious obstacles to compliance. They are undoubtedly restrictive in nature but any arguments for relaxing the requirements of the regulations seem to be based entirely on matters of opinion.

Any applicant submitting the necessary and properly prepared information for the approval of a cask must wait a few months for the review by the USAEC to be completed.

2. Bureau of Explosives of the Association of American Railroads

The Bureau of Explosives of the Association of American Railroads has been authorized by the United States Interstate Commerce Commission to act on behalf of the Interstate Commerce Commission in administering and enforcing those provisions of the Interstate Commerce Commission regulations that apply to dangerous articles.

The Bureau of Explosives must approve and issue a permit number to each type of container intended for the carriage of dangerous articles. In each case, the permit number will be issued only after the Bureau has satisfied itself that the proposed container can safely contain and transport the intended contents.

The United States Coast Guard has said that they will accept the issuance of a Bureau of Explosives permit number as adequate proof that the container is suitable for the safe carriage of the contents.

Since the Interstate Commerce Commission regulations do not provide a detailed description of the construction of the type of container allowed for the carriage of large radioactive sources the Bureau of Explosives has promulgated and issued specifications. These specifications are intended to guide those who will be seeking the approval of the Bureau and are considered to be the minimum container requirements.

The requirements of the Bureau relative to the issuance of a permit for a cask to carry spent fuel are less restrictive and less detailed than those of the U.S. Atomic Energy Commission. The information contained in the application to the USAEC in compliance with the proposed Part 72 is more than adequate for the purposes of the Bureau.

The highlights of the requirements of the Bureau are as follows:

(a) If mechanical devices are used for aiding in the cooling of the cask a duplicate standby system must be included, and the shipment must be escorted.

(b) Coolant should be prevented from freezing.

(c) Maximum external surface temperature shall not exceed 180° F.

2. Bur. of Explosives of the AAR (cont.)

(d) Shielding material must be held in place and encased in steel. If lead is thicker than six inches then the steel shell shall be no less than 1/4 inch thick.

(e) Radiation level at the surface not to exceed 200 milliroentgen per hour and at one meter from the source 10 milliroentgen per hour.

(f) If container is intended for shipment by water it must be marked with the gross weight.

(g) The name "Radioactive Material" and the permit number must be permanently applied to the container so that it cannot be obliterated by fire.

(h) Container must be designed and maintained so that criticality cannot occur.

A complete copy of the Bureau's requirements can be obtained from the Bureau.

The Bureau's approval based on operating procedures, contents and cask design is indicated by a letter assigning a permit number to the cask. Approximately seven days are required for the Bureau to rule on an application.

3. International Atomic Energy Agency - Regulations for the Safe Transport of Radioactive Material

These regulations are broadly written and intended to apply to any type of shipment of radioactive materials. The portions of the regulations which apply to or influence the design of a cask are of a general nature and the authority to approve any particular type of cask is relegated to the competent authority of the country within which the shipment originates.

The shipment of spent fuel falls within the classification of large radioactive sources. As such the cask used must comply with the type B packaging specifications. The type B packaging specification requires that the cask be designed to withstand "conditions normally incident to transport and for the maximum credible accident" that could be encountered using the intended mode of transportation. "Withstand" meaning the retention of shielding efficiency and not allowing the contents to be dispersed.

In applying for approval from the competent authority, the applicant must explain the nature of the "maximum credible incident" postulated and the ability of the cask to withstand the incident.

The criticality of the cask will be controlled by special arrangement, that is, by providing criticality controls which are determined by a nuclear safety specialist to be adequate.

In assessing the adequacy of these criticality controls, the following criteria are to be applied:

(a) a double contingency is required to achieve criticality.

(b) the worst combination of conditions with regard to absence or presence of water.

(c) the presence of other types of shipments which could increase reactivity

(d) the effective neutron multiplication factor of the system not to exceed 0.9 or the mass of the material is not to exceed 80% of that amount necessary for criticality.

3. IAEA - Regulations for Safe Transport (cont.)

(e) if fuel elements are not held in place, then spacing which would cause maximum reactivity must be assumed.

(f) the fuel must be considered either fresh or irradiated whichever gives greatest reactivity

(g) if meltdown can occur fuel must be considered melted.

Packages or casks containing "large sources" are considered a category "yellow" package and shall comply with the following radiation requirements:

(a) No more than 200 milliroentgen per hour at the accessible surface.

(b) No more than 10 milliroentgen per hour at 3 meters from the accessible surface.

The heat dissipation abilities of the cask must be such that the accessible external surface temperature shall not exceed 180 °F, and the parts of the fuel shall not exceed a temperature of 180 ° below their respective melting points with no liquid being circulated.

Liquid coolant which comes in contact with the radioactive material is not to circulate outside the shielding of the cask.

In the event a mechanical cooling system is employed, the design shall be such that failure of the system shall not result in an excessive pressure increase or a radiation hazard.

If the container is not designed to withstand internal pressures due to the boiling of the coolant then the cask shall be designed to maintain the coolant temperatures at least 20°F below the boiling point of the coolant.

In any case, a shipment of spent fuel will always be made by special arrangements, and these must be approved by the competent authority of each country involved.

3. IAEA- Regulations for Safe Transport (cont.)

Any application for approval from the competent authority of the countries involved must include a complete summary of the arrangements made, the handling and operating procedures, the precautions and safeguards associated with the shipment, the physical and chemical composition of the fuel, and an engineering analysis of the adequacy of the cask to meet the requirements specified and contain the material in a safe manner.

For the purposes of this application, copies of the information and analysis which is submitted to the U.S. Atomic Energy Commission appear to be quite adequate.

4. Savannah River Plant - Cask Acceptance Criteria

The Savannah River Plant which has been designated by the U. S. Atomic Energy Commission as the reprocessing facility for low enrichment fuel has published a "Cask Acceptance Criteria". These criteria are included as an appendix to the model reprocessing contract.

The acceptance criteria list physical and operational specifications which the cask must meet so that it can be safely and efficiently handled at the reprocessing site.

The reprocessing plant must review all shipping and handling arrangements and details to insure compatibility with the existing facilities. Six copies of the desired information are required and approximately one month will be required for review. The information contained in the application to the U. S. A.E.C. is complete enough for this purpose.

The six copies of this information should be submitted to the:

Savannah River Operations Office
United States Atomic Energy Commission
P. O. Box A
Aiken, South Carolina

The external contamination allowed on a cask shall be limited to 500 disintegrations per minute per 100 square centimeters of alpha activity and 4000 disintegrations per minute per 100 square of beta-gamma activity. These readings must be the result of a wipe test.

The coolant activity is to be tested prior to shipment and then upon arrival at the Savannah River Plant. If any appreciable increase in beta-gamma activity is noted then failure of the fuel element cladding is assumed and encapsulation of the assembly prior to processing will be required.

If the total contained activity of the coolant exceeds one curie then special handling procedures may be required.

The heat dissipation ability of the cask must be such that the coolant temperature will remain 20°F below the boiling point. These calculations must be based on an ambient air temperature of 100°F and a no wind condition.

Pressurized casks are not expressly forbidden but will be considered on an individual basis.

The cask and fuel arrangement must be so designed as to prevent the possibility of criticality occurring during normal cask and fuel handling operations.

Any individual fuel element package to be removed under water must not weigh more than three tons, must not exceed 28 inches in diameter or width, and must not be more than 17.5 feet long.

All inner cask surfaces which are in contact with the coolant must be of stainless steel construction. The exterior surfaces must be designed for ease of decontamination, and the use of a 300 series stainless steel is recommended. If other materials are used and undue effort is required for decontamination then the shipper will be charged accordingly.

Cask lifting devices must be part of the cask and not of the lid.

In the event a fuel element ruptures during transit and special nuclear material becomes exposed, special handling procedures will be required and delay will occur in the unloading. Any costs incurred due to special handling will be charged to the shipper.

The cask design must include the following features:

(a) Means of guiding the lid into place so that hold down studs will not be damaged.
(b) Means of sampling and artificially circulating the primary coolant.
(c) Means for determining the temperature of internal cask wall.
(d) Means for siphoning water from cask.
(e) All casks must be top opening.

The lifting facilities consist of one 100 ton bridge crane haveing two separately operated hooks of 50 ton capacity each. The distance between the centerlines of the two hooks can be varied from 7 feet 8 inches to 25 feet.

The hooks to be used for the lifting of the cask have a 6 inche width, a throat inside diameter of 7 inches, and require a minimum clearance under the trunnions of 13 inches for engagement.

The bridge crane and the two separate hooks are oriented in relation to the railroad track entering the unloading area in such a way that only casks can be handled whose lifting trunnion centerlines are parallel to the centerline of the railcar. In the event the trunnion centerlines are perpendicular to the centerline of the car an adapting yoke of some sort must be provided.

The dimensional limitations applicable to a cask which is intended to be unloaded while in the vertical position are as follows:

Maximum Dia. of Cask (Including Trunnions)	9 ft.
Maximum cask height (x = Max. fuel element length in feet)	33 ft. -x

Any non-routine operations required for the efficient and safe handling of casks or fuel must be discussed and agreed upon in advance. Charges for such non-routine operations will be discussed at the same time.

The above discussion is based on the acceptance criteria dated June 21, 1961. At the present time new acceptance criteria is being issued, but is not available as yet. The revisions are expected to be of a minor nature.

C. PHYSICAL QUANTITIES GOVERNING DESIGN

1. Fuel Properties

Those properties of the fuel which contribute most to and in many ways govern the basic configuration of a cask design are: (a) the physical size of the fuel , (b) the amount of heat liberated by the radioactive decay of the fission products, and (c) the amount of radiation emanating from the spent fuel for which shielding must be provided.

(a) Physical size of SENN fuel

Total Weight of Each Assembly	770 lbs.
Total Length of Each Assembly	129 inches
Cross section dimensions	6.4 inches x 6.4 inches

(b) Decay heat properties

The following initial information with regard to reactor operating characteristics and fuel management was supplied by the General Electric Company, designers of the SENN reactor.

Number of Assemblies per core	208
Expected Reactor Power Level	507 MW
Maximum power per assembly	3.96 MW
Average power per assembly	2.43 MW
Expected burn-up	12,000 MWD/TofU
Weight of fuel per assembly	560 lbs. of UO_2

It is planned that each batch removed from the core will be from zones of maximum burn-up and that peripheral fuel elements will be shifted into these zones so that a uniform burn-up over the entire life of the core will be achieved.

1. Fuel Properties (cont.)

The greatest amount of decay heat possible at any given time after reactor shutdown would be caused by operation at the maximum power level and shortest in-core life consistent with the allowable burn-up. This continuous irradiation time is calculated in the following way;

Amount of Uranium per assembly:

$$560 \times \frac{238}{270} \times \frac{1}{2000} = .247 \text{ tons}$$

MWD per Assembly:

$$12{,}000 \times .247 = 2965 \text{ MWD}$$

Irradiation time:

$$\frac{2965}{3.96} = 750 \text{ days}$$

Decay heat calculations will, therefor, be based on a residence time of 750 days and a power level of 3.96 MW per assembly. A conservative design will result from the use of these values. After the cask is constructed and experimental verification of the actual heat dissipation ability of the cask is made, the cool time allowed prior to shipment can be more accurately determined.

Using the above information and data contained in a paper written by J. R. Stehn and E. F. Clancy entitled "Fission-Product Radioactivity and Heat Generation", the graph of Figure IV-1 is produced.

This information and especially that of Figure IV-1 will be utilized in section E for the design of the cask to meet the heat dissipation requirements.

DECAY HEAT PER ASSEMBLY

Ref. A/CONF/15/P/107 -J. R. Stehn and E. F. Clancy

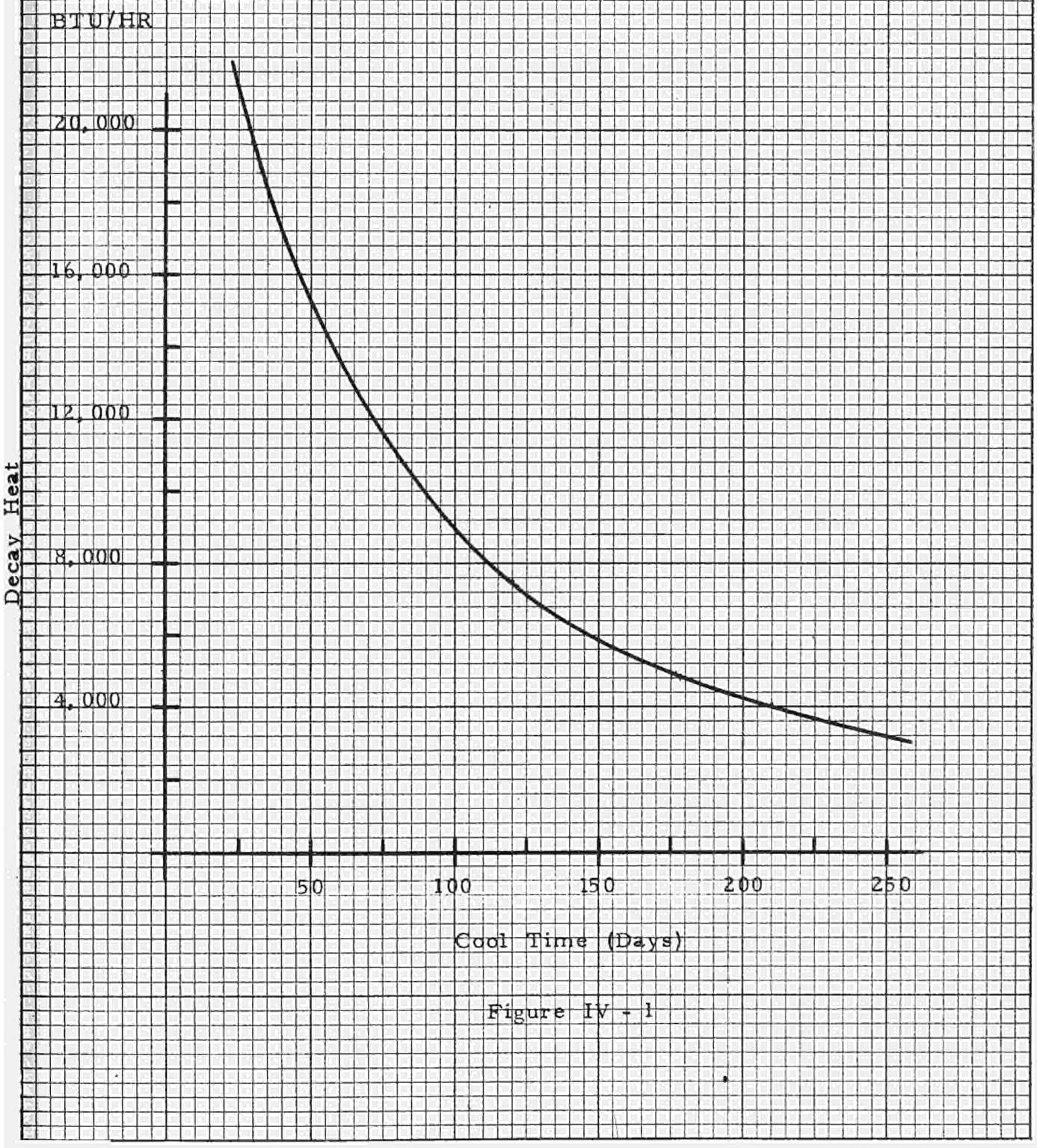


Figure IV - 1

1. Fuel Properties (cont.)

(c) Shielding information

The cask design, being a preliminary one, shall be analyzed from a radiation dose standpoint by the use of the "effective energy method". This method is discussed by R. L. Ashley in "Graphical Aids in the Calculation of the Shielding Requirements for Spent U-235 Fuel"(NAA-SR-1992). Although a more exact analysis by the use of more rigorous methods may be preferred in some cases, the "effective energy method" provides a quick effective means of determining the adequacy of any shielding assumption made.

The fuel information necessary to calculate the dose rate by the use of the effective energy method can be divided into two broad groups; (1) that information and data peculiar to the specific reactor, and (2) information or data which applies to all fuels whose basic constituent is UO_2 - uranium dioxide, and information based on the physics of certain materials.

Those items included in (1) are:

Active length of assembly - 105.7 inches

Weight of active portion of assembly - $\sim$ 700 lbs.

Irradiation time - 750 days

Cool time - based on decay heat

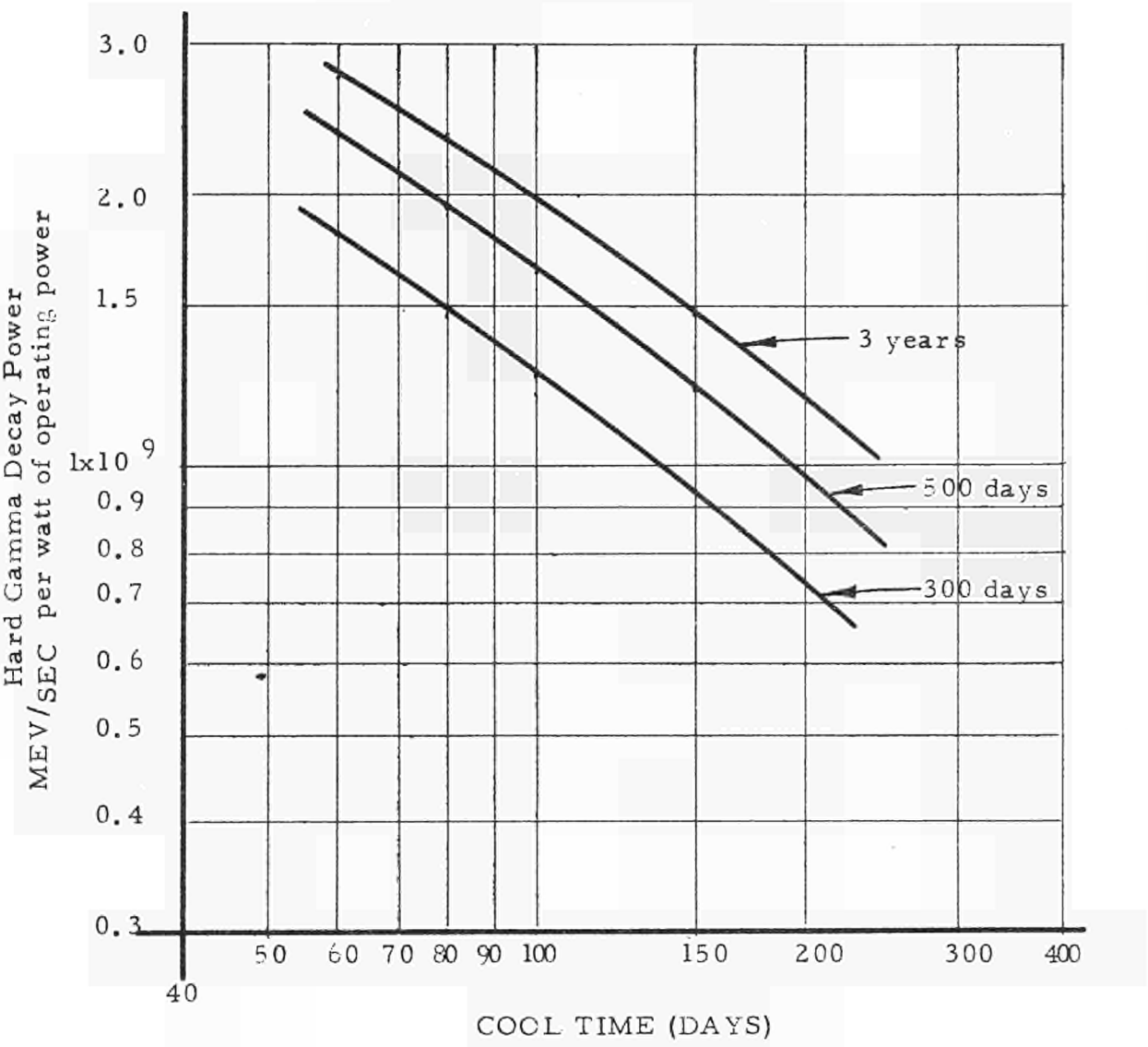
Power per assembly - 3.96 MW

The information which would be included in (2) above is normally found in graphical form. Typical graphs of the type necessary are included as Figures IV-2 to IV-9.

Figure IV-2: Hard gamma decay power per watt of of operating power as a function of irradiation time and cool time.

Figure IV-3: Effective energy of gamma ray spectrum as a function of irradiation time, cool time, and shield thickness.

DECAY OF HARD GAMMA-RAY POWER AFTER SHUTDOWN FOR VARIOUS IRRADIATION PERIODS



Ref. Fig. 2 Pg. 24 NAA-SR-1992

Figure IV -2

EFFECTIVE ENERGY OF GAMMA RAYS

AFTER 750 DAYS IRRADIATION

[Ref. Fig. 14-17 NAA-SR-1992]

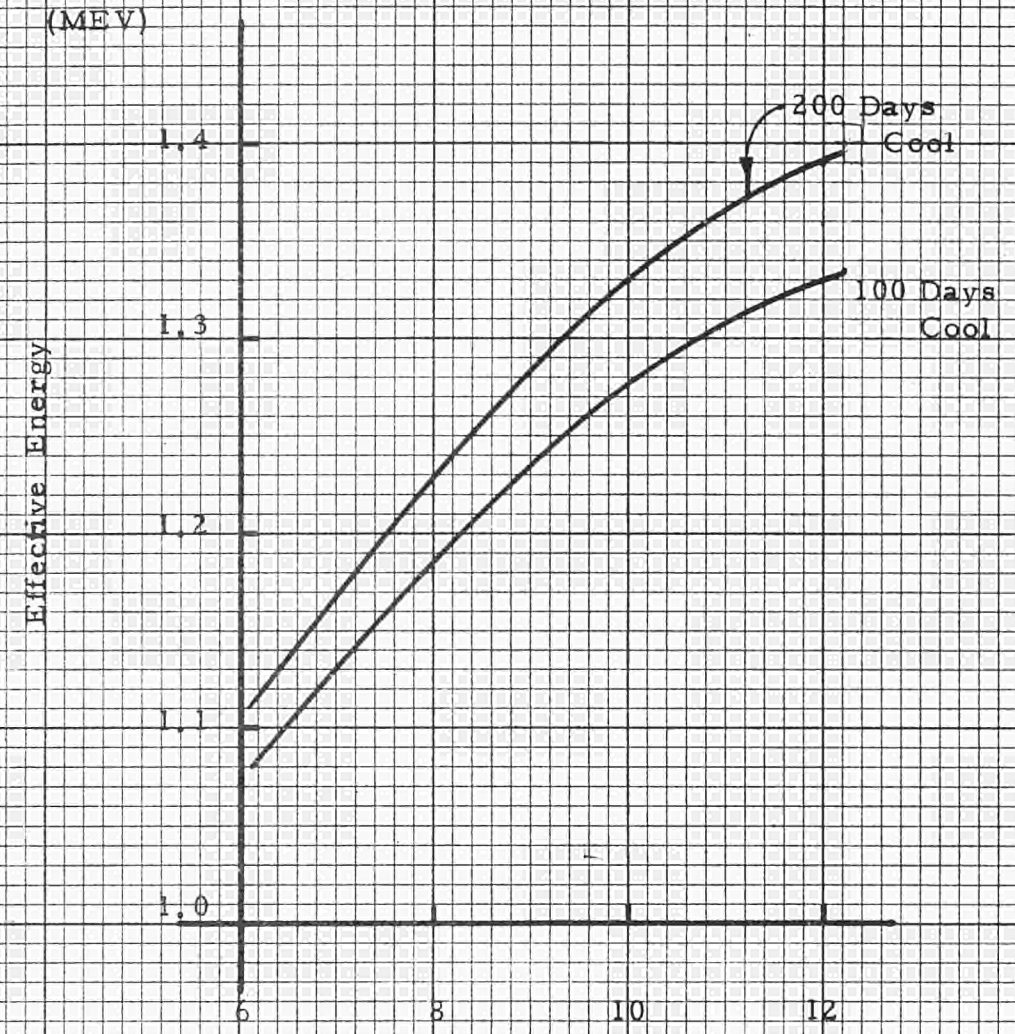


Figure IV - 3

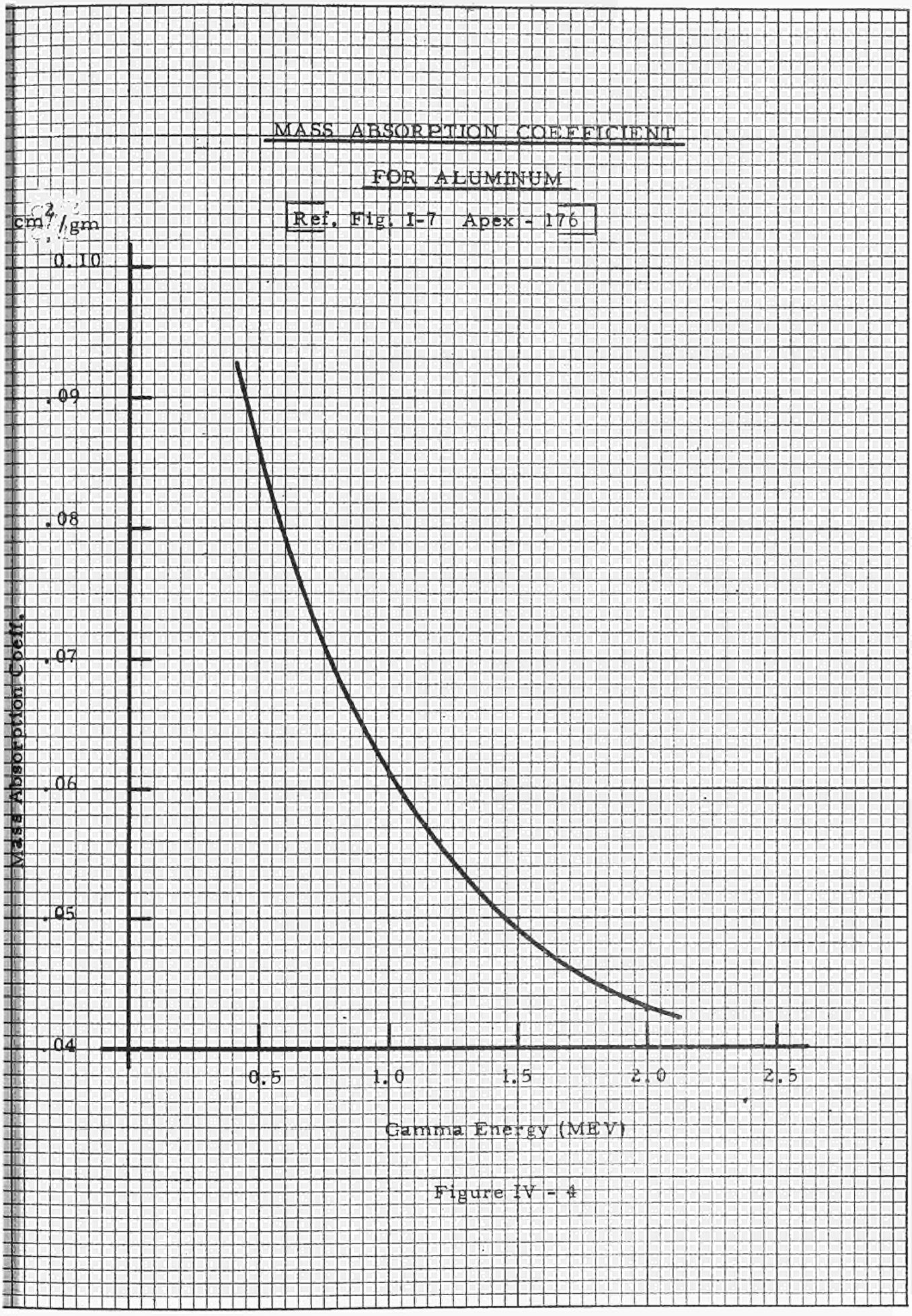

MASS ABSORPTION COEFFICIENT
FOR ALUMINUM
Ref. Fig. I-7 Apex - 176
cm²/gm
0.10
.09
.08
.07
.06
.05
.04
Mass Absorption Coeff.
0.5
1.0
1.5
2.0
2.5
Gamma Energy (MEV)

Figure IV - 4

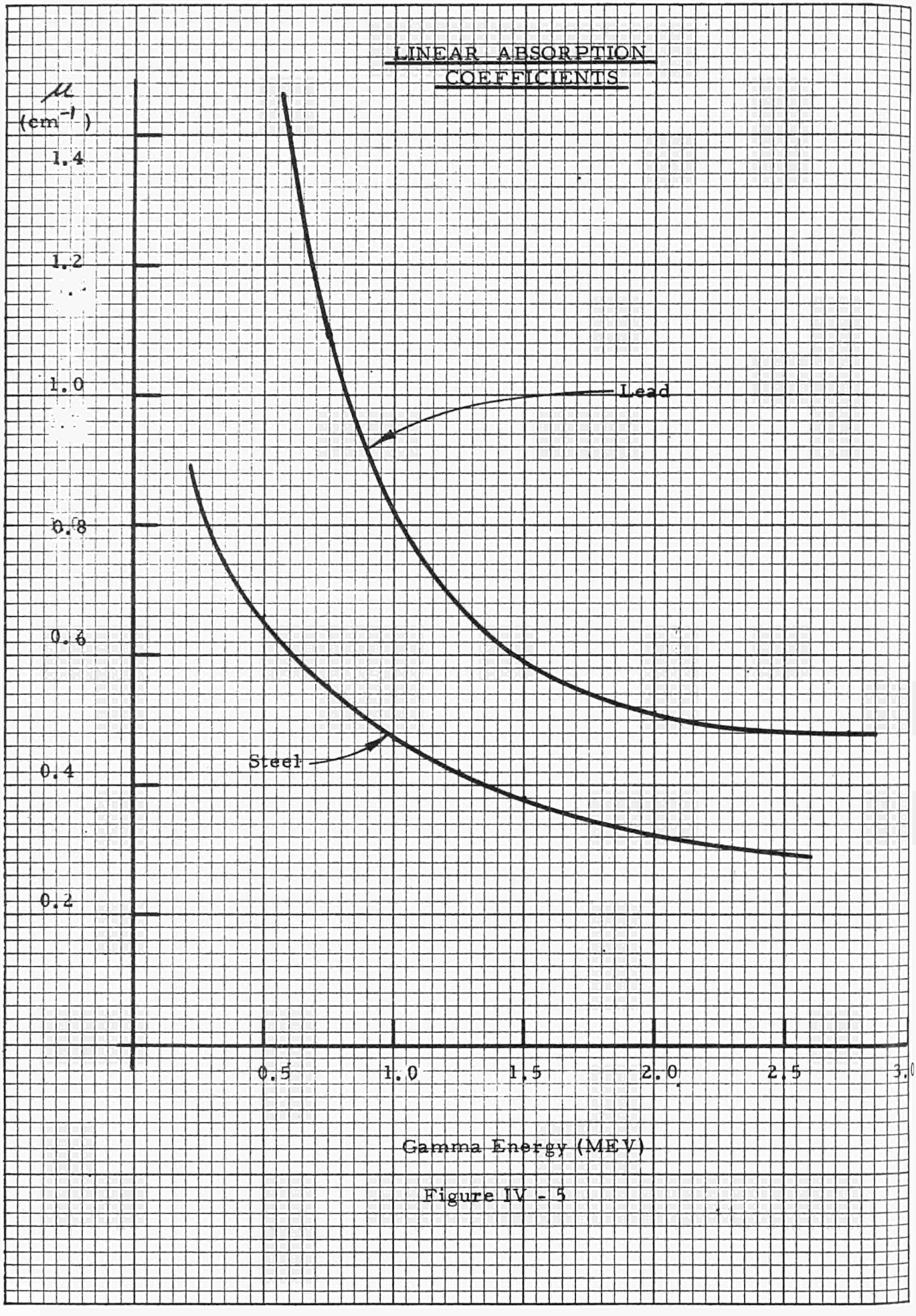

LINEAR ABSORPTION COEFFICIENTS
μ (cm⁻¹)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
Lead
Steel
0.5
1.0
1.5
2.0
2.5
3.0
Gamma Energy (MEV)

Figure IV - 5

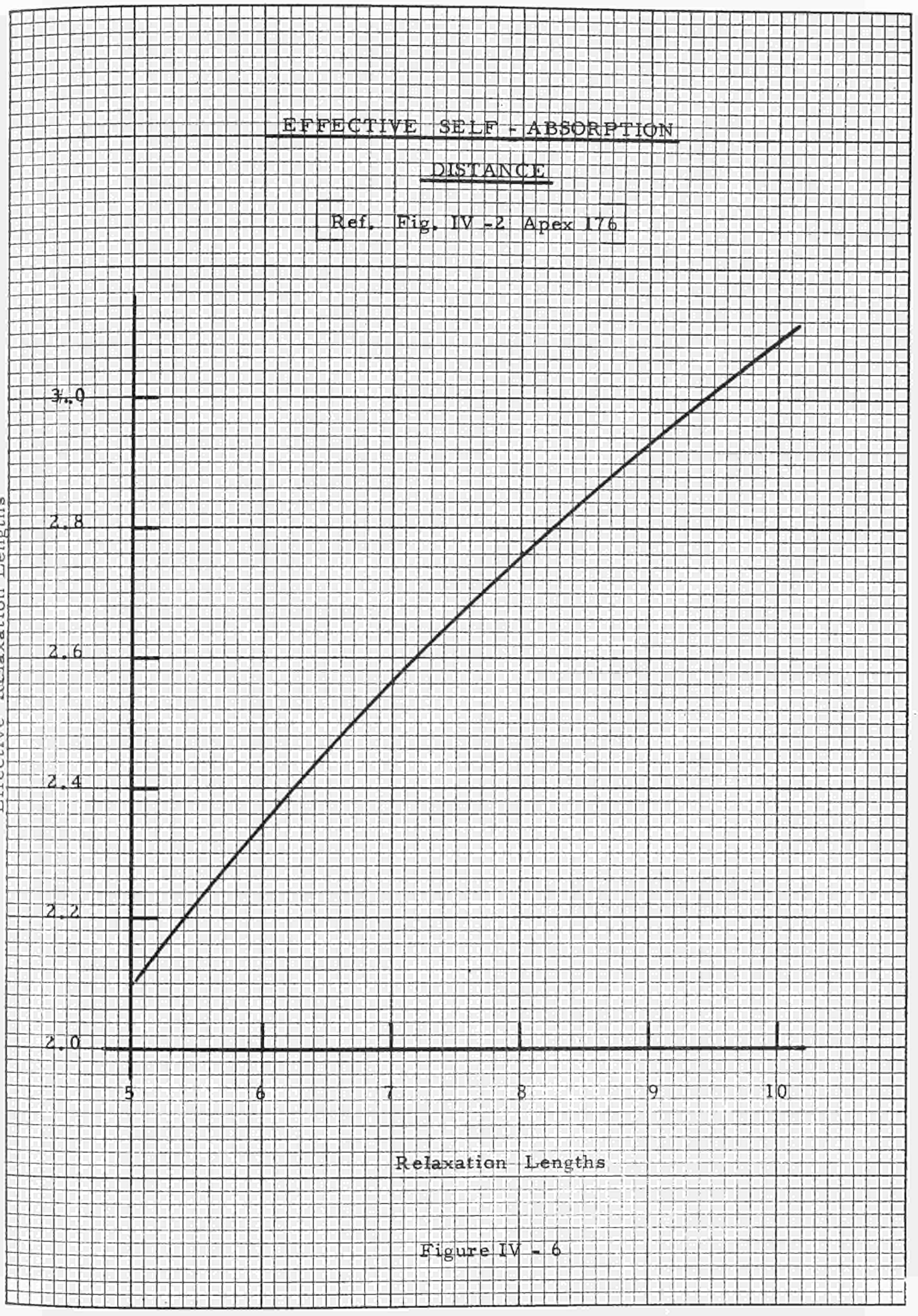

EFFECTIVE SELF - ABSORPTION
DISTANCE
Ref. Fig. IV -2 Apex 176
3.0
2.8
2.6
2.4
2.2
2.0
Effective Relaxation Lengths
5
6
7
8
9
10
Relaxation Lengths

Figure IV - 6

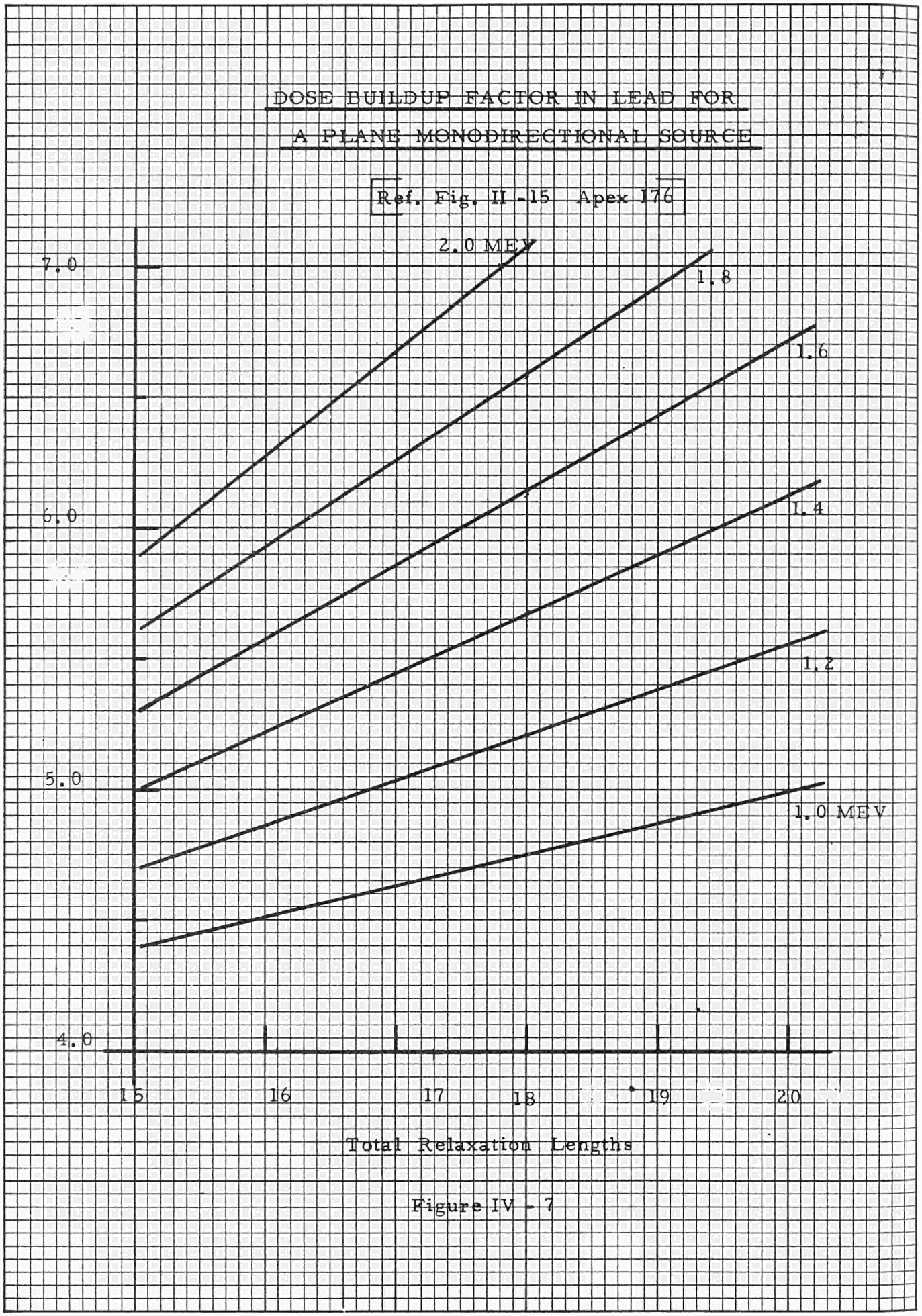

DOSE BUILDUP FACTOR IN LEAD FOR
A PLANE MONODIRECTIONAL SOURCE
Ref. Fig. II -15 Apex 176
2.0 MEV
1.8
1.6
1.4
1.2
1.0 MEV
7.0
6.0
5.0
4.0
15
16
17
18
19
20
Total Relaxation Lengths

Figure IV - 7

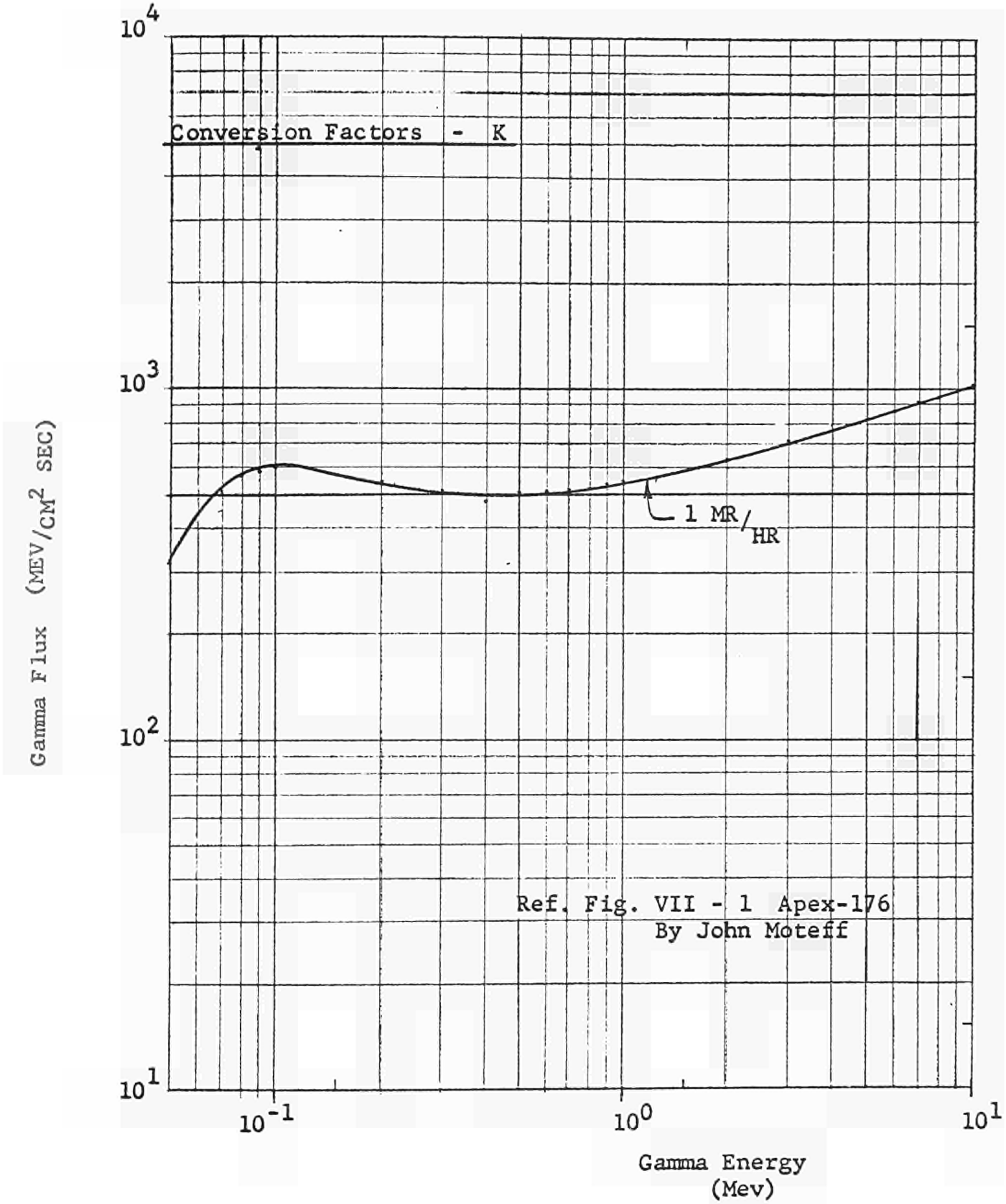

Conversion Factors - K
10^4
10^3
10^2
10^1
1 MR/HR
Gamma Flux (MEV/CM^2 SEC)
Ref. Fig. VII - 1 Apex-176
By John Moteff
10^{-1}
10^0
10^1
Gamma Energy
(Mev)

Figure IV - 8

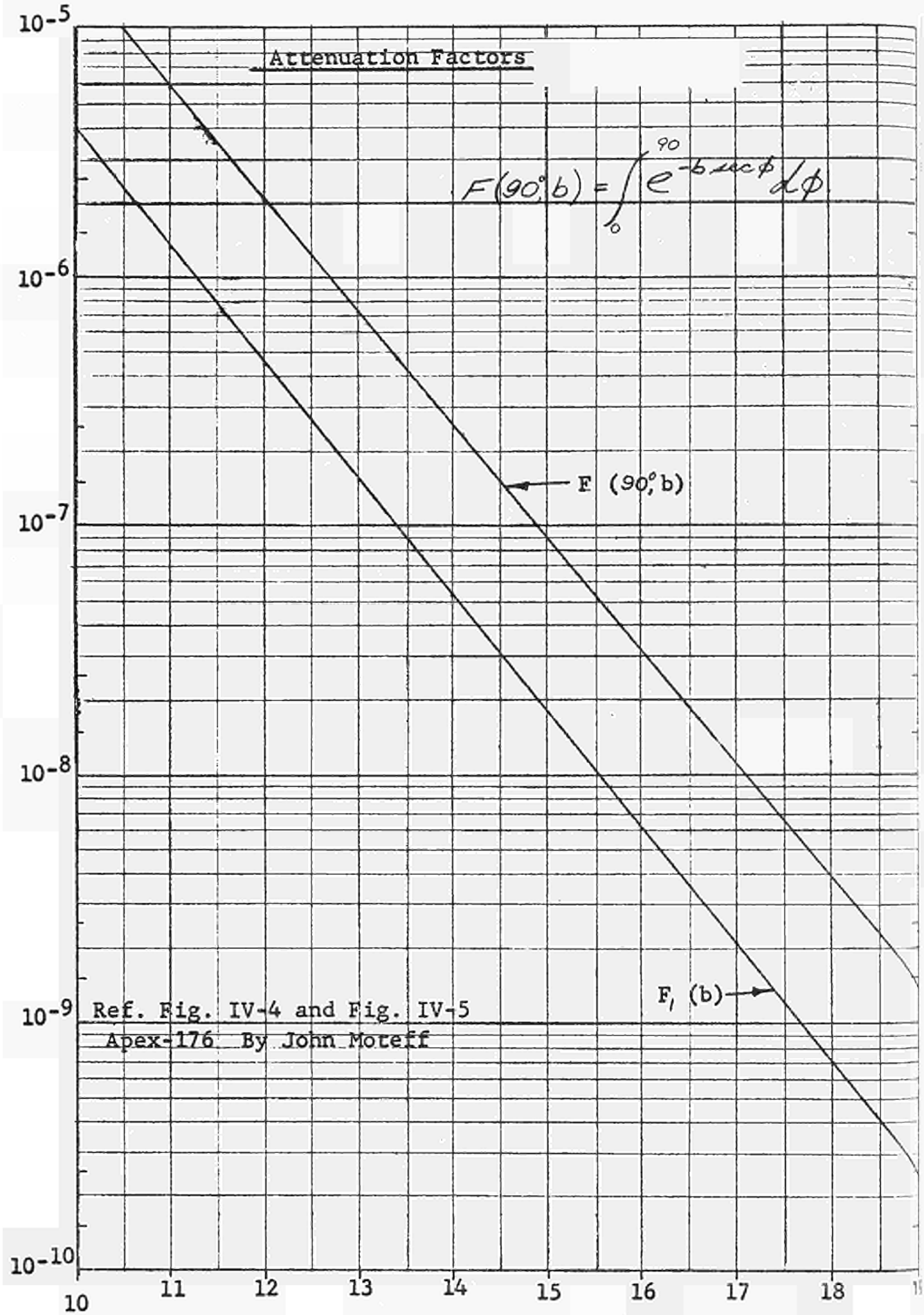

Attenuation Factors
$F(90°,b) = \int_0^{90} e^{-b \sec\phi} d\phi$
F (90°, b)
F_1 (b)
Ref. Fig. IV-4 and Fig. IV-5
Apex-176 By John Moteff
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10
11
12
13
14
15
16
17
18
Total Relaxation Lengths
b

Figure IV - 9

Figure IV-4: Mass absorption coefficient for aluminum as a function of gamma ray energy.

Figure IV-5: Linear absorption coefficients for lead and steel as a function of gamma ray energy.

Figure IV-6: Effective relaxation lengths as a function of calculated relaxation lengths.

Figure IV-7: Dose buildup factor as a function of gamma ray energy and total relaxation lengths.

Figure IV-8: Conversion factors to change gamma ray energy to gamma flux for a given dose rate.

Figure IV-9: Attenuation factors as a function of total relaxation lengths.

2. Reactor Handling Facilities

In the design phases of the reactor itself, consideration must be given to an overall scheme and method of spent fuel removal.

The designers of the SENN reactor, the General Electric Company, intended that the shipping cask be placed in the fuel storage pool in a vertical position. Since the cask, for ease of loading and unloading, must be top opening, this meant that the fuel assemblies were to stand on end while the cask was in the pool. The area within the pool allotted for the cask is 9.8 feet (3 meters) by 9.2 feet (2.8 meters) and is covered by water to a depth of 45 feet (13.7 meters)

Servicing the pool is a single bridge crane of 60.6 ton (55 metric ton) capacity whose highest hook position above the top of the pool is 14.5 feet (4.4 meters).

The cask is removed from the loading pool while in the vertical position, moved horizontally, still in the vertical position, to an area where it can be lowered to the reactor operating floor proper. The reactor operating floor is 38 feet (11.6 meters) below the top of the pool.

2. Reactor Handling Facilities (cont.)

When the cask is lowered to the reactor operating floor it is placed upon a trolley or wagon and rotated into the horizontal position. The trolley with the cask aboard is then moved out of the containment sphere through an air lock which is 8 feet (2.4 meters) by 8 feet (2.4 meters) by 25 feet (7.6 meters) long.

Once outside the containment sphere, another 60.6 ton (55 metric ton) crane is available to remove the cask from the trolley and place it on the vehicle to be used for further transportation.

We can summarize the above facilities as they affect the physical configuration of the cask as follows:

(a) Maximum cask length - 14.5 feet
(b) Maximum cask width - 8 feet
(c) Maximum cask height - 6 feet
(assuming trolley height of 2 feet)
(d) Maximum cask weight - 60.6 tons

3. Transportation Facilities

The SENN reactor is not serviced by a railroad siding. The road servicing the reactor site is suitable, however, for loads up to approximately 200 tons (181.5 metric tons). This road is being used to bring in all the reactor components including the pressure vessel which weighs approximately 150 tons (136.1 metric tons).

Since the cask, on leaving the reactor, will be in a horizontal position, it would appear to be advantageous to leave the cask in this position while being transported to the port. Shipping horizontally lowers the center of gravity of the cask and removes the necessity of constructing a special superstructure on the vehicle to help support the load.

Within the Port of Naples there are available floating cranes with a capacity of 150 tons. No problems within the port are therefor expected.

3. Transportation Facilities (cont.)

Shore based or floating heavy lift equipment is necessary because the ocean freighters in common use do not have equipment on board capable of lifting a cask of 60 tons. Most vessels are limited to lifts of between 5 and 10 tons. A vessel capable of lifting more than this is fitted with special equipment and very rarely can lift over 30 tons.

Any ship used to carry the cask will require that its deck be reinforced to help carry the load and distribute it over a wider surface area. This is a relatively common procedure.

While aboard ship the cask will be in the horizontal position here again to lower the center of gravity and remove the necessity of erecting a special structure to keep the cask in place. If the cask were in the vertical position it would increase the problems of load distribution to the point where it would affect the allowable cask weight and size.

The Ports of Charleston and Savannah, both of which are being considered as ports of entry, have shore based and floating heavy lift facilities so that cask handling within the port area presents no real problem.

The cask will be removed from the ship and placed directly onto a special railcar. The load carrying ability and the physical clearances of the railroad are more than adequate for a 60 ton cask which is being shipped in the horizontal position.

4. Reprocessing Plant Facilities

The Savannah River Plant is located within the state of South Carolina, approximately 20 miles southeast of Augusta, Georgia and borders the Savannah River. It is serviced by highways and a railroad. The delivery point for the plant is Dunbarton, South Carolina.

The Savannah River is navigable up to and beyond the plant but facilities for receiving barge type shipments have not been made available . Even if dock facilities were available this would not be considered a desirable solution since the cask would have to be loaded onto another type of vehicle, after removal from the barge, for delivery to the unloading area.

The cask unloading area is serviced by a 100 ton capacity moveable bridge carrying two 50 ton cranes. The bridge and cranes are oriented in relation to the railway track so that the cranes can only lift casks whose trunion centerlines are parallel with the centerline of the railcar.

Within the basin area the maximum clearance under the hooks is 27 feet (8.2 meters). The distance between the hook centerlines can be varied from 7 feet 8 inches (2.3 meters) to 25 feet (7.6 meters)

The maximum cask height can be 33 feet minus the length of the fuel element in feet. In the case of the SENN reactor this maximum cask height becomes 22.25 feet (6.78 meters).

The maximum diameter of the cask is limited to 9 feet (2.7 meters) including trunions.

The cask is to be top opening and constructed of stainless steel where corrosion or contamination could become a problem.

Fuel element packages are not to weigh in excess of 6000 pounds and are not to exceed 17.5 feet (5.3 meters) in length and 28 inches (0.7 meters) in width or diameter.

D. PHYSICAL DESIGN

The physical design of the cask, when completed, must satisfy the following criteria: (1) contain the number of fuel assemblies desired, (2) dissipate the contained decay heat safely, (3) provide adequate radiation shielding, (4) be compatible with all the handling facilities that may be encountered during transport, and (5) satisfy each of the specific design requirements that may be found in the applicable regulations.

The initial assumptions are all based on good design practice and experience in the design of this type of equipment. Only those assumptions which would directly affect the heat dissipation ability and radiation shielding ability of the cask were checked by calculation.

An arbitrarily selected number of fuel assemblies were arranged in relation to one another so that the space required was at a minimum. The necessary area was compartmented with one fuel assembly intended for each compartment. A single large cavity with the fuel assemblies to be held by a basket-like arrangement within the cavity was not considered suitable since two baskets would be required as soon as seven or more fuel assemblies were involved. This is due to the limitation imposed, by the reprocessing plant, of three tons maximum weight on packages to be handled within the unloading pool.

The thickness of the interior cavity wall, and the thickness of the lead, was arbitrarily selected. The external skin thickness selection is based on paragraph 72.34(a) of the AEC's Proposed Part 72 which specifies the minimum skin thickness allowed based on the gross weight of the cask.

One end of the cask was left completely smooth and free of fittings so that it could rest on this end while in the loading and unloading pools.

One side of the cask was fitted with three saddles which are intended to act as points of rest while the cask is in the horizontal position.

Four lifting trunnions were added which are to be symmetrical about the center of gravity of the cask, so that when lifted the centerline of the cask will rest in a horizontal position.

Twelve tie down points, six on each side, were placed on the cask. These tie down points are to be used when securing the cask to the ship.

A large turning trunnion was added to each side near the smooth end of the cask. These trunnions provide a means of rotating the cask from the vertical to the horizontal position and back again. The turning trunnions are also used as the primary hold down point while the cask is aboard the railway car in the United States.

Fins were added to the exterior of the cask wherever possible to aid in the dissipation of the contained decay heat. These fins are circumferential because the cask is intended to be transported in the horizontal position. The size and spacing of the fins was an arbitrary selection based on past experience. No attempt was made to maximize the efficiency of these fins.

An engineering analysis of the overall structure was not performed. A brief examination of the tie down points and methods, indicated that the devices provided would most likely satisfy the various regulatory requirements. In the event a modification would be found necessary in order to satisfy the regulations, the overall size and weight of the cask would change very slightly.

In addition, the final design should include, provisions for water circulation, provision for taking temperature readings, a pressure valve, and a particulate filter.

The weight and dimensions of the cask, designed for both nine and twelve assemblies, including a representation of the manner in which the central cavity is compartmented is found in Figure IV-10.

A comparison of the physical specifications of the cask with the various physical limitations imposed by the facilities to be used shows the following:

(1) The nine assembly cask satisfies the maximum weight limitations of 60.6 tons imposed by the reactor handling facilities.

(2) The width of the nine assembly cask satisfies the maximum width limitation of 8 feet imposed by the reactor air lock.

(3) The height of the nine assembly cask, when resting in the horizontal position satisfies the maximum height limitation of 6 feet imposed by the reactor air lock.

(4) The length of the cask satisfies the maximum length limitation of 14.5 feet imposed by the reactor crane facilities.

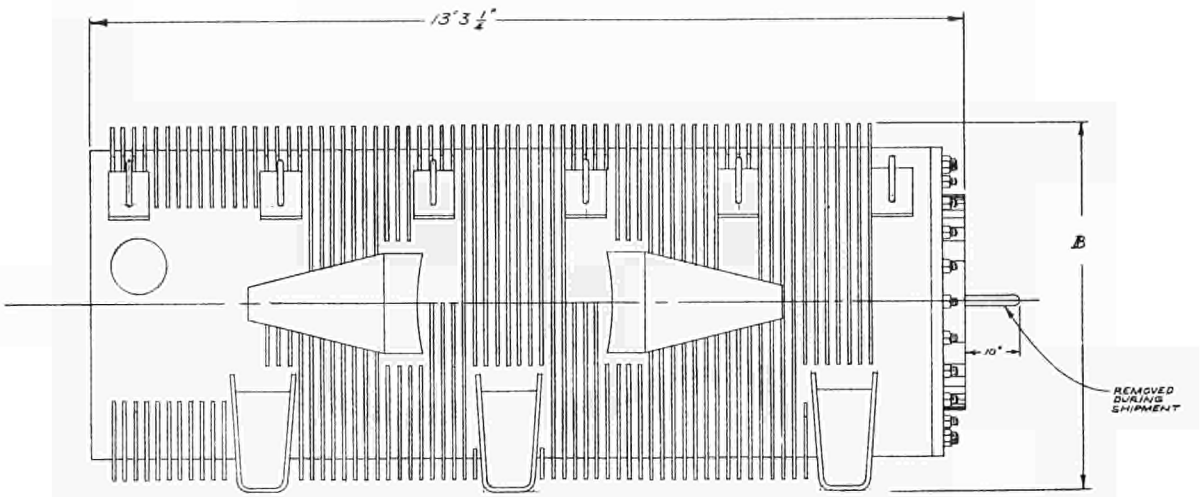
(5) The cask design provides for the rotating of the cask about its turning trunnions both at the reactor site and the reprocessing site.

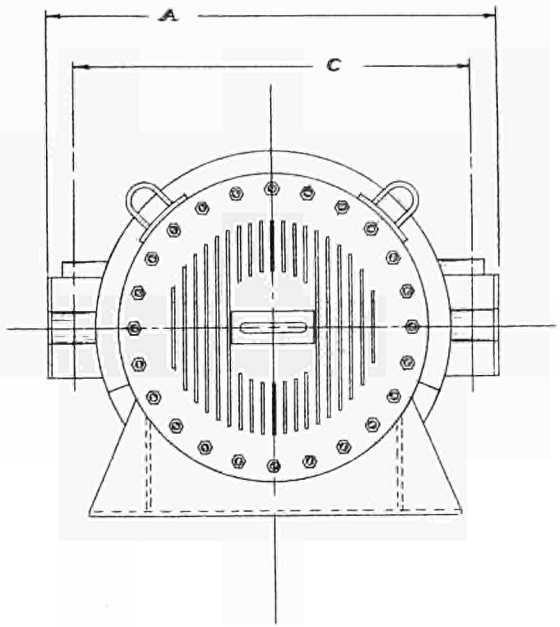
(6) The cask provides twelve tie down points for adequate securing of the cask to the ship during transport.

(7) The cask is top opening.

(8) The lifting trunnions are compatible with the crane hooks at the reprocessing plant though this is not necessary since an adapting yoke is required to lift the cask.

NUMBER OF ASSEMBLIES IN CASK	A	B	C	CASK INTERIOR CROSS SECTION	SHIPPING WEIGHT OF CASK - FULL	SHIPPING WEIGHT OF CASK - EMPTY	WEIGHT OF COVER	WEIGHT OF FUEL	WEIGHT RATIO CASK TO FUEL
9	6'5"	5'1"	5'7"		105,000 LBS.	94,965 LBS.	6070 LBS.	6930 LBS.	14.2 LBS./LB.
12	6'10"	5'6"	6'0"		125,000 LBS.	112,020 LBS.	7405 LBS.	9240 LBS.	12.5 LBS./LB.





ITEM	DATE	REVISION	BY
B	9/21	HOLD DOWN LUGS ADDED	GF
A	7/26	MODIFIED FOR R-CAR	GF

STANRAY CORPORATION
Research & Development Dept.
Chicago 8, Illinois

CONCEPTUAL CASK DESIGN
SENN REACTOR
CONTRACT NO. AT(11-1)-963

DRAWN	DATE	SCALE	SHEET
GF	5/19/61	1"=1'0"	SK-AA-1

FIG. IV-10

E. HEAT DISSIPATION DESIGN

The ability of the cask to dissipate the contained decay heat is dependent upon the size and shape of the various components, the material from which they are made and the manner in which they are arranged.

The various applicable regulations require:

(1) Maximum surface temperature no greater than 180° F.
(2) Maximum coolant temperature not to exceed 192° F.
(3) Calculations to be made based on a 100° F ambient temperature and a no wind condition.

In evaluating the ability of the cask to dissipate the contained heat if we assume that the primary coolant water is at a temperature of 192° F and that the air outside the cask is at a temperature of 100° F, we can calculate, using thermal resistance methods, the total allowable rate of heat flow.

The curves of Figures IV-11 were produced in this manner.

Figures IV-11 shows that for an allowed primary water temperature of 192 °F, there will be a corresponding surface temperature of 167° F and a total contained decay heat rate of 44,200 BTU per hour.

This corresponds to a total decay heat per fuel assembly of 4,900 BTU per hour and a cool time of 177 days. (See Fig. IV-1)

A pressurized cask can normally increase the allowable total decay heat contained, however, Figure IV-11 indicates that the maximum primary water temperature that can be attained while still maintaining a surface temperature of 180° F is 210° F.

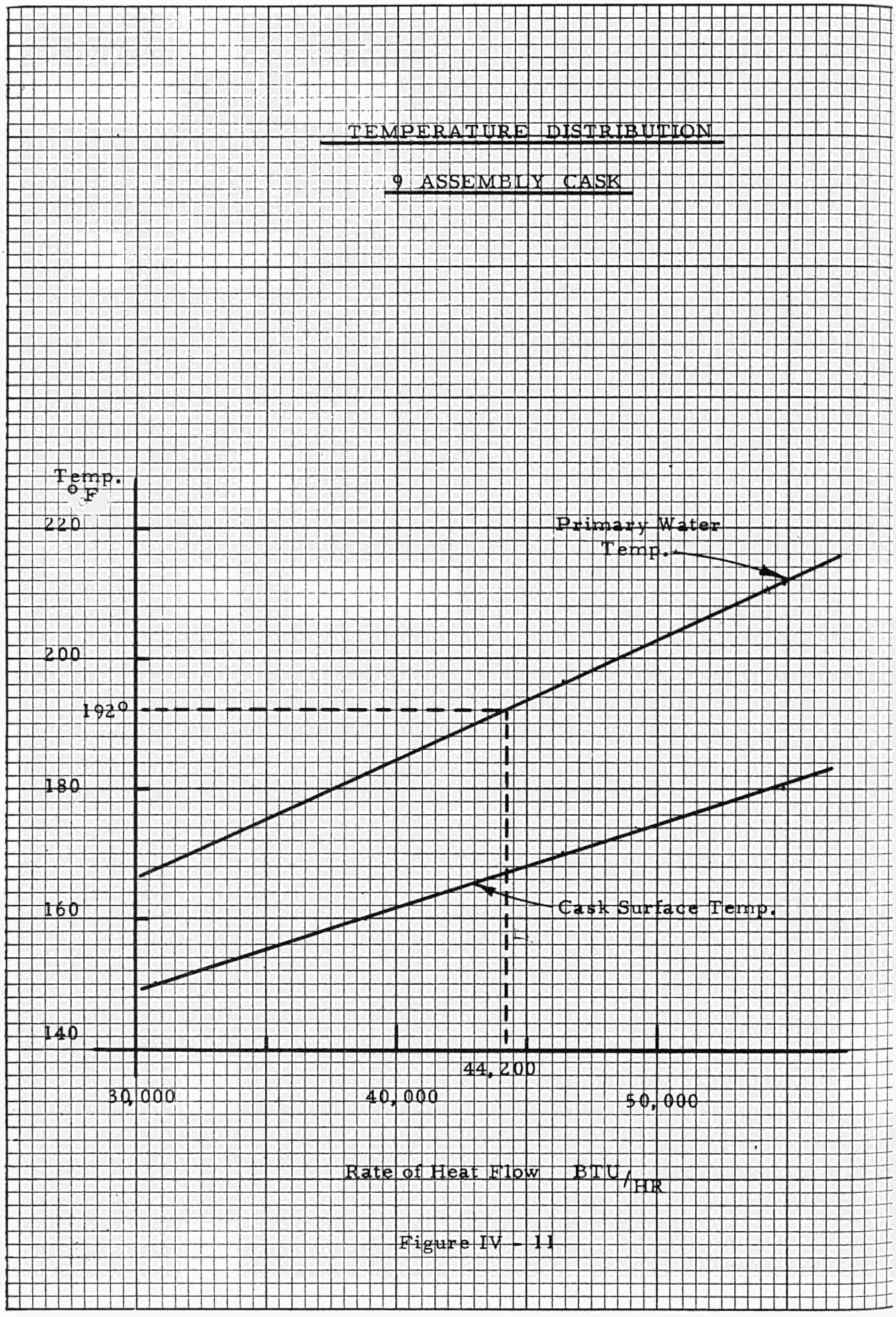

TEMPERATURE DISTRIBUTION
9 ASSEMBLY CASK
Temp. °F
220
200
192°
180
160
140
Primary Water Temp.
Cask Surface Temp.
44,200
30,000
40,000
50,000
Rate of Heat Flow BTU/HR

Figure IV - 11

F. RADIATION SHIELDING

The criteria which determine the amounts of radiation shielding required are to be found in the applicable regulations and the acceptance criteria of the reprocessing plant.

The cask designed in Section D was analyzed for compliance with these criteria by the use of the "effective energy method" which is found in "Graphical Aids in the Calculation of the Shielding Requirements for Spent U-235 Fuel", by R. L. Ashley (NAA-SR-1992). Additional information which was used is to be found in "Miscellaneous Data for Shielding Calculations" by John Moteff (Apex-176)

Evaluation using the above method leads to a reliable indication of the adequacy of the shielding assumptions made. The major inaccuracies to be found are not introduced by the method itself, but by the fact that interpolation and extrapolation of the available graphs is very often required.

The external radiation levels allowed by the various criteria are 200 milliroentgen per hour at the surface of the cask and 10 milliroentgen per hour at one meter from the source of radiation.

In estimating doses at various distances from a known source, the "inverse square law" has been used in the past. This is a correct approximation in the event the radioactive source relative to the point at which the dose is to be estimated can be considered a point source.

Assuming that a radioactive source eleven feet long is a point source for purposes of estimating dose at a distance of 10 or even 20 feet is not correct. For purposes of estimating dose within the vicinity of the cask a direct proportion relationship is more nearly correct.

Application of the "effective energy method" to the SENN cask, using the information and graphs contained in Section C-1, yields for a 175 day cool period a calculated dose at the surface of 10 milliroentgens per hour, at one meter from the source, 5 milliroentgens per hour and at 3 meters from the source 2 milliroentgens per hour.

Calculations were also made for other cool times and the variation was so slight as to be considered within the expected error of the method. It is possible, for this reason, to consider that the dose rate remains constant within the period of 150 days cool time to 200 days cool time.

Criticality calculations were not made because the k_{eff} of the array can be reduced to below 0.9 by the addition of poison material to the individual cavity walls. The addition of this material will not be reflected in an appreciable increase in cask weight or size.

G. AUXILIARY EQUIPMENT

The auxiliary equipment that may be needed to insure the safe and efficient transport and handling of the cask can be divided into two major groups, (1) equipment necessary regardless of cask design, and (2) equipment which is entirely dependent on the configuration of the cask and the shipping scheme.

The equipment which would be necessary regardless of cask size and design is that which is used for various tests performed on the cask. These items are; pumps, hoses, valves, etc. for circulating the primary coolant, and temperature reading devices for determining the temperature within the cask and insuring that equilibrium is reached prior to shipment.

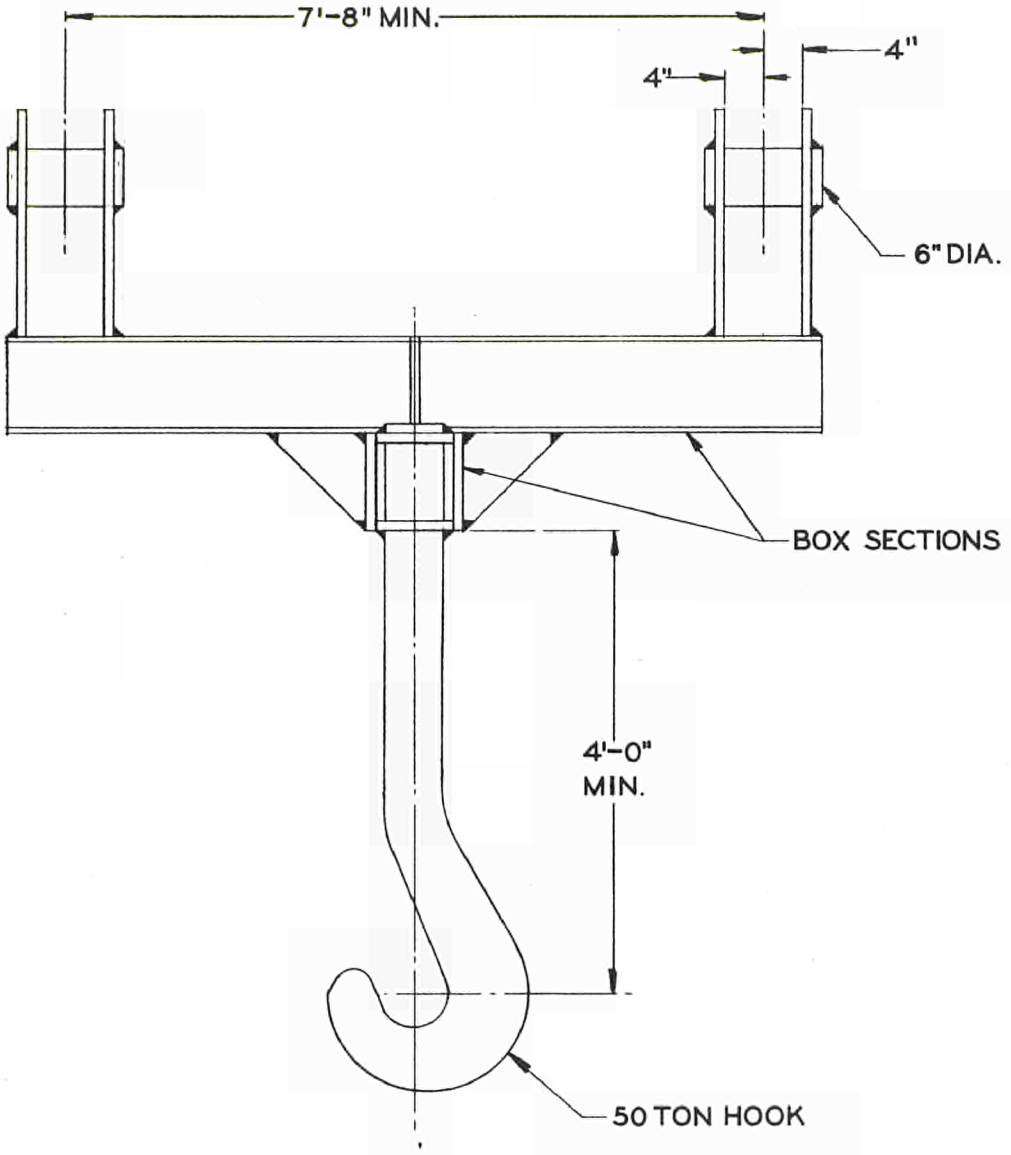
These items are normally "off the shelf" types of equipment and not of a special design.

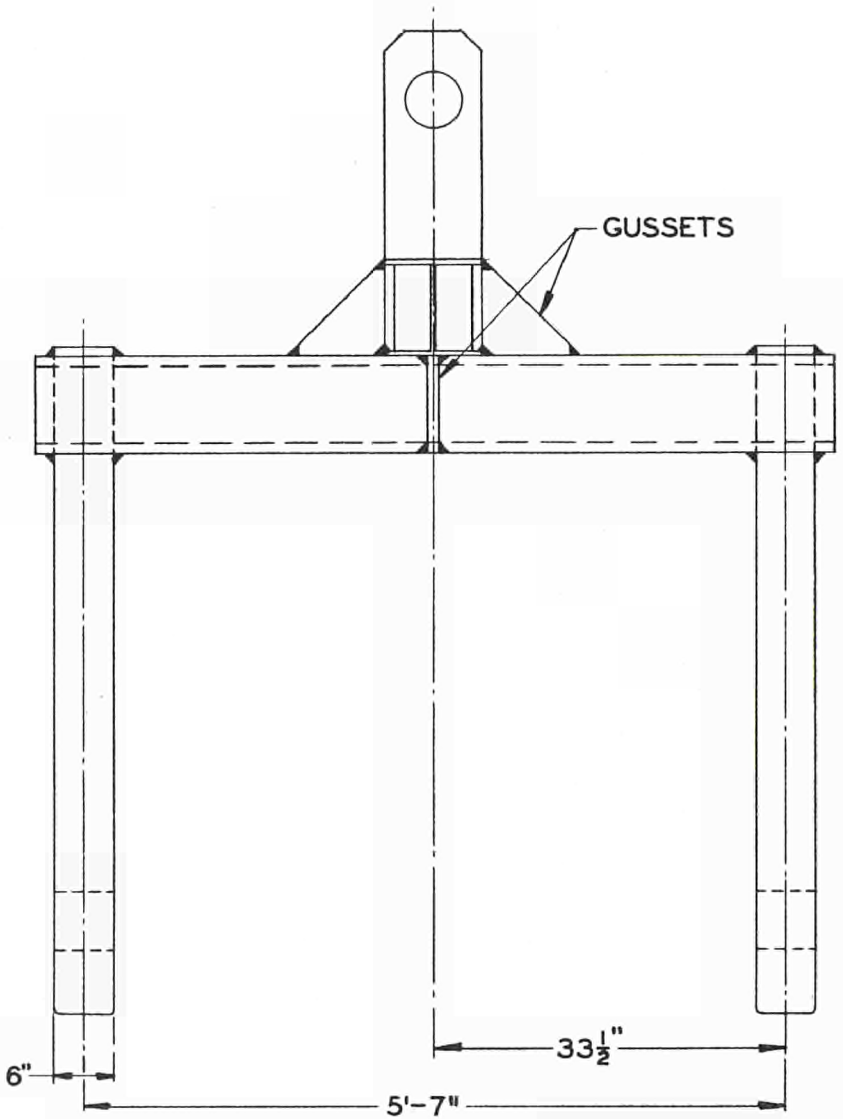
The other pieces of equipment which are entirely dependent on cask design are items needed to aid in the securing and handling of the cask.

The auxiliary equipment needed at the Savannah River Plant consists of a special "Cask Lifting Yoke" which is illustrated in Figure IV-12. This yoke is necessary since the facilities at the plant are designed to handle casks whose trunion centerlines are parallel with the centerline of the railcar on which it is secured. The yoke can take many different forms and shapes and the drawing of Figure IV-12 is only intended to serve as an illustration.

A second piece of auxiliary equipment needed is a special skid to help distribute the weight of the cask while aboard ship. The use of this skid is more fully discussed in the chapter entitled "Sea Transportation". Figure IV-13 shows the details of this skid.

The equipment necessary to safely transport the cask in Europe and the United States is discussed in the appropriate chapter.





CASK LIFTING YOKE

FIG. IV-12

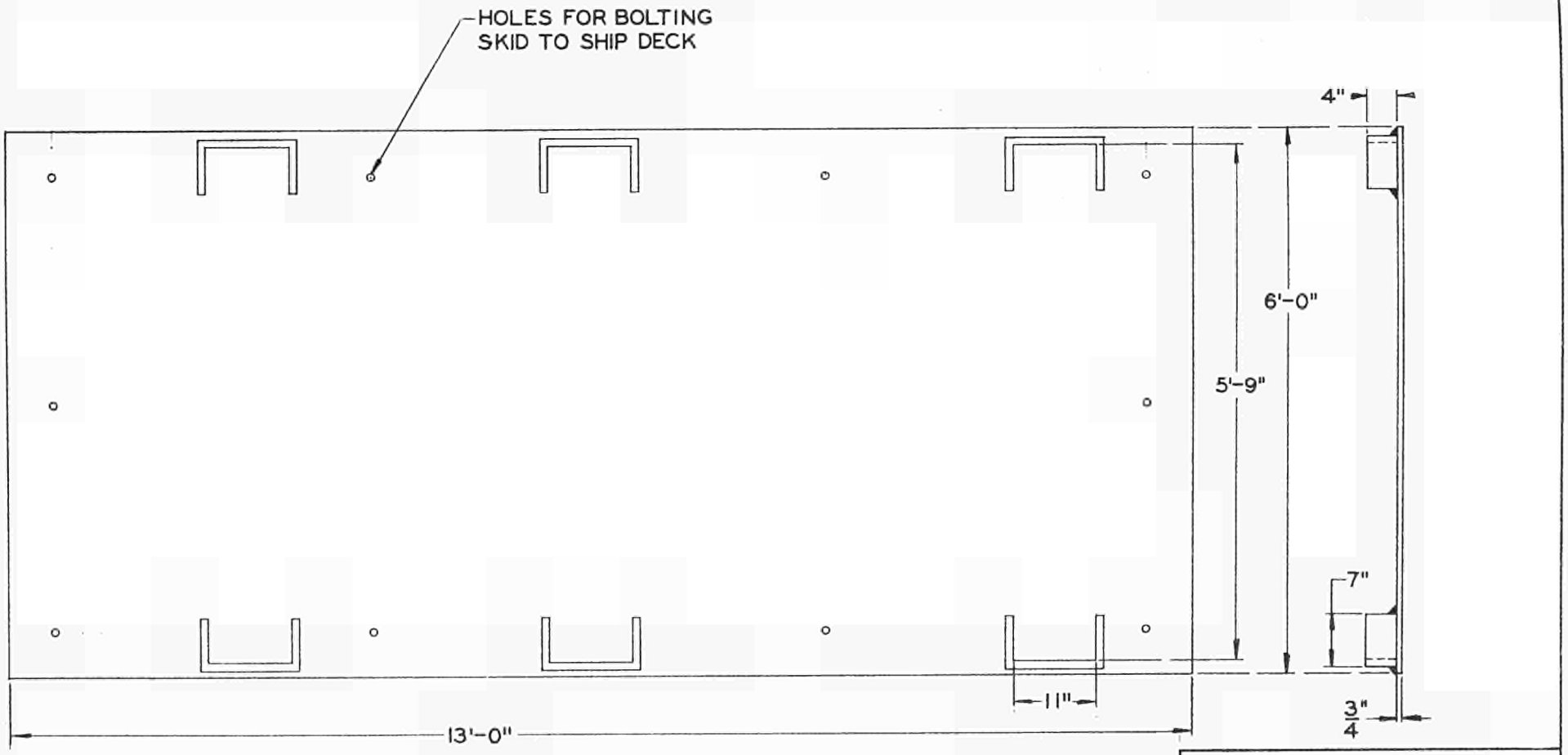
STANRAY CORPORATION
200 South Michigan Avenue Chicago 4, Illinois

JOINT U.S.–EURATOM RESEARCH & DEVELOPMENT PROGRAM

DESIGN & ECONOMIC STUDY OF SPENT FUEL SHIPPING

CONTRACT NO. AT(11-1)-963

DATE 4-23-62 DRW'G NO. SK-44-4



SHIPBOARD SKID

FIG. IV-13

STANRAY CORPORATION
200 South Michigan Avenue Chicago 4, Illinois

JOINT U.S.-EURATOM RESEARCH & DEVELOPMENT PROGRAM
DESIGN & ECONOMIC STUDY OF SPENT FUEL SHIPPING
CONTRACT NO. AT(11-1)-963

DATE 4-23-62 | DRWG. NO. SK-44-5

H. COST ESTIMATE

The annual cost of the equipment used is dependent to a great degree on the expected life of the equipment.

The life expectancy of a cask is extremely difficult to determine. Besides the normal wear and tear to which a piece of transportation equipment might be exposed, the gradual accumulation of radioactive residue within the cask could shorten its useful life.

It is impossible to estimate, at this time, with any degree of accuracy the useful life of a spent fuel shipping cask. For this reason we have arbitrarily assumed a useful life of 10 years. We have also arbitrarily assumed an interest rate of 7% per annum.

The estimated cost of preparing the basic design and placing it in a form that could be submitted to the various regulatory groups for their approval, is set at $30,000.

The cost of the cask can vary, depending on the source, by as much as 40%. We have estimated the cost of the 95,000 pound cask of Figure IV-10 at $1.00 per pound or approximately $95,000. Let us also assume that $5,000 of the cost of the cask is a non-recurring initial engineering cost so that subsequent casks of identical design will cost $90,000 each.

The cost of the skid of Figure IV-13 is estimated at $625 and of the cask lifting yoke of Fibure IV-12 at $3,000.

If we assume that the trip from the SENN reactor to the Savannah River Plant requires 30 days travel each way then the minimum number of casks that can be used and still complete the delivery of a batch in 60 days, is three. We shall investigate the cost of this arrangement and also the cost of utilizing five casks with each making only one round trip per batch.

The annual cost of these capital expenditures will be determined on the basis of a year-end annuity, for a period of 10 years at an interest rate of 7% per annum, which is equivalent to the present required capital expenditure. In the following formula $i = 7\%$ and $n = 10$ years.

Annual cost of engineering:

$$\$35,000 \left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] = 35,000\ (.1424) = \$4,984/\text{yr.}$$

Annual cost of cask lifting yoke:

$\$3000\ (.1424) = \$427.20/\text{year}$

Annual cost of three casks:

$\$270,000\ (.1424) = \$38,448/\text{year}$

Annual cost of three skids:

$\$1875\ (.1424) = \$267/\text{year}$

Annual cost of five casks:

$\$450,000\ (.1424) = \$64,080/\text{year}$

Annual cost of five skids:

$\$3125\ (.1424) = \$445/\text{year}$

Annual cost of two railcars with a 20 year life:
(Shown in Figure V-10)

$\$100,000\ (.0944) = \$9440$

Annual maintenance cost per year per cask = $1000
(Assumed)

An average of seven cask trips per year would be made during a ten year operational period.

Annual cost of three casks:

Engineering	$ 4,984.00
Cask Lifting Yoke	427.20
Casks	38,448.00
Skids	267.00
Railcars	9,440.00
Maintenance	3,000.00
Total Annual Cost =	$ 56,566.20
Cost per round trip =	$8,080.89

Annual Cost of five casks:

Engineering	$ 4,984.00
Cask Lifting Yoke	427.20
Casks	64,080.00
Skids	445.00
Railcars	9,440.00
Maintenance	5,000.00
Total Annual Cost =	$ 84,376.20
Cost per round trip =	$ 12,053.74

APPENDIX A

REGULATIONS FOR THE SAFE TRANSPORT OF RADIOACTIVE MATERIALS

(EXCERPTS FROM THE REGULATIONS)

International Atomic Energy Agency
Vienna, 1961

The regulations of the International Atomic Energy Agency (IAEA) set forth principles of performance applicable to shipments of both large and small sources of radiation.

The regulations are written in general terms leaving the actual details of construction of the casks and the details of operation to the judgement of the competent authority of the country within which the shipment originates.

These regulations are recommended safety standards which were presented to the seventy-four member nations of the IAEA by two panels which were convened for that purpose. Countries whose scientific and technical status do not require at this time that they study and promulgate regulations applicable to this problem, will most likely use these recommendations as the basis for their own national regulations.

Other countries expecting increased activity in the transportation of radioactive materials will no doubt promulgate regulations which they consider to be more suitable for their own particular needs.

In any event a shipment must comply with the regulations of each country through which it may pass.

We will consider and discuss, in this appendix, only those portions of the regulations which may become applicable to shipments of spent fuel.

1. GENERAL

Radioactive material in the form of spent fuel is classified as a large source.

The known radioisotopes are categorized into three groups according to their radiotoxicity. These groups are:

Group I:	very high radiotoxicity
Group II:	high radiotoxicity
Group III:	moderate or low radiotoxicity

A list of the isotopes and the group to which it belongs is found in the regulations. For our purposes, it is sufficient to know that spent fuel contains isotopes belonging in all three groups and must therefor be considered in Group I, the most hazardous.

Radioactive materials must not be stowed next to explosives inflammables, corrosives, or oxidizing substances. Stowage next to persons or undeveloped film is covered by the data of Figure A-1 and Figure A-2.

Packages of large radioactive sources can be divided into two categories depending on the amount of radiation emanating from the cask. A shipment of spent fuel will always be a category "yellow" package. Category yellow requirements are found in the section on radiation regulations.

SAFE DISTANCES FOR UNDEVELOPED FILM AND PLATES

(CARRIAGE OF PACKAGES CONTAINING RADIOACTIVE MATERIALS)

TOTAL NUMBER OF RADIATION UNITS SHOWN ON THE PACKAGES	MINIMUM DISTANCE IN METERS															
	4 - DAY VOYAGE				9 - DAY VOYAGE				16 - DAY VOYAGE				25 - DAY VOYAGE			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
UP to 1	4.5	3	3	4.5	6	4.5	3	4.5	9	6	3	4.5	10.5	7.5	3	4.5
2 to 5	10.5	4.5	3	4.5	15	4.5	3	4.5	22.5	7.5	3	4.5	28.5	9	3	4.5
6 to 10	15	4.5	3	4.5	24	7.5	3	4.5	33	10.5	3	4.5	42	12	3	4.5
11 to 25	25.5	7.5	3	4.5	40.5	12	3	4.5	54	15	3	4.5	67.5	19.5	3	4.5
26 to 50	37.5	12	3	4.5	57	16	3	4.5	75	22.5	3	4.5	91.5	27	4.5	4.5
51 to 100	44	15	3	4.5	79.5	24	4.5	4.5	102	31.5	4.5	4.5	121.5	39	6	4.5

Figure A - 1

SAFE DISTANCES FOR PERSONS

(CARRIAGE OF PACKAGES CONTAINING RADIOACTIVE MATERIALS)

TOTAL NUMBER OF RADIATION UNITS SHOWN ON THE PACKAGES	MINIMUM DISTANCE IN METERS FROM LIVING ACCOMODATIONS OR REGULARLY OCCUPIED WORKING SPACE			
	A	B	C	D
Up to 1	3	3	3	4.5
2 to 5	7.5	3	3	4.5
6 to 10	10.5	4.5	3	4.5
11 to 25	18	6	3	4.5
26 to 50	27	9	3	4.5
51 to 100	40	12	3	4.5

Figure A-2

Column A: No intervening cargo or bulkheads screening the radioactive materials from the living accommodation or undeveloped film or plate.

Column B: The radioactive materials to be surrounded by at least 0.6m of cargo of unit density and at least one steel bulkhead between the radioactive materials and the living accommodation or undeveloped film or plate.

Column C: The radioactive materials to be surrounded by at least 2 m of cargo of unit density and at least two steel bulkheads between the radioactive materials and the living accommodation or undeveloped film or plate.

Column D: The radioactive materials to be surrounded by at least 4.2m of cargo of unit density and at least two steel bulkheads between the radioactive materials and the living accommodation or undeveloped film or plate.

Cargo of Unit Density: Means cargo stowed at a density of 1 t (metric) $/m^3$. Where the density is less than this, the depth of cargo specified in the notes on columns B, C and D, i.e. 0.6m, 2m and 4.2m must be increased in proportion.

2. RADIATION REGULATIONS

Shipments of spent fuel will be classed as a category "yellow" package.

Category "yellow" packages must normally comply with the following limits of radiation:

a) 200 mr/hr on the external surfaces
b) 10 mr/hr at one meter from the external surface

A large source category "yellow" package can substitute the following radiation limits:

a) 200 mr/hr on the readily accessible external surface
b) 10 mr/hr at 3 meters from the accessible external surface.

if it also complies with the following:

a) shipment made in car-load or truck-load lots
b) shipment is loaded by consignor and unloaded by consignee.
c) vehicle labeled and marked in accordance with regulations.

The allowable external contamination on any package must be less than:

a) 10^{-4} c/cm^2 of non-fixed beta-gamma emitters
b) 10^{-5} c/cm^2 of non-fixed alpha emitters

A cask can be considered empty when the internal residue is beneath the following activity levels:

a) Group I material - 1 c or 10^{-4} c/cm^2
b) Group II material - 0.1 mc.
c) Group III material - 1 mc.

The internal residue levels stated above are extremely difficult to comply with. A wipe test of the interior along with a spectrographic analysis of the residue is required, and even then the identification of all the Group I materials present may be questionable. For reasons of safety, we must therefor assume that all internal residue is of Group I material.

Comparing the allowed activity of Group I with the allowed external contamination we find that the interior must be as clean as the exterior.

Since a cask will be completely sealed during both empty and full shipments, it appears unreasonable to require such extreme conditions of cleanliness within the cask.

Criticality safeguards must be of such a nature that a double contingency must occur before criticality can take place. By double contingency is meant that two separate and unrelated events must occur.

When calculating or considering the possibilities of criticality, the material and the cask must always be considered in that condition which would make the fuel most reactive.

Where mass is the factor controlling criticality, the cask must not contain more than 80% of the critical mass.

If calculations are used, then the effective neutron multiplication factor (k_{eff}) must not exceed 0.9.

3. HEAT DISSIPATION

Containers must be so designed that they efficiently and safely dissipate the contained decay heat.

The heat dissipation ability of the cask shall be such that the following temperatures shall not be exceeded:

a) accessible external surface 180°F (82°C).
b) primary coolant 20°F (10°C) below its boiling point in unpressurized casks.
c) all parts of fuel, cladding and container 180°F (100°C) below their respective melting points, with no coolant present.

Prior to shipment the cask shall be held by the consignor until temperature equilibrium within the cask is reached and it can be accurately determined that the above temperatures will not be exceeded.

The primary coolant, that is the coolant in contact with the radioactive material, shall not be circulated outside the cask. Provisions shall also be made to insure that at no time during shipment will the coolant become frozen.

4. CASK DESIGN

Any cask intended for use in the transportation of large radioactive sources must meet the type B packaging specifications.

A type B package must be capable of safely and efficiently containing the material during the normal condition of transport and also in the event of the maximum credible accident relevant to that mode of transport.

Each cask must be so designed that the actions of fire, shocks, water, corrosion, temperature changes and pressure changes will not adversely affect the degree of safety afforded by the cask.

Means shall be provided for sealing the cask so that the cask cannot be opened without breaking the seal.

The cask shall be so designed that it can be safely and properly secured to the transporting conveyance.

5. ADMINISTRATION

The final decision as to whether or not a cask design satisfactorily complies with the regulations and provides the degree of safety required in such a shipment is left to the judgement of the competent authority of the country in which the shipment originates.

An application for approval of a cask must include the following information:

a) nature of accident postulated in satisfying the requirements of type B packaging and an evaluation of the ability of the cask to withstand this accident.
b) amount, physical state and chemical compositions of the material to be shipped
c) design and construction specifications of the container including calculations relative to radiation shielding, criticality and heat dissipation.
d) operating and handling instructions
e) periodic test information
f) route to be followed

Upon approval the competent authority will issue a certificate attesting to the fact that the shipment is being made in accordance with the regulations. Also listed will be any conditional statements that affect the overall shipping procedures.

The cask itself must on two sides bear the proper label and any serial or approval numbers assigned. It is the responsibility of the consignor to see that the cask is properly marked and labeled.

Any documents accompanying the shipment must contain the following information:

a) class of criticality safeguards
b) toxicity group
c) description of the contents
d) highest surface radiation levels
e) type of packaging ("A" or "B")
f) any special instructions
g) labels required on cask

The shipping papers must also include a certification by the shipper that the cask and contents are accurately described and comply with all applicable regulations.

Prior to any shipment the certificate issued by the competent authority of the country in which the shipment originates plus other pertinent data must be submitted to each country through which the shipment must pass.

APPENDIX B

REFERENCES and ACKNOWLEDGEMENTS

1. "Regulation to Protect Against Radiation in the Shipment of Irradiated Fuel Elements," Title 10, Code of Federal Regulations, Proposed Part 72, September 23, 1961. (10 CFR 72)

2. F. R. Farmer, "The Packaging, Transport and Related Handling of Radioactive Materials," Review Series No. 12 International Atomic Energy Agency, Vienna, 1961.

3. "Regulations Governing the Transportation of Explosives and Other Dangerous Articles," Title 49 Code of Federal Regulations Part 71-78 (49 CFR 71-78)

4. "Cask Acceptance Criteria - Receiving Basin For Off Site Fuels", Savannah River Plant, June 21, 1961.

5. "Regulations Governing the Transportation or Storage of Explosives or Other Dangerous Articles", Title 46 Code of Federal Regulations Part 146 (46 CFR 146).

6. "Regulations For the Safe Transport of Radioactive Materials", Safety Series No. 6, International Atomic Energy Agency, Vienna, 1961.

7. R. L. Ashley, "Graphical Aids in the Calculation of the Shielding Requirements For Spent U-235 Fuel", NAA-SR-1992, U.S. AEC November, 1957.

8. Moteff, John, "Miscellaneous Data For Shielding Calculations", APEX-176, U.S. AEC, December, 1954.

9. J. R. Stehn and E. F. Clancy, "Fission-Product Radioactivity and Heat Generation," A/Conf/15/P/107.

CHAPTER V - TRANSPORTATION IN U. S. A.

INDEX

A. Abstract

B. Regulations Applicable to the Shipment of Spent Fuel

1. United States Atomic Energy Commission Proposed Part 72

2. Bureau of Explosives of the Association of American Railroads

3. United States Coast Guard Regulations - Title 46 Code of Federal Regulations Part 146

4. Interstate Commerce Commission Regulations - Title 49 Code of Federal Regulations Part 71-78

5. State Regulations

C. Approvals and Notifications

D. Port Operations

1. Procedures

2. Costs

E. Inland Transportation

1. Procedures
2. Time schedule
3. Costs

F. Financial Protection

1. Public Liability Insurance

2. Property Insurance

APPENDIX A United States Coast Guard Regulations

APPENDIX B Interstate Commerce Commission Regulations

Figure V-1	United States Coast Guard Regulations on Levels of Radiation
Figure V-2	United States Coast Guard Regulations on Levels of Radiation
Figure V-3	Loaded Cask Label
Figure V-4	Loaded Label
Figure V-5	Interstate Commerce Commission Regulations Governing Allowable Levels of Radiation
Figure V-6	Labeling and Marking Requirements
Figure V-7	I.C.C. Radioactive Materials Label
Figure V-8	I.C.C. Empty Label
Figure V-9	"Dangerous-Radioactive Material" Placard
Figure V-10	Modified 125-ton Depressed Center Flat Car
Figure V-11	Unloading Cask At Reprocessing Plant
Figure V-12	Cask In Transit

A. ABSTRACT

The regulations applicable to a shipment of spent fuel originating within Europe and destined for a reprocessing plant within the United States pose no real obstacles to the successful completion of such a shipment.

One of the major regulatory difficulties lies in the method of determining if a cask is loaded or empty, from a regulatory standpoint.

Both the Interstate Commerce Commission and the U.S. Coast Guard require that an empty cask contain no more than 1.35 millicuries total activity. The shipper must, on the shipping papers, certify that this is true.

Determining the curie content of a large cask with internal areas that are difficult to reach would be extremely difficult and any stated result would be highly questionable.

Failure to comply with this regulations could lead to a serious financial burden since the cask would be considered full and would have freight rates charged accordingly.

In the course of the study, we have assumed that this regulation could be complied with and that the return trip would be of an empty cask.

The physical handling arrangements required and any special equipment necessary reduce themselves to a matter of good engineering design.

The problem of shipping spent fuel was approached with the intention of accomplishing the shipment on a "purely commercial basis". By "purely commercial basis" is meant the following:

1. Government intervention kept to a minimum.

2. Government indemnity to apply wherever the law allows.

3. Only presently active carriers and routes of commerce to be used.

It can be safely predicted that a shipment of spent fuel can be successfully shipped on the above basis.

At the time of our initial contacts with the carriers and other commercial and governmental groups, we were met with a general attitude which was not encouraging for commercial shipments. As a result of many discussions and considerable correspondence we feel the atmosphere has improved considerably.

Initially the carriers, both inland and ocean, were very hesitant to accept the loaded cask as freight. Very recently, however, we were informed by one ocean shipping line that they would accept as freight a cask loaded with spent fuel. The matter of obtaining the approval of the railroad to carry the material as freight is the major obstacle remaining.

The hesitancy on the part of the carriers stemmed from their belief that the presently available insurance is incapable of providing them with adequate financial protection.

Although the Atlantic Coast Line Railroad, the inland carrier, readily admits they cannot determine the exact amount of insurance necessary, they feel they should be at least as well protected as when carrying material for the U.S.A.E.C. On that basis, we were informed that financial protection in the amount of $500,000,000 would be required.

The only way of satisfying the above requirement is to convince the railroad that government indemnity applies to import shipments of spent fuel which are intended for the Savannah River Plant. All those with whom this matter has been discussed agree that Price-Anderson indemnity does cover such shipments. The railroad is also expected to agree very shortly.

In the not too distant future, the entire matter of carrying this type of material by common carrier will be resolved by the various Freight Traffic Associations.

Possibly one of the greatest benefits derived from our entire effort is an intangible one. Throughout the course of the study, we continually found ourselves doing educational and missionary work amongst the carriers and other groups. As knowledge of the nature of this material spreads amongst the commercial carriers, we are certain they will be more receptive to requests to transport spent fuel.

B. REGULATIONS APPLICABLE TO THE SHIPMENT OF SPENT FUEL

The transportation, within the jurisdictional boundaries of the United States, of spent reactor fuel can conceivably come under the regulatory authority of many different groups operating at all levels of government.

The regulations in existence at the present time can be divided into two major groups, those which are specifically written to guard against undue hazards during the shipment of spent fuel, and those which are more broadly written and intended, at the time of issuance, to apply to the isotope type of shipments then taking place.

Within the first group are the Proposed Part 72 "Protection Against Radiation in the Shipment of Irradiated Fuel Elements" issued by the U. S. Atomic Energy Commission, and the Bureau of Explosives circular entitled "Permits - Spent (Irradiated) Fuel Elements".

The second group contains the Interstate Commerce Commission "Regulations Governing the Transportation of Explosives and Other Dangerous Articles" (49 CFR 71-78), the U. S. Coast Guard "Regulations Governing the Transportation or Storage of Explosives or Other Dangerous Articles" (46 CFR 146), and those rules and regulations originating at the state and local levels.

1. United States Atomic Energy Commission - Proposed Part 72

The Proposed Part 72 regulations promulgated by the U.S. Atomic Energy Commission have not as yet been finalized and changes can be expected in the regulations as they presently exist.

The Proposed Part 72 is primarily a set of technical design criteria against which the U.S. AEC will measure any cask which is intended for use in the shipment of spent fuel. Although the regulations are specifically intended to apply to licenses of the Commission they have been made applicable, by an administrative decision, to import shipments.

Only that small portion of the regulations which is applicable to the routine procedures involved in shipping and transporting the cask will be discussed here. Those portions which are applicable to cask design (the largest part of the regulations) are discussed in the chapter entitled "The Cask".

Assuming that the cask intended for use has been approved by the U. S. AEC as suitable for shipment of the SENN fuel then it is up to the shipper to comply with the following requirements.

The cask lid must have a seal applied so that the seal must be broken in order to open the cask. The primary water drain lines must also be sealed.

The bracing and dunnaging of the cask must prevent movement of the cask and be capable of withstanding a static load whose horizontal component is equal to 10 times the weight of the loaded cask and whose vertical component is equal to 2 times the weight of the loaded cask.

The internal pressure of the cask must not exceed 50 pounds per square inch gauge or 50 percent of the design pressure whichever is less.

The temperature distribution within the cask shall be such that the cask surface temperature does not exceed 180°F during transport and the primary coolant remains no less than twenty degrees below the boiling point of the coolant. Surfaces in contact with dunnage material shall remain below 350°F.

The surface temperature of the fuel within the cask must not exceed the highest of the following temperatures:

a) 300°F
b) temperature that the fuel has maintained within the reactor for at least 30 days without rupturing.
c) 300°F below the expected failure temperature.

In the event all primary liquid coolant is lost the surface temperature of the fuel must remain at 200°F below the temperature at which the fuel is expected to fail.

The allowable radiation dose levels with respect to a loaded cask are 200 milliroentgens per hour on the accessible cask surface and 10 milliroentgens per hour at one meter from the accessible surface. In the event the cask has the exclusive use of a car or truck, then 10 milliroentgens per hour at 3 meters may be substituted for the one meter requirement.

The shipper can insure satisfying the above requirements of heat removal and shielding by maintaining proper records of irradiation and cool times for each fuel assembly, and loading the cask with carefully selected assemblies.

Ruptured fuel elements prior to shipment shall be enclosed in an internal container so as to prevent the primary coolant from becoming contaminated.

Any cask which is damaged or which is suspected of being damaged shall not be used.

The shipper is also required throughout the lifetime of the cask to periodically test the cask to insure that any built-in poison material is still in place and effective.

Prior to each shipment the shipper shall also take a wipe test of the surface to determine the external contamination level. This level must be less than 4000 disintegrations per minute of beta-gamma per 100 square centimeters of surface or 500 disintegrations per minute of alpha per 100 square centimeters of surface.

The cask must also be subjected to a leak test by raising the internal pressure to at least 50% over the maximum expected operating pressure.

The primary coolant prior to shipping must be tested and the amount of contained activity shall not exceed:

(a) 10^{-5} curies of beta-gamma per milliliter

(b) 10^{-7} curies of alpha per milliliter

The shipper is also required to keep records of the results of the above tests.

2. Bureau of Explosives of the Association of American Railroads

The Bureau of Explosives is the organization authorized by the Interstate Commerce Commission to act on its behalf with regard to the enforcement and administration of those I.C.C. regulations applicable to dangerous articles.

With the advent of increased traffic in radioactive materials the Bureau has issued guidelines and criteria which it will use to judge compliance with the Interstate Commerce Commission regulations.

These criteria are applicable to both the cask design and transportation phases. Only the transportation phases will be discussed here. Those portions applicable to cask design have already been discussed in the chapter entitled "The Cask".

In the event the primary coolant is circulated by mechanical means, not only must a standby system be provided, but the shipment must be escorted.

The cask after loading and prior to shipment must satisfy the following conditions:

(a) Cask accessible surface temperature not to exceed 180° F.

(b) Radiation dose reading at the surface of the cask not to exceed 200 milliroentgens per hour.

(c) Radiation dose reading at one meter from the radioactive source not to exceed 10 milliroentgens per hour. The source is defined as the material within the cask.

The requirement of 10 milliroentgens per hour at one meter is in conflict with that allowed by the AEC for full carload shipments. The Interstate Commerce Commission has in the past issued a waiver of its regulation in favor of the AEC's regulation. This waiver is binding on the Bureau.

Each cask must be fitted with a seal which must be broken in order to open the cask. Each cask must also be permanently marked with the words "RADIOACTIVE MATERIAL" and the permit number issued by the Bureau. These markings must be of such a nature that they cannot be destroyed by fire.

In the event the cask is to be transported by water it must also be plainly marked with the gross weight of the cask.

3. United States Coast Guard Regulations
Title 46 Code of Federal Regulations - Part 146

The United States Coast Guard has issued "Regulations Governing the Transportation or Storage of Explosives or Other Dangerous Articles or Substances". (See Appendix A) These regulations are applicable to any vessel within the limits of jurisdiction of the United States.

The Coast Guard regulations were not specifically written for the purpose of regulating shipments of spent fuel. In fact any shipment of spent fuel would exceed the limits of contained radioactivity as prescribed in the regulations. A shipment of spent fuel will require that the United States Coast Guard Headquarters issue an approval to exceed the specified maximum.

Portions of the regulations are applicable only to the carrier. Even so, it behooves the shipper to be aware of these requirements so that an inadvertent infraction of the regulations will be less likely.

Within the Coast Guard classification of dangerous articles, radioactive material is classified as a "Class D. Poison."

The package or loaded cask must be designed and fabricated so that the contents can be safely and efficiently handled under the conditions normally to be encountered while being transported.

Import shipments of radioactive materials must also comply with all marking, labeling, and other applicable requirements of the Interstate Commerce Commission. This is required by the U. S. Coast Guard and applies regardless of whether the material is destined for further transport or not.

Fortunately, for the sake of simplicity, these two sets of regulations are almost identical.

The stowage of radioactive material is governed in two ways:

(a) by the amount of radiation an area will be exposed to and
(b) by specifically stated allowed stowage.

The allowable stowage based on radiation level is summarized in Figure V-1. The specific paragraph from which these values were drawn is 146.25-35.

The stowage criteria for radioactive material regardless of level of radiation is found in paragraphs 146.25-400, 146.03-34 and 146.25-45.

Only three types of stowage are allowed, (1) "on deck protected", (2) "on deck under cover", and (3) "Tween decks readily accessible". These are clearly defined in paragraph 146.03-34.

Radioactive materials must not at any time be stowed with explosives, inflammable liquids, corrosive liquids, compressed gases, cotton, or food stuffs.

UNITED STATES COAST GUARD REGULATIONS ON LEVELS OF RADIATION

AS THEY APPLY TO STOWAGE OF A CASK LOADED WITH SPENT FUEL

	ALLOWABLE MAXIMUM LEVEL
Any person	300 mr in any 7 day period
Continuously occupied area	40 mr in 24 hours
In any area	40 units or 40 mr/hr at a distance of one meter (at least 60 feet between areas of 40 units)

FIGURE V -1

The radiation levels applicable to a cask of spent fuel being shipped in accordance with the regulations of the United States Coast Guard are summarized in Figure V-2.

These requirements do no conflict in any way with those of other groups or agencies.

The requirement of 10 milliroentgen per hour at one meter from the source is more stringent in some cases than that of other agencies.

These other agencies have indicated a willingness to waive this requirement, in the case of car load shipments, and allow 10 mr per hour at three meters.

The U. S. Coast Guard has indicated that they feel a waiver of the existing requirement for a less restrictive one is not in the best interests of safety aboard ship.

UNITED STATES COAST GUARD REGULATIONS ON LEVELS OF RADIATION

(AS THEY APPLY TO AN EMPTY CASK AND A CASK LOADED WITH SPENT FUEL)

CONTAINER CONDITIONS	ALLOWABLE MAXIMUM LEVEL
At the Surface	200 milliroentgens per hour at any point of readily accessible surface.
At one meter from source	10 milliroentgens per hour
Surface Contamination	* Beta-gamma level of 10 mr per 24 hours at the surface. Alpha radiation of 500 counts per minute per 100 cm^2 on surface
Empty Container	Beta-gamma level of 10 mr per 24 hours at the surface . Alpha radiation of 500 counts per minute per 100 cm^2 on surface. Total activity within container - 1.35 millicurie

FIGURE V - 2

* It is not possible to determine levels of surface contamination by taking dose readings at the surface of a loaded cask. This regulation will undoubtedly be modified in the near future.

With regard to labeling and marking of the cask, the U.S. Coast Guard requires only that the proper label be applied to the outside of the cask.

In the event of a loaded cask this would be the label in Figure V-3.

In the event of an empty cask then the label in Figure V-4 must completely cover the previous label.

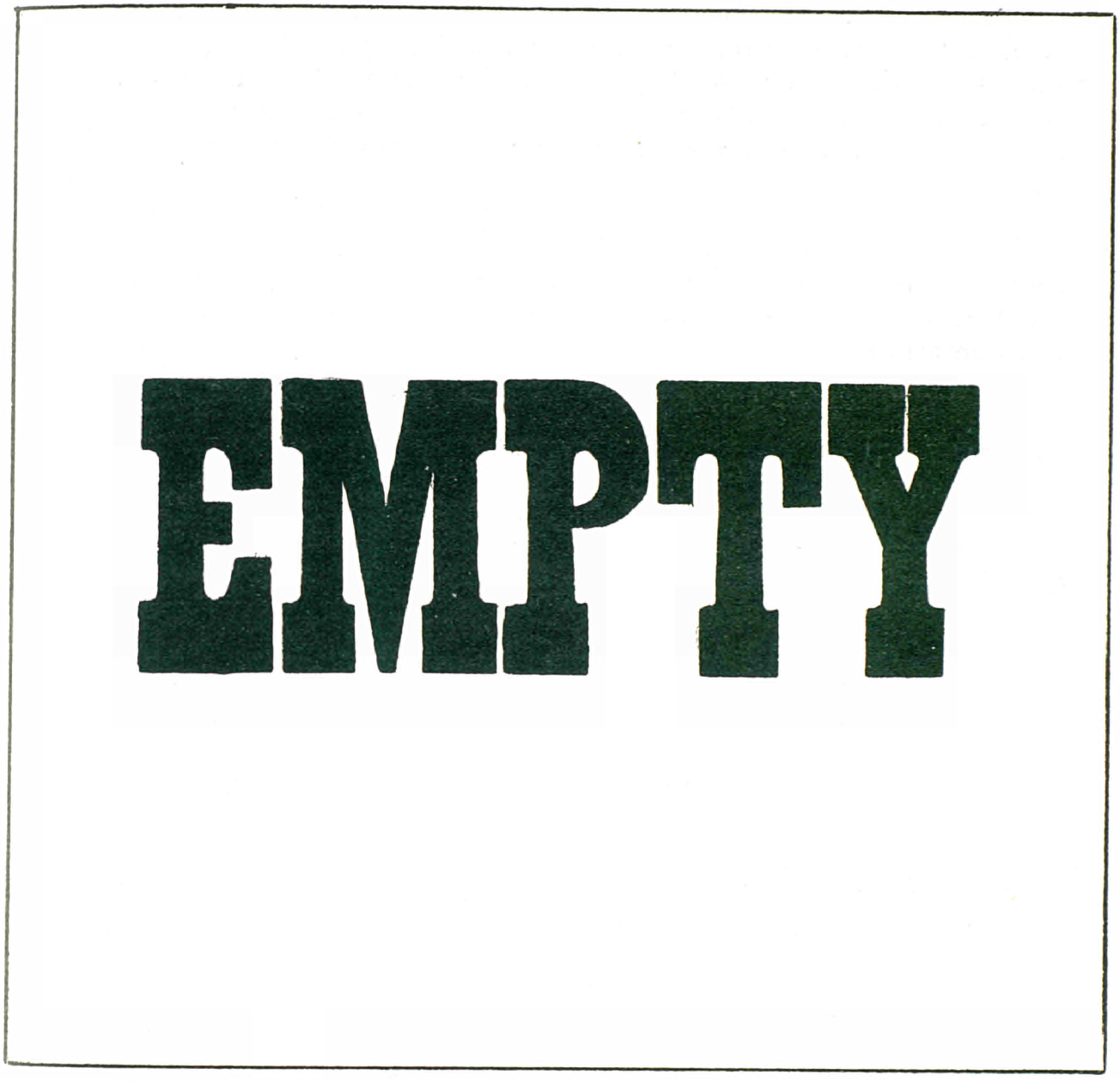
Other markings or tags must be of such a shape and size so as to prevent them from being mistaken for the labels in Figures V-3 and V-4.

The above required labels are identical with those required by the U. S. Interstate Commerce Commission.

Certain information and certifications are required by the Coast Guard to be included on the original shipping papers. These are clearly listed in the regulations and require no discussion or explanation.

Label required on cask loaded with spent fuel.

Figure V-3



Label to be attached to cask which no longer contains spent fuel.

Figure V-4

4. Interstate Commerce Commission Regulations -Title 49 Code of Federal Regulations Part 71-78

The Interstate Commerce Commission has issued "Regulations Governing The Transportation of Explosives And Other Dangerous Articles". (See Appendix B) These regulations apply to all shipments within the continetnal limits of the United States and also to all import and export shipments.

The Interstate Commerce Commission Regulations were not written with large source shipments in mind. In fact, any shipment of spent fuel exceeds the allowable total curie content for one container.

In the event that a shipment will comply with all the I.C.C. regulations, except that which sets forth the allowable amount of contained radioactivity, then only the review and approval of the Bureau of Explosives is necessary. The Bureau of Explosives acts as the administrative agent of the Interstate Commerce Commission on matters of dangerous articles.

If a waiver of any other regulation is requested then the Interstate Commerce Commission will issue, upon approval, a special permit for that shipment.

Radioactive materials are classified within the regulations as a "Class D Poison". They are broken down into three groups;

Group I: materials emitting gamma-rays or gamma rays and beta particles or alpha particles.

Group II: materials emitting neutrons and gamma rays or beta particles or alpha particles.

Group III: materials that emit alpha particles or beta particles only, or any package whose radiation level at the surface does not exceed 10 milliroentgens for 24 hours.

Shipments of spent fuel will always consist of Group I material.

Containers must be capable of withstanding the conditions normally incident to the mode of transportation selected, and must always be maintained in such a condition that its efficiency is not less than when it was new.

The allowable levels of radiation during shipment are summarized in Figure V-5.

The labels and markings required during shipment are summarized in Figure V-6.

When shipments are made in carload lots, which is always the case with spent fuel , then the shipper is required to apply whatever placards and labels are necessary. Samples of these labels are available from the Bureau of Explosives.

The various labels and placards required must be listed on the shipping papers along with a certification by the shipper that the shipment is being made in accordance with applicable regulations.

Radioactive material must not be stored with explosives of any kind and may not be transported next to cars loaded with explosives or undeveloped film.

Since large casks of spent fuel will travel in carload lots many of the duties of the carrier fall on the shipper's shoulders.

The allowable radiation levels and the labels and markings required by the Interstate Commerce Commission are in agreement with the requirements of other agencies and pose no particular obstacles in the matter of compliance.

The complete regulations with a more detailed commentary on its provisions are found in Appendix B.

INTERSTATE COMMERCE COMMISSION REGULATIONS
GOVERNING ALLOWABLE LEVELS OF RADIATION

Container Condition	ALLOWABLE MAXIMUM LEVEL
At the Surface	200 Milliroentgens per hour at the accessible surface
One Meter From Source	10 Milliroentgens per hour
Surface Contamination	10 Milliroentgens per 24 hours of beta-gamma 500 disintegrations per minute per 100 square centimeters of alpha activity.
Empty Container	10 milliroentgens per 24 hours of beta gamma at the surface 500 disintegrations per minute of alpha contamination per 100 square centimeters Total contained activity 1.35 millicuries

Figure V-5

LABELING AND MARKING REQUIREMENTS

"Dangerous Radioactive Material" Placard (Figure V-9)	Four required. One on each end of car and one on each side.
Proper Shipping Name Radioactive Materials. Group I	On Cask
Proper Label (Figure V-7) or (Figure V-8)	On Cask

Figure V-6

I. C. C. RADIOACTIVE MATERIALS LABEL

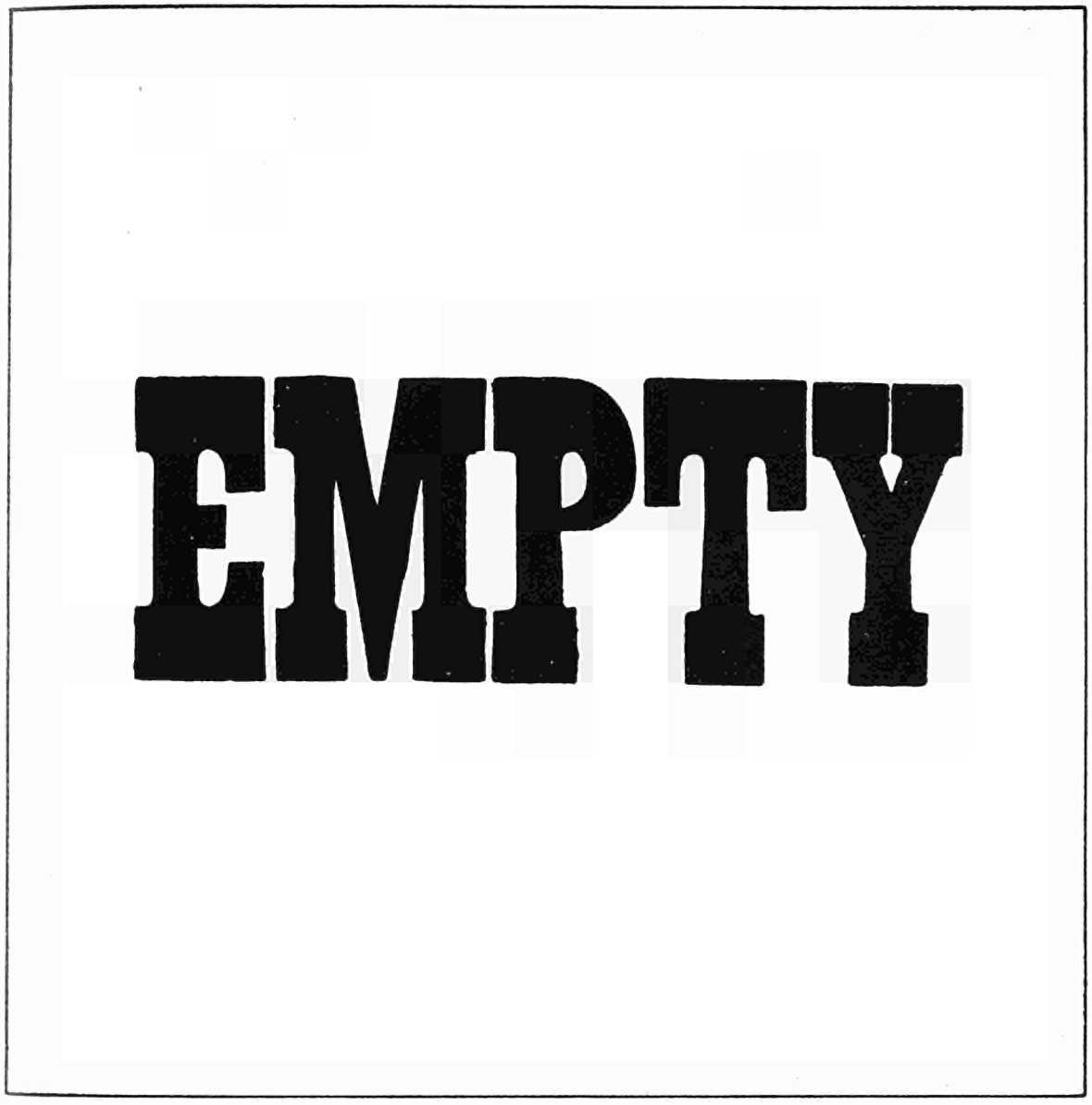
(Red Printing on White)

Label required on cask loaded with spent fuel

Figure V-7

I. C. C. EMPTY LABEL

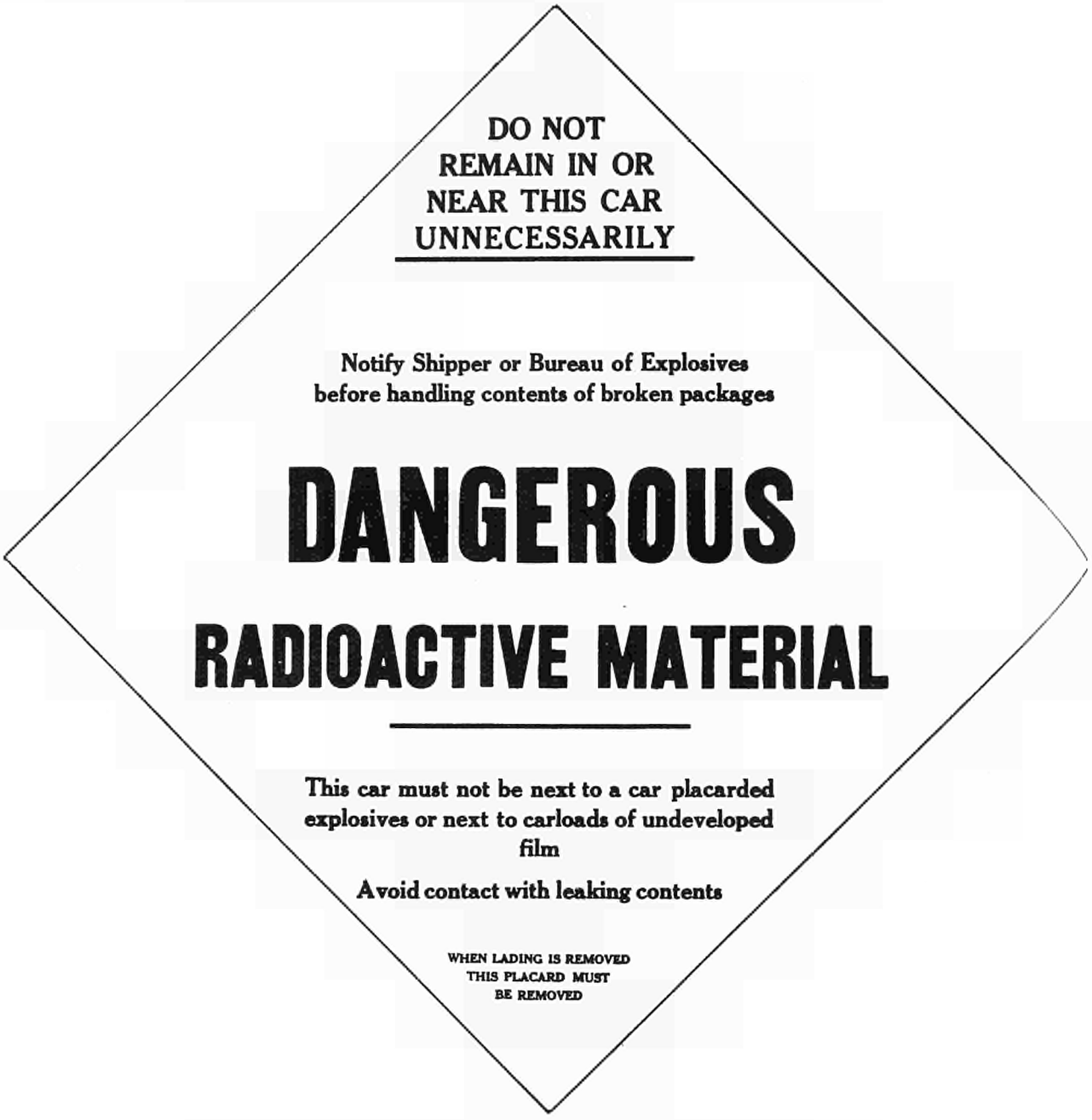
(Black Printing On White)



Label to be attached to cask which no longer contains spent fuel.

Figure V-8

"DANGEROUS - RADIOACTIVE MATERIAL" PLACARD
(Red Printing on White)



Label to be attached to each side of railway car.

Figure V-9

5. State Regulations

At the present time, the development of State Regulations is in its infancy. Very few states have passed laws or promulgated regulations which apply to the transportation of radioactive material. The efforts of most states to date have been in the areas of regulation of industrial or medical uses. Those states which have considered the problem of transportation exempt from regulation those shipments which are being made in accordance with the Interstate Commerce Commission regulations. The State of South Carolina, within which the entire SENN shipment takes place, is one of these.

State governments, along with other regulatory groups, such as Tollway Commissions, Port Authorities, etc., are becoming more concerned with the possible need for regulation of shipments of radioactive material. This concern does not stem from a feeling that the current regulations are inadequate or improperly administered, but rather from a desire to insure that all regulations are complied with.

Since the shipment of a hazardous article, such as radioactive material, is always judged by an evaluation of the hazards versus the public benefits, it is reasonable to expect that the state regulations that may be instituted will not be of a uniform nature.

At the present time, there are groups within the United States which have barred shipments of spent fuel from the use of their facilities. The primary reason for this action is their contention that the available insurance protection, in the event of an incident, is inadequate. As more experience is gained with shipments of this type of material these attitudes are expected to become more flexible.

C. APPROVALS AND NOTIFICATIONS

Many months prior to the first shipment of spent fuel , the cask desi gn, operating procedures, and shipping scheme must have been formulated.

An analysis of the ability of the cask to satisfy the design criteria of the U. S. Atomic Energy Commission's Proposed Part 72, along with specific operating instructions for the entire movement must be submitted to the AEC . (See Chapter IV, Section B-1) Since the shipper is neither a licensee nor eligible for a license, approval of the cask and shipping and operating arrangements will be indicated by the AEC by an informal written communication or cablegram.

The analysis sent to the AEC will contain all the information that is required by other agencies also. The report should, therefor, be sent to the following additional interested parties:

Director and Chief Inspector
Bureau of Explosives
Association of Amerian Railroads
63 Vesey St.
New York 7, New York, U.S.A.

Commandant (OPL)
United States Coast Guard
U. S. Coast Guard Headquarters
Washington 25, D.C., USA

Director
Bureau of Safety and Service
Interstate Commerce Commission
Washington 25, D.C., U.S.A.

Manager
Savannah River Operations Office
United States Atomic Energy Commission
P. O. Box A
Aiken, South Carolina, U.S.A.

The Bureau of Explosives will examine the information submitted and if satisfied that the proposed container and operating procedures are sufficiently safe will issue an approval and a permit number to the cask. This approval and permit number will be in a written communication, and is also an approval on behalf of the Interstate Commerce Commission and the U. S. Coast Guard.

At this point the I. C. C. and the Coast Guard will only reply in the event portions of the plan do not meet with their approval.

The reprocessing plant will indicate its approval of the cask and shipping arrangements by a statement in the reprocessing agreement or by a separate letter.

These approvals can require a great deal of additional correspondence and supplementary information.

The preceding approvals are all essentially an approval of the cask and operating procedures. These approvals are not an authorization to actually ship the material.

Thirty to sixty days in advance of the proposed shipping date all pertinent information on the details of shipment are to be submitted to the Division of International Affairs of the U. S. Atomic Energy Commission:

Typical of the information to be submitted is:

(1) Name, type and curie amount of radioactive material
(2) Expected radiation levels
(3) Name of shipper and consignee
(4) Port of departure (pier, if known) and destination
(5) Name of vessel (if known) and shipping firm
(6) Bureau of Explosives permit number
(7) Gross weight of container
(8) Date of shipment and expected date of arrival
(9) Name and address of representative in the United States
(10) Carrier within the United States

Some of the essential information may not be available this far in advance of shipment. In that case supplementary notices must be submitted to the AEC as soon as the information becomes available.

The representative or agent of the shipper within the U.S. should also be kept apprised of the above information.

The AEC upon receipt of the above information will notify the various other agencies that must issue authorization, such as the Bureau of Explosives, the Interstate Commerce Commission, the U. S. Coast Guard, the U. S. Customs Bureau, the reprocessing plant and officials at the port of entry.

Acknowledgement of receipt of this information will be made by the AEC. They will also indicate approval or disapproval of the arrangements. As soon as approval is received the shipper may send the cask on its way.

Information supplied to the AEC during this procedure must be kept up to date and accurate in all respects.

The U. S. Coast Guard has specified that a shipment of spent fuel can enter the United States only through ports approved by the Coast Guard.

The only requirement for port approval is that all public officials of the port area be made aware of the shipment, its dangers and the safeguards taken. These officials must indicate to the Coast Guard by letter or resolution their willingness to allow this material to pass through the port.

The U. S. Coast Guard obviously does not wish to expose a community to a potential hazard unless the community is aware of the nature of the hazard and is willing to accept it.

Only three ports to date have taken the steps necessary to qualify. These ports initiated the necessary meeting themselves in a desire to promote business.

The three ports in question are Charleston, South Carolina, Savannah, Georgia, and Jacksonville, Florida. Only Charleston and Savannah have so far issued the necessary letter or resolution of approval.

In the event the selected port of entry has not been cleared by the Coast Guard, then the A.E.C. may take steps to get it approved.

The establishment of a port as a qualified port of entry, could involve a great deal of time and effort. When initial shipping plans are made it would be advisable therefor, to select, if possible, a port which is already established as an approved port of entry for spent fuel.

Since United States laws at the present time require that title to all "special nuclear material" within the jurisdictional boundaries of the United States rest with the United States a title transfer must be executed.

The transfer of title to the material being imported can be accomplished in many ways, and is a matter to be arranged by the signatories. Most likely the actual signing of the title transfer papers will take place in Washington, D.C. after the shipment leaves Europe and prior to its arrival in the United States.

Since all transfers of "special nuclear material" are on a govern ment to government basis, the person signing for the European interest must be an authorized representative of Euratom or the country which has title to the material.

D. PORT OPERATIONS

1. Procedures

When the shipment leaves Europe all the information needed by the various regulatory agencies, the carriers, and the reprocessing plant will be known. The U.S.AEC and the agent within the United States representing the shipper should be sent this final information.

During the normal course of business the ocean carrier will notify the port of entry of the types of cargo to be unloaded at the port. The port will notify the inland carrier and if matters proceed smoothly no further efforts on the part of the shipper or his representatives should be required.

It is advisable, however, that the representative of the shipper check with the port authorities and the inland carrier to make certain that the necessary arrangements are being made.

It is also advisable that the shipper's representative be present at the dock during the unloading.

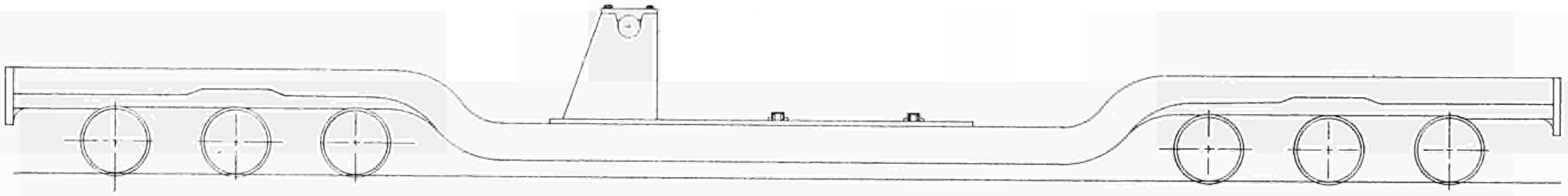
It is considered essential by the U.S. AEC and the local port authorities that this type of a shipment be forwarded without delay.

The Port of Charleston, which for the purposes of this study is the primary port of entry, has indicated that this type of material must be on its way out of the port area within 48 hours after arrival.

The transportation within the United States is to be accomplished by rail. It will be necessary, because of the cask weight and special tie down requirements, to furnish a special railroad car for each cask.

This special car is shown in figure V-10. It is a standard 125 ton capacity drop-center flat car. It has a steel cast underframe and is equipped with roller bearings.

SENN SHIPPING EQUIPMENT



MODIFIED 125-TON DEPRESSED CENTER FLAT CAR

Figure V-10

JOINT U.S. - EURATOM RESEARCH AND DEVELOPMENT PROGRAM

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING

BY STANRAY CORP. CHICAGO, ILLINOIS

CONTRACT NO. AT(11-1)-963

JAN. 25, 1962

Upon arrival in the port of Charleston, S.C., the ship will berth at the North Charleston Terminal, which has available for use two 50-ton capacity gantry cranes and one 75-ton capacity stiff-legged boom crane.

The rail car will be removed from the railroad holding yard and spotted on the dock alongside the ship.

The stevedoring crew will untie the cask and the heavy lift equipment will lift it from the deck and place it on the railcar. During this movement the cask will be in the horizontal position. Special handling slings or yokes will not be necessary at the port. The stevedoring crew is capable of handling the cask with the types of cable slings that are normally available.

After the cask is placed in position on the car it will be securely fastened to the car using the bolts and hold down devices especially furnished. This work will be performed by personnel furnished by the Port Terminal Railroad Company which is responsible for all rail movements within the port area.

The loaded car will be placarded and moved to the holding yard where it will await departure for the Savannah River Processing Plant.

The special skid (Figure IV-13) which is used to help distribute the weight of the cask while aboard ship will be unfastened by the stevedoring crew and removed from the ship. This skid will be stored in the terminal warehouse until the cask makes its return trip. The storage and handling of the skid will be performed by port operations personnel.

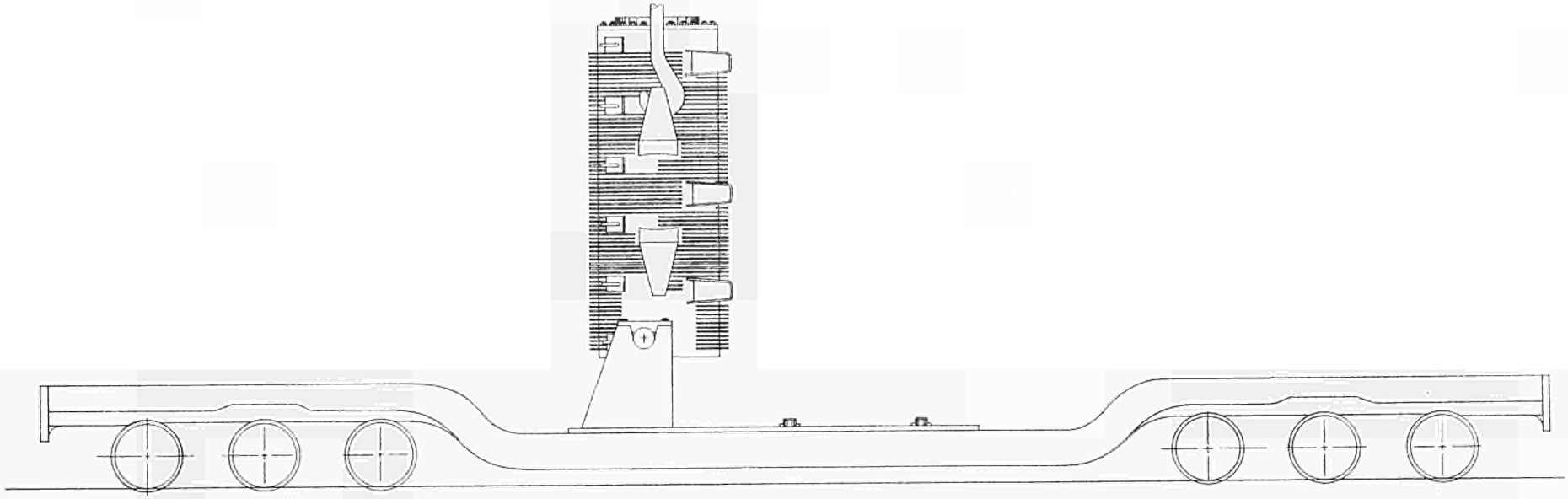
The major portion of the car has been fitted with a stainless steel skin for ease of decontamination if that should ever be necessary.

The dropped center section is fitted with a base and trunion seats. The large turning trunions of the cask rest in these trunion seats. This trunion seat is the primary means of securing the cask to the car, and is also used when rotating the cask into the vertical position at the reprocessing plant. (See Figure V-11)

The car as it is shown in Figure V-10 can be supplied by a car building firm for approximately $50,000.

The car design, like the cask design, was not optimized, but was based on recommendations of the Atlantic Coast Line Railroad, the inland carrier. It is entirely possible that a car of lesser capacity could be used and thereby effect a cost savings.

SENN SHIPPING EQUIPMENT



UNLOADING CASK AT REPROCESSING PLANT

Figure V-11

JOINT U.S.-EURATOM RESEARCH AND DEVELOPMENT PROGRAM

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING

BY STANRAY CORP
CHICAGO, ILLINOIS
CONTRACT NO. AT(11-1)-263

JAN. 25, 1962

2. Costs

The ocean freight rate normally includes all costs applicable from the time the freight is picked up by the lifting equipment at the port of departure until it is placed on the dock at the port of entry. These charges could be handled in other ways but any deviation would be a matter for negotiation.

A wharfage charge is assessed by the port for the use of its docks. These wharfage charges are based on the commodity and the quantity handled.

The charge quoted for the use of docks at Charleston, South Carolina is $0.40 per ton of cargo. This is the rate applied to cargo which is not otherwise classified in wharfage fee lists. This rate is applicable to all the public docks in the port of Charleston. It could conceivably be changed at some time in the future to reflect the general attitude regarding the hazardous nature of the material.

Wharfage fees are billed by the port operators to the railroad or the ocean carrier. The railroad or the ocean carrier can pass this fee on to the shipper or absorb it as part of their own operating expenses. These arrangements will vary with each particular situation, and are strictly a matter of negotiation between the shipper and carrier.

The rail car which is stored on leased trackage in the port area is moved to the dock by switching equipment which belongs to the Port Terminal Railroad Company.

The charge for the leased trackage is $.05 per car per day.

The charge for moving the car is $26.60 per car. This is referred to as the switching charge. The charge for movement of the car from the dock to the railroad pick up point is included in the railroad freight rate. The charge for movement from the pick up point to the dock is also included in the freight. Therefor, only two switching charges per car will be associated with each cask round trip.

A handling charge is assessed by the port on most items. The rate for items of the size of the cask is unpublished and is a matter for negotiation. It has been suggested that no handling charge will be assessed the cask since its movement from ship to rail car is a direct transfer with no intermediate handling necessary.

Tie down of the cask to the railcar will be performed free of charge.

The steel plate skid which is used aboard ship for the purpose of aiding in the distribution of the load is subject to a handling charge of $1.50 per 2000 pounds.

This skid is stored at the port for the first thirty days free of charge, but is subject to a storage charge of $1.20 per 2000 pounds for every 30 days thereafter.

The following costs per cask will be associated with each round trip.

Switching charges: (Inbound & Outbound)	$ 53.20
Wharfage fee:	
Cask (.40/2000# assumed)	40.00
Skid (.40/2000#)	1.20
Handling Charge:	
Skid (1.50/2000#)	4.50
Track Leasage: (.05/car per day) (assume 300 days)	15.00 /year
Total Costs per cask per round trip: (average of 7 round trips/year)	$101.

E. IN LAND TRANSPORTATION

1. Procedures

The loaded car will be picked up at the railroad holding yard by the Atlantic Coast Line Railroad which services both the Port of Charleston and the Savannah River Plant.

The car will travel by regularly scheduled freight train. Each evening at 7:25 a freight train departs Charleston for Sumter, South Carolina. At Sumter the car is switched to a train for Dunbarton, South Carolina which is the delivery point for the Savannah River Plant.

The total distance traveled is 172 miles and the cask is scheduled to arrive at Dunbarton at 12 noon, 16.5 hours after leaving Charleston.

The car while in transit will appear as it does in Figure V-12.

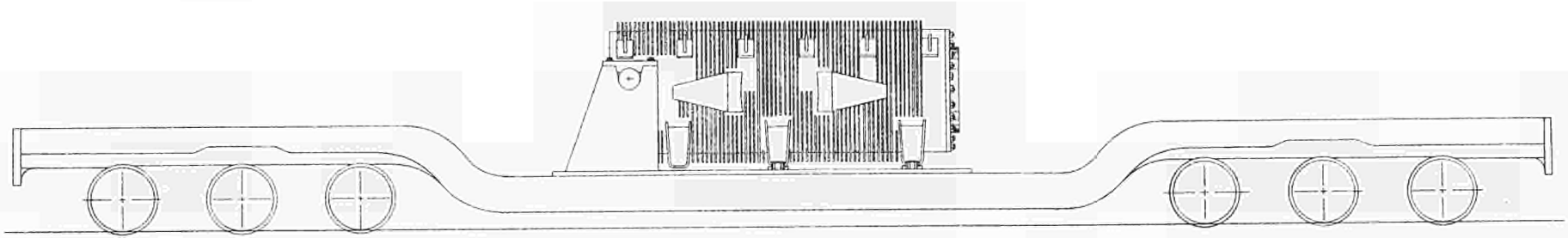
The type of car used could possibly, through some arrangement with the railroad, be furnished by the railroad. The railroad has not indicated the conditions under which they would be willing to furnish such a car, therefor, we have assumed the shipper would purchase the car and it would solely be owned by him. This is a more logical approach in any case.

If the shipper did not own the car and it were not captive to his service, he might encounter difficulty in having it available when necessary.

The Atlantic Coast Line Railroad has indicated the freight rate for which it would be willing to handle this type of car. Since there are no rates published by the Freight Traffic Associations, this was a contractual rate. The Atlantic Coast Line Railroad could quote this rate since the entire trip was to be made on their trackage.

The acceptance of this type of material by the railroad is dependent on furnishing the railroads with "satisfactory insurance protection". Investigation of exactly what, in the railroad's opinion, constitutes "satisfactory insurance protection" led to the conclusion that the railroads must be convinced that they are protected by government indemnity.

SENN SHIPPING EQUIPMENT



CASK IN TRANSIT

Figure V-12

JOINT U.S. - EURATOM RESEARCH AND DEVELOPMENT PROGRAM

DESIGN AND ECONOMIC STUDY OF SPENT FUEL SHIPPING

BY STANRAY CORP. CHICAGO, ILLINOIS

CONTRACT NO AT(11-1)-963

JAN. 25, 1962

The railroad desires that they be furnished with an insurance policy in the amount of $500,000,000. This amount obviously comes from the amount of government indemnity available when the railroads transport material for the U.S. A.E.C. The nuclear insurance pools are not in a position to provide this amount of coverage.

The law department of the railroad is of the opinion that government indemnity protects them only if the shipper is a contractor or licensee of the U.S. A.E.C. This opinion is based on an examination of their contract with the U.S. A.E.C.

We have been unable to convince them that they are protected by the desired amount of indemnity through the provisions of the Savannah River Plant indemnity agreement.

Until such time as they can be convinced that they are adequately protected, they will be unwilling to accept import shipments of spent fuel as freight. However, the railroads are discussing this problem with the A.E.C.

2. Time Schedule

The breakdown of the entire shipment while in the U.S. is expected to be as follows:

a. Unloading of the full cask from the ship - 6 hrs.
b. Loading of the cask on the railway car, including tie down - 2 hrs.
c. Delay of railway car within port area - This depends on when the rail car is loaded. If loading is completed after 7:30 P.M. then a 24 hr. delay will occur.
d. Port to Savannah River Plant - 17 hrs.
e. Unloading the cask at the Savannah River Plant - 20 hrs.
f. Delay prior to unloading of fuel - Depends on work load at plant.
g. Unloading of the fuel - 48 hrs.
h. Decontamination of the Cask - 5 days.
i. Delay prior to reloading of railway cars - none.

j. Loading of casks on railway cars - 3 hrs.
k. Trip to Port - 17 hrs.
l. Delay at Port - depends on shipping schedule; if a ship is waiting there should be no delay, provided there is daylight.
m. Unloading of the cask from the railway car - 3 hrs.
n. Loading of the casks on board ship, including tie down - 10 hrs.

Based on these estimates, a shipment of 5 casks can be expected to be in the U.S. for not less than 8 days or more than 14 days.

3. Costs

The freight rate quoted by the Atlantic Coast Line Railroad is as follows:

Empty cask:	$0.605 per 100#
Loaded cask:	$1.60 per 100#

The above rate applies to shipments between Charleston, S.C. and Dunbarton, S.C.

The cost per loaded cask is therefor:

$(1050)(1.60) = \$1680/\text{cask}$

The cost per empty cask is therefor:

$(950)(\$0.605) = \$575/\text{cask}$

The cost per round trip is therefor:

$\$2255/\text{cask}$

These costs are based on using the 95,000 pound cask of Figure IV-10.

F. FINANCIAL PROTECTION

One of the most troublesome problems to be encountered with regard to the overall planning and operations of a shipment of spent fuel is the matter of securing adequate financial protection for the parties involved.

Insurance protection within the United States is furnished by four pools of insurance companies. Two of these pools, the Nuclear Energy Liability Insurance Association (NELIA) and the Mutual Atomic Energy Liability Underwriters (MAELU) provide third party liability coverage. The other two pools, the Nuclear Energy Property Insurance Association (NEPIA) and the Mutual Atomic Energy Reinsurance Pool (MAERP) provide first person property coverage.

The liability insurance pools provide coverage which is normally similar to U. S. government indemnity as allowed by the Price-Anderson amendments to the Atomic Energy Act of 1954.

The entire question of financial protection for a shipment of spent fuel, and in reality whether or not such a shipment can actually be made, revolves about the government supplied indemnity.

1. Public Liability Insurance

The NELIA and MAELU pools issue a common policy, that is, the provisions of each are the same, for the coverage of public liability within the United States which may result from the "nuclear energy hazard". "Nuclear energy hazard" being defined as the radioactive, toxic, explosive, or other hazardous properties of the radioactive material.

The policy applicable to a shipment of fuel from the SENN reactor is the domestic "Supplier's and Transporter's Policy". This policy is specifically written to apply to shipments of radioactive material within the territorial limits of the United States. "Territorial limits" according to our best informed sources, means the 3-mile limit.

The NELIA and MAELU pools represent an insurance capacity of 60 million dollars for any one policy; 46.5million of coverage being furnished by NELIA and 13.5 million of coverage being furnished by MAELU.

Although our major contacts and discussions have been with the NELIA group, we are assuming that the premium rates and provisions of MAELU are identical. To the best of our knowledge this is true.

The standard policy as is currently written is of no value to a shipper whose material is destined for the Savannah River Plant. Division (2) of exclusion (i) of the policy provides that the policy does not apply to incidents which are covered by indemnity from the United States government.

Most authorities on the subject agree that the indemnity agreement entered into between the operators of the Savannah River Plant and the Atomic Energy Commission does provide coverage for a shipment of spent fuel from the time it enters the jurisdictional boundaries of the United States until it arrives at the Savannah River Plant.

The problem of financial protection while the shipment is on Savannah River Plant property is covered in Chapter III.

A standard endorsement to the basic policy is available so that the applicable exclusion can be deleted and the policy made to apply.

The question then arises as to the desirability of the insurance with the endorsement.

Many reasons for carrying the insurance can be put forth but the desirability of this coverage becomes a matter of personal opinion, since it provides essentially no coverage that is not provided by government indemnity.

The policy, although it is written with only one named insured, protects all those acting for or on behalf of the named insured to whom legal liability may attach.

Since the policy protects only against claims as a result of the "nuclear energy hazard" the shipper must also carry the normal types of liability and workmen's compensation insurance.

The insurance does not provide coverage for the nuclear material. Where the car and cask are not owned by the shipper and damage results to them for which the shipper is legally liable, the policy would provide protection.

In the case of rail shipments, railroad property, such as the right of way, tracks, and other cars, are covered. Although this is not expressly stated in the policy, interpretation by most persons including the NELIA group substantiates this.

The premium charged for a policy is based on an evaluation of each application and the conditions under which each shipment is to be made.

The standard policy is sold on a yearly premium basis with unlimited useage allowed. A typical premium schedule is as follows:

Amount of Insurance	Annual Premium
First $ 1,000,000	$ 750
Next $ 9,000,000	375 each million
Over $ 10,000,000	250 each million

The standard policy is of interest only in the event the shipments were not covered by U.S. indemnity. In that event, the above premiums would probably be increased.

The policy with division (2) of exclusion (i) deleted has been quoted on the following basis:

Amount of Insurance	Rate per loaded day
First $ 1,000,000	$ 25.00
Next 4,000,000	12.50 each million
Next 5,000,000	5.00 " "
Over 10,000,000	2.50 " "

The modified policy is subject to a minimum yearly premium of $ 1000 for the first million of coverage and $500 for each additional million.

The cost of the modified insurance based on the maximum available is as follows:

Minimum annual premium for $ 60 million coverage = $30,500

The reasons for carrying insurance which would apply in addition to government indemnity are based on theoretical situations from which smaller claims could result. For purposes of arriving at a reasonable cost estimate, we shall assume that $ 10 million coverage is purchased. This is not an unreasonable assumption since many of the inland carriers, within the United States, carry this amount of insurance.

The cost, therefore, would be:

Minimum annual premium for $10 million coverage: $5500

Assuming 5 loaded days within the United States per shipment and an annual average of seven round trips, if the casks traveled separately, this would be a total of 35 loaded days per year. With a daily rate of $100 the total daily charges would be $3500 which is below the minimum premium charged.

The liability insurance cost per round trip for $ 10,000,000 of coverage is therefore:

$$\frac{5500}{7} = \$785.70$$

2. Property Insurance

The two property insurance pools restrict their coverage to the continental limits of the United States. Insurance coverage will not attach to a SENN shipment until the material is placed on the railcar at the dock side.

Because of the extreme difficulty in determining exactly which damage is due to the nuclear risk and which is due to other causes the property insurance pools have written an all risk policy. That is, the cask, car and contents are covered regardless of cause of loss:

The policy does not, however, insure against the following:

(a) Gradual accumulation of radioactive contamination
(b) Loss caused by radioactive material other than contents
(c) Depreciation, deterioration or corrosion
(d) Acts of war or rebellion
(e) Confiscation or seizure by government order

The property covered is the fuel, cask, and car and is only covered while it is in the custody of certain specified parties and is not covered while at the reprocessing site.

The insurance coverage is in the amount of the face value and in no case in excess of the actual value.

The premium rate for this type of insurance is dependent on the conditions of shipment and how much responsibility the carrier is willing to accept. The rates quoted seem to range from $.075 to $.05 per $100 of insurance per shipment.

The cost of this property insurance based on an assumed rate of $.075 per $100 is as follows:

Fuel Value (9) ($14,162.50) (See Chapter III, Section E7)	$ 127,462.50
Cask Value (See Chapter IV, Section H)	$ 90,000.00
Car Value (See Chapter V, Section D1)	$ 50,000.00
TOTAL	$267,462.50
Insurance Premium (2,674.62) ($.075) (for cask, fuel and car)	$ 200.60 per shipment

The amount of insurance available from the property insurance pools is more than adequate for purposes of a shipment of fuel.

Our contacts have been entirely with representatives of the NEPIA pools. We are assuming that provisions and rates of the MAERP pool are identical.

Property insurance similar to NEPIA and MAERP is available through the marine insurance markets. Although no written policy is in existence, we have been informed that the NEPIA policy can be used as a guide to the terms and provisions of this marine type policy.

Like NEPIA this would be an all risk policy but in addition would provide coverage over the entire trip, that is, from the reactor site to the reprocessing site.

The rates quoted for this coverage are dependent on the type of stowage while aboard ship: $.60 for $100 of value for on deck stowage and $.30 per $100 of value for under deck stowage.

The cost of this type of coverage for cask and fuel only would be:

(2,174.62) ($.60) = $1,304.77 per shipment

The entire question of how much insurance is necessary and what types are preferred is a matter to be decided by the shipper.

In some instances the U. S. Atomic Energy Commission has required that financial protection, most often in the form of insurance be maintained by the parties responsible for creating the hazardous condition. In the case of import shipments of spent fuel no financial protection or insurance is required of the shipper by the AEC at the present time.

In the foregoing discussions we have not attempted to indicate a preference for any particular coverage nor have we attempted to interpret the provisions of the policy other than to determine its applicability to the intended shipment.

APPENDIX A

UNITED STATES COAST GUARD REGULATIONS

GOVERNING THE TRANSPORTATION

OR STORAGE OF EXPLOSIVES OR

OTHER DANGEROUS ARTICLES

Note: The information contained herein is based on the text and the interpretation of the regulations as they existed on March 15, 1962. Any person prior to using this appendix should bring this information up to date.

COMMENTARY

The United States Coast Guard is charged with the responsibility of formulating and administering regulations for the safe transportation of explosives and other dangerous articles. The regulations of this part are applicable to all vessels, shippers, owners, agents, masters, etc., when the shipment is to be made wholly or in part on waters within the jurisdictional boundaries of the United States.

The regulations when originally written were intended to apply to those small amounts of isotopes being shipped. As they apply to shipments of spent fuel they are inadequate.

The basic framework and requirements of the regulations are still suitable since they were originally conceived with the protection of persons and property as the primary goal.

The regulations can be broken down into five major subgroups:

(1) Those portions that apply specifically to administrative matters.

(2) Those portions that state general regulations which set forth overall principles of performance.

(3) Statements which are of the nature of general information.

(4) Stowage requirements, and

(5) Those portions relative to the allowable radiation levels.

First and foremost, administratively, is the matter of obtaining approval, from the Commandant of the Coast Guard, to use the cask contemplated to carry the intended material.

None of the containers specified in paragraph 146.05-4 (a) are suitable for the carriage of spent fuel. A special permit, in accordance with paragraph 146.05-4 (b) must therefore be obtained from the Commandant of the Coast Guard.

The Commandant of the Coast Guard has indicated that if the Bureau of Explosives of the Association of American Railraods issues a permit and permit number for the use of the cask with the intended contents then this will be considered as satisfying the requirements of paragraphs 146.05-4 (b) and 146.25-30 (b) and no further approval for the cask will be required by the Coast Guard.

Since a shipment of spent fuel will exceed the maximum curie content allowed by the regulations in any one package it will be necessary to obtain from the Commandant special authorization to make the shipment.

Consideration by the Commandant of applications for special authorization or approval will be based on the following information:

a) Name, type and curie amount of radioactive material.

b) Name of shipper and consignee.

c) Name of vessel (if known) and shipping firm.

d) Port of departure (pier if known) and destination.

e) Bureau of Explosives permit number.

f) Gross weight of container.

g) Date of shipment.

The requested approval or special authorization will only be issued in the event the destination, under item (d) of the above listed information, is a port of entry which is listed with the Commandant as one willing to accept shipments of spent fuel.

The Commandant requires that this expression of willingness by the port authorities be made only after an informational meeting has been held. This informational meeting is for the purpose of acquainting officials of the port and adjacent community or communities of the hazards involved and the precautions taken in the handling of shipments of spent fuel.

Shipping papers both import and export are required to contain certain information and bear certain certifications. The applicable sections of the regulations are clear and easily complied with.

The regulations require that certain labels be affixed to the exterior of the cask. These labels must be attached by the shipper and must survive the types of weather encountered during the shipment so that they are still legible when they arrive at the destination.

Each label must be filled out completely and include the following information:

a) Principal radioactive content "Chemical, N. O. S. "

b) Activity of contents - (in curies)

Samples of these labels can be obtained from the Bureau of Explosives of the Association of American Railroads.

During the course of shipment, because of variations in ambient air temperature, thermal expansion of the liquid and air in a liquid cooled cask can increase the internal air pressure.

The Coast Guard has indicated that in this event compressed gas regulations will not become applicable. They consider the cask integrity requirements for the carriage of radioactive material to be adequate insurance against the rupture of the cask due to internal pressure.

The allowable stowage of any cargo considered to be radioactive material is clearly stated and defined in the regulations. The ultimate responsibility for compliance with these requirements and for the safe stowage of the cask rests with the master of the vessel.

The regulations relating to levels of radiation and amounts of surface contamination were written based on the recommended allowable exposure of persons to ionizing radiations. For this reason these regulations are still applicable.

Paragraph 146.25-30 (a) limits the curie content of any one cask except by special approval of the Commandant of the Coast Guard. This is the same approval or special authorization previously discussed.

Paragraph 146.25-30 (b) mentions a specification 2R container or other container. A specification 2R container is not suitable for the shipment of spent fuel because of its small size. The approval of another container has been discussed earlier.

The regulations limit the amount of radiation to which undeveloped film is to be exposed by referring to an amount of penetrating gamma rays of radium. This regulation, found in paragraph 146.25-30 (c), calls for the exposure of undeveloped film at a distance of 15 feet to be no more than 11.5 milliroentgens of penetrating gamma rays of radium filtered by 1/2 inch of lead over a period of 24 hours.

In the event the shipment is one of spent fuel in a large lead lined cask, the radiation emitting from the spent fuel after shielding by the lead will have the same photographic effectiveness as gamma radiation from radium which has been filtered by 1/2 inch of lead.

This limits the radiation level at 15 feet from the cask to 0.48 milliroentgens per hour.

If the "inverse square law" is applied to the allowed level of 10 mr/hr at one meter then we do not exceed 0.48 mr/hr at 15 feet. The "inverse square law" is not applicable, however, to our large cask.

No information has been received as yet clarifying this requirement. It appears at the present as if these two regulations conflict.

The package or cask, according to paragraph 146.25-30 (d) must have "no significant radioactive surface contamination". Significant surface contamination has been defined by the Coast Guard to mean beta-gamma radiation at the surface in excess of 10 milliroentgen per 24 hours, and alpha radiation greater than 500 disintegrations per minute per 100 square centimeters. The determination of 10 mr/24 hrs. on a loaded cask is not possible.

In paragraph 146.25-30 (g) reference is made to a level of gamma radiation "at one meter from any point on the radioactive source". The "source" is defined as the material within the cask and not the cask itself.

A cask is officially considered empty by the Coast Guard when it can satisfy the requirements of paragraph 146.25-25 (a).

In determining compliance with the required levels of radiation and curie content the Atomic Energy Commission is of the opinion that any commercially available instrument which is recommended by a reputable manufacturer as suitable to take the desired readings may be used.

This commentary is provided for the purpose of clarifying certain portions of the regulations. It is not intended as a substitute for or summary of the regulations.

The United States Coast Guard Regulations Governing the Transportation or Storage of Explosives or Other Dangerous Articles or Substances are contained in Code of Federal Regulations Title 46, Part 146 (46 CFR 146).

The specific portions applicable to a shipment of radioactive material are not available except as a portion of the entire document; for this reason all applicable portions are reproduced.

INDEX

To aid in locating certain portions of the regulations the following broad listings are provided.

A. Paperwork, Marking and Labeling Requirements

Section: 146.04-5
146.05-10 (b) and (c)
146.05-11 (a), (c) and (d)
146.05-12 (f)
146.05-13 (a), (b), (c), (f) and (g)
146.05-14
146.05-17 (a), (b), (c), (d), (e), (q), (r) and (u)

B. General Procedures and Regulations

Section: 146.02-5 (a), (c) and (e)
146.02-10 (a)
146.02-11 (a)
146.02-14 (a) and (c)
146.05-3 (b) and (c)
146.05-10 (a), (b) and (c)
146.06-9 (a) and (b)
146.25-1 (a) and (b)
146.25-20 (a)
146.25-25 (a)

C. Radiation Regulations

Section: 146.25-25 (a)
146.25-30 (a), (b), (c), (d), (f), (g), (h) and (k)

D. General Information

Section: 146.01-4
146.02-3
146.03-20
146.03-21
146.03-33
146.03-34 (b), (c), (e) and (h)
146.25-35 (a), (b), (d), (e) and (f)
146.25-45 (a), (b), (c), (d), (e), (f), (g), (h) and (i)

146.25-400
146.27-10
146.27-15
146.27-20
146.27-100

The sections listed under "General Information" are for the most part stowage and handling regulations. These are sections which do not apply to the shipper but will certainly aid him in understanding what is required by the U.S. Coast Guard.

SUBPART - PREFACE

Sec. 146.01-4 Classifications.

Explosives or other dangerous articles or substances, and combustible liquids are classified in the regulations in this part according to their principal characteristics and properties as follows:

Poisons:

Radioactive materials, Class D.

SUBPART - GENERAL REGULATIONS

Sec. 146.02-3 Application to shippers.

Regulations with respect to definitions, descriptive name, shipping name, packing, marking, authorized containers, labeling and certification of shipments of explosives or other dangerous articles or substances, and combustible liquids, apply to all shippers offering such articles or substances for transportation or storage on board vessels to which the regulations in this part apply.

Sec. 146.02-5 Compliance.

The applicable provisions of the regulations in this part shall be observed by:

(a) All vessels, domestic or foreign, subject to the regulations in this part, and the owners, charterers, agents, masters or persons in charge of such vessels;

(c) All shippers, their agents or other persons offering explosives or other dangerous articles or substances, and combustible liquids for transportation on board vessels;

(e) All shippers or carriers of explosives or other dangerous articles or substances, and combustible liquids shall instruct their employees relative to the provisions of the regulations in this part.

Sec. 146.02-10 Export shipments.

(a) Export shipments of commercial Class A explosives and radioactive materials, Groups I, II or III, regardless of whether in interstate transportation prior to delivery to the vessel, shall be packed, marked, labeled or otherwise in conformity with the Interstate Commerce Commission requirements for the transportation of explosives or other dangerous articles in effect at the time of shipment.

Sec. 146.02-11 Import shipments.

(a) Import shipments of commercial Class A explosives and radioactive materials, Groups I, II, and III, regardless of whether destined upon arrival at domestic ports for further transportation or not shall be packed, marked, labeled, or otherwise in conformity with the Interstate Commerce Commission requirements for the transportation of explosives or other dangerous articles in effect at the time of shipment.

Sec. 146.02-14 Damaged containers.

(a) Any outside container that is sufficiently damaged as to permit the escape of the contents therein, or shows marks of having leaked, or the securing means give evidence of failure to properly contain the package, shall not be accepted on board any vessel for transportation or stowage, nor shall such damaged containers be on board any vessel entering the navigable waters of the United States except in accordance with the provisions of sec. 146.02-15.

(c) Damaged, leaking or insecure outside containers in which radioactive materials, other than low activity ores, are packed shall be handled in accordance with the safety precautions set forth in sections 146.25-1 to 146.25-400, inclusive, pertaining to the care following leakage or sifting of radioactive materials. This provision shall be complied with by all vessels to which the regulations in this part apply when upon the navigable waters of the United States.

Sec. 146.02-15 Emergency shipments.

(a) In event of a casualty occurring to or on board a vessel involving explosives or other dangerous articles or substances on board the vessel as cargo, the master or person in charge of the vessel is authorized to adopt such procedure as will, in his judgment, provide a maximum safety to the vessel, its passengers and crew. When such a casualty results in damaged containers or the emergency use of unauthorized containers, such containers upon arrival at a port shall not be offered to any forwarding carrier for transportation. The vessel, owner, agent, charterer, master or other person in charge of the vessel shall report immediately to the nearest District Commander of the United States Coast Guard or his authorized representative and request instructions as to disposition of the damaged or unauthorized containers.

SUBPART - DEFINITIONS OF WORDS AND TERMS CONTAINED WITHIN THE REGULATIONS IN THIS SUBCHAPTER

Sec. 146.03-20 Label.

The term "label" means the caution label required by the regulations in this subchapter and the regulations of the ICC to be affixed to outside containers of explosives or other dangerous articles or substances.

Sec. 146.03-21 Marking.

The term "marking" refers to the descriptive name, instructions, cautions, weight data, or specification marks that are required by the regulations in this subchapter and the regulations of the ICC to be placed upon outside containers of explosives or other dangerous articles or substances or combustible liquids.

Sec. 146.03-33 Stowage.

For the purposes of the regulations in this subchapter the term "stowage" embraces the art of placing and securing goods on board a vessel within the holds of the vessel, or on the decks, in such manner as to enhance safety during the period of transportation.

Sec. 146.03-34 Stowage terms defined.

For the purposes of the regulations in this part the following stowage terms are defined:

(b) "On deck protected" means the articles may be stowed on the open weather deck of a vessel. It is required that dangerous cargo stowed under such conditions shall be protected from the elements by structural erections or from the direct rays of the sun by means of awnings or dunnaging.

(c) "On deck under cover" means the articles may be stowed on the weather deck of a vessel under covered erections, such as forecastle, bridge house, poop, and deck houses, having permanent structural openings to the atmosphere, but no structural openings such as doors, hatches, companion ways, or manholes to any living quarters, cargo carrying, or other compartments, unless such doors, hatches, companionways, or manholes are provided with hinged means for closing off and securing such openings. Stowage shall not be utilized in any deck house containing living quarters, a steering engine or refrigerating unit or refrigerated stowage boxes unless the areas occupied by such units are isolated from the stowage area by permanent and tight metallic division bulkheads.

(e) "Tween decks readily accessible" means the articles may be stowed in upper cargo spaces below or off the weather deck, and so stowed as to be readily accessible from the cargo openings (but not in the square of the hatch if the latter is made up of wooden hatch covers) or in a shelter deck directly inboard of structural openings from the weather deck. A vessel having cargo carrying holds which extend from the tank top or lower flat to the weather deck and having no enclosed cargo stowage space imposed above such single holds may substitute "Under deck away from heat" in lieu of "Tween decks readily accessible" stowage.

(h) "Under deck" means that the articles may be stowed in a cargo space in a deep hold or a tween deck hold capable of being ventilated. A hold is defined as an area allotted entirely to the carriage of cargo and is bounded by permanent steel bulkheads and decks, and the shell of the vessel, the deck openings being provided with means for effectively closing the hold against the weather, and in the case of superimposed holds, effectively closing off each hold. A cargo space or hold coming within

the above definition shall not be used for the stowage of explosives (except fireworks or relatively safe - Class C - explosives) unless closed off to traffic while the vessel is on its voyage. A cargo space or hold containing a crew passage formed by battens or by a mesh or wire screen bulkhead shall not be used for stowage of other dangerous articles or substances, including fireworks and relatively safe explosives - Class C, unless watchman service is provided for such areas.

SUBPART - LIST OF EXPLOSIVES OR OTHER DANGEROUS ARTICLES CONTAINING THE SHIPPPING NAME OR DESCRIPTION OF ARTICLES SUBJECT TO THE REGULATIONS IN THIS SUBCHAPTER

Sec. 146.04 lists the proper shipping name to be used in reference to the various articles that are subject to these regulations.

Those listings in paragraph 146.04-5 which are of interest are as follows:

ARTICLE	CLASSED AS
Drums, empty	Hazardous article
Radioactive materials, groups I and II	Poison, Class D
Radioactive materials, group III	Poison, Class D

SUBPART - SHIPPER'S REQUIREMENTS RE: PACKING, MARKING, LABELING AND SHIPPING PAPERS

Sec. 146.05-3 Prohibited packing.

(b) The offering for transportation of any package or container of any liquid, solid or gaseous material which under conditions incident to transportation may polymerize (combine or react with itself) or decompose so as to cause dangerous evolution of heat or gas is prohibited. Such materials may be offered for transportation when properly stabilized or inhibited.

(c) The offering for transportation of any package or container of any material which will cause a dangerous evolution of heat or gas under conditions normally incident to transportation is prohibited.

Sec. 146.05-4 Prescribed containers.

(b) In the interest of national defense or at such times as it shall be determined that the interest of safety would not be impaired, the use of containers other than those specified in this part, for the transportation of permitted explosives and other dangerous articles or substances may be authorized in the discretion of and upon special permit to be issued by the Commandant of the Coast Guard.

Sec. 146.05-10 Reuse of containers.

(a) Containers used more than once (refilled and reshipped after having been previously emptied) shall be in such condition, including closing devices and cushioning materials, that they will protect their contents during transit as efficiently as new containers. Repairs must be made in an efficient manner and parts that are weak, broken, or otherwise deteriorated shall be replaced.

(b) Markings applied as prescribed by the specifications shall be maintained in a legible condition.

(c) If, on account of painting or any other reason, the markings as prescribed for any container cannot be kept plain and legible, a metal plate, brazed or soldered or otherwise securely fastened to the container, with a reproduction of the prescribed markings plainly stamped thereon, may be permitted.

Sec. 146.05-11 Certification.

(a) The shipper offering for transportation by vessels subject to the regulations in this part any Class A or Class B explosive and blasting caps or electric blasting caps in any quantity, and any inflammable liquid, inflammable solid, oxidizing

material, corrosive liquid, compressed gas, or poison requiring labels, shall show the following certificate in the lower lefthand corner of the originating shipping paper over the written or stamped facsimile signature of the shipper or of his duly authorized agent:

> This is to certify that the above articles are properly described by name, and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission.

(c) For the relief of shippers from multiplicity of certifications required for packages which may move by rail freight, highway, and water, and pending further consideration and order of the Interstate Commerce Commission, such shipments may in lieu of the certification required by paragraph (a) or (b) of this section be certified as follows:

> This is to certify that the above articles are properly described by name, and are packed and marked and are in proper condition for transportation according to the applicable regulations prescribed by the Interstate Commerce Commission and the Commandant of the Coast Guard.

(d) Detailed regulations in Sec. 146.21-100 to 146.27-100 require specific certification for certain substances. When these substances are required to be certificated under paragraph (a), (b), or (c) of this section the certificate required by the detailed regulations shall be in addition thereto.

Sec. 146.05-12 Originating shipping order, transfer shipping paper.

(f) The minimum information required by this section to be shown upon an originating shipping order is as follows:

(1) Shipper's name and address.

(2) Consignee's name and address. (When required by the detailed regulations.)

(3) Either the number of packages or pieces or the quantity or weight, as the case may be, and the type of packages (cylinders, barrels, boxes, etc.).

(4) Shipping or leading marks and numbers if appearing on packages.

(5) Shipping name of each article, as shown in roman type in the commodity list herein. Further description not inconsistent with the shipping name may be shown. Unauthorized abbreviations shall not be used.

(6) In connection with the entry of each dangerous article, show the kind and color of label applied to the package or the markings upon the package when label or marking is required by the regulations in this part.

(7) Gross weight of container and contents when such information is required to be shown on a package by the regulations in this part.

(8) Certification over the written or stamped facsimile signature of the shipper or of his duly authorized agent as required by the regulations in this part. (Not required except on originating bill of lading and shipping order.)

Sec. 146.05-13 Originating export shipping paper.

(a) The requirements of this section apply when an export shipment is offered for transportation by vessel.

(b) A shipper of any explosive or other dangerous article or substance to be offered for export on board vessels subject to the regulations in this part shall prepare an originating shippping order or otherwise describe the shipment in writing as required by this section.

Note 1. This "originating shipping order" may be any one of the following papers: (1) Uniform through export bill of lading. (2) Ocean bill of lading. (3) Dock receipt. (4) Delivery receipt (5) Government bill of lading. (6) Engagement note. (7) Permit

Note 2. By "otherwise describe the shipment in writing" is meant that the shipper or his authorized agent or representative shall in writing advise the vessel operator in advance regarding the characteristics of the shipment and such description shall conform to the provisions of this section.

(c) For a shipment originating in the interior and moving to the seaboard under a domestic bill of lading the shipper or his authorized agent or representative shall advise the vessel regarding the shipment in the manner set forth under Note 2 of this section.

(f) No person other than the shipper or his duly authorized agent or representative shall prepare an originating shipping order or written instrument otherwise describing the shipment covering transportation of explosives or other dangerous articles or substances.

(g) The minimum information required by this section to be shown upon an originating shipping order or written instrument "otherwise describing the shipment" is as required by Sec. 146.05-12 (f).

Sec. 146.05-14 Import shipping papers

An importer of explosives or other dangerous articles or combustible liquids shall furnish the foreign shippper full and complete information required by Sec. 146.05-12 (f) to be shown on shipping papers. Bills of lading, manifests,

consular invoices or other important shipping papers shall show such information. Applicable certifications as required by Sec. 146.02-3, Sec. 146.02-9, or Sec. 146.02-11 (c), and Sec. 146.05-11 shall also be shown thereon. (See Carrier Regulations re Import Shipments Sec. 146.06-1) (Attention of importers is called to Sec. 146.02-11 re Import Shipments.)

Sec. 146.05-17 Labels.

(a) Shippers shall furnish and attach the labels prescribed for their packages.

(b) Labels shall not be applied to packages containing articles which are not subject to the regulations in this part.

(c) Shippers shall not apply labels which by their size, shape and color, may readily be confused with standard caution labels prescribed in this part.

(d) Labels shall conform to standard as required by the Interstate Commerce Commission regulations.

(e) A combination diamond-shaped label-tag of proper size and color, bearing on one side the shipping information and on the reverse side the wording prescribed in this section will be permitted.

(b) A shipper of any explosive or other dangerous article or substance to be offered for export on board vessels subject to the regulations in this part shall prepare an originating shippping order or otherwise describe the shipment in writing as required by this section.

Note 1. This "originating shipping order" may be any one of the following papers: (1) Uniform through export bill of lading. (2) Ocean bill of lading. (3) Dock receipt. (4) Delivery receipt (5) Government bill of lading. (6) Engagement note. (7) Permit

Note 2. By "otherwise describe the shipment in writing" is meant that the shipper or his authorized agent or representative shall in writing advise the vessel operator in advance regarding the characteristics of the shipment and such description shall conform to the provisions of this section.

(c) For a shipment originating in the interior and moving to the seaboard under a domestic bill of lading the shipper or his authorized agent or representative shall advise the vessel regarding the shipment in the manner set forth under Note 2 of this section.

(f) No person other than the shipper or his duly authorized agent or representative shall prepare an originating shipping order or written instrument otherwise describing the shipment covering transportation of explosives or other dangerous articles or substances.

(g) The minimum information required by this section to be shown upon an originating shipping order or written instrument "otherwise describing the shipment" is as required by Sec. 146.05-12 (f).

Sec. 146.05-14 Import shipping papers

An importer of explosives or other dangerous articles or combustible liquids shall furnish the foreign shippper full and complete information required by Sec. 146.05-12 (f) to be shown on shipping papers. Bills of lading, manifests,

consular invoices or other important shipping papers shall show such information. Applicable certifications as required by Sec. 146.02-3, Sec. 146.02-9, or Sec. 146.02-11 (c), and Sec. 146.05-11 shall also be shown thereon. (See Carrier Regulations re Import Shipments Sec. 146.06-1) (Attention of importers is called to Sec. 146.02-11 re Import Shipments.)

Sec. 146.05-17 Labels.

(a) Shippers shall furnish and attach the labels prescribed for their packages.

(b) Labels shall not be applied to packages containing articles which are not subject to the regulations in this part.

(c) Shippers shall not apply labels which by their size, shape and color, may readily be confused with standard caution labels prescribed in this part.

(d) Labels shall conform to standard as required by the Interstate Commerce Commission regulations.

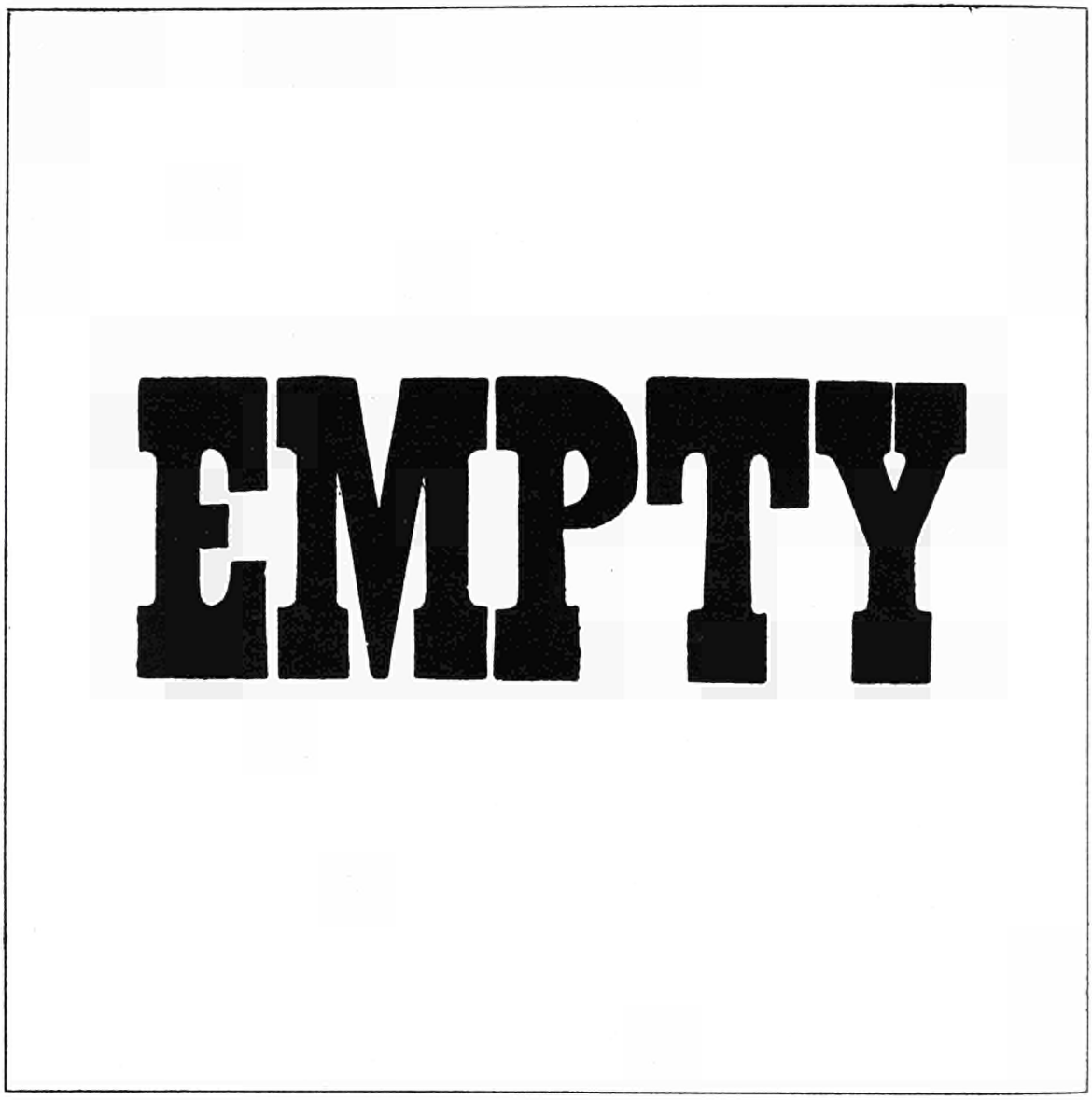
(e) A combination diamond-shaped label-tag of proper size and color, bearing on one side the shipping information and on the reverse side the wording prescribed in this section will be permitted.

(q) Radioactive materials, Group I or II.

(Red printing on white)

(r) Radioactive materials, Group III

(Blue printing on white)



(u) Empty label (white) for empty containers.

(Black printing on white)

SUBPART - VESSEL'S REQUIREMENTS, RE: ACCEPTANCE, HANDLING, STOWAGE, ETC.

Sec. 146.06-9 Stowage on board vessels.

(a) Stowage of a particular explosive or other dangerous article or substance or a combustible liquid on board a vessel may be any permitted stowage in accordance with the provisions as shown in the tables as applying to the character of vessel upon which the substance is permitted to be transported or stored.

(b) When only one stowage is shown, no other stowage shall be utilized. When more than one stowage is indicated any or all of the indicated stowages may be utilized. When "Tween decks" is authorized for stowage "Tween decks readily accessible" may also be used, but not the reverse thereof. When "Under deck" is authorized for stowage "Under deck away from heat" may also be used, but not the reverse thereof.

SUBPART - DETAILED REGULATIONS GOVERNING POISONOUS ARTICLES

Sec. 146.25-1 Definition of poisonous articles.

(a) Poisonous articles are divided by the Interstate Commerce Commission regulations into four classes according to degree of hazard in transportation. These are:

Extremely dangerous poisons - Class A.
Less dangerous poisons - Class B.
Tear gases or irritating substances - Class C.
Radioactive materials - Class D.

(b) These poisonous articles are defined by the Interstate Commerce Commission regulations as set forth in Sec. 146.25-5, 146.25-10, 146.25-15, and 146.25-20, and such definitions are binding upon all shippers making shipments of poisonous articles by common carrier vessels engaged in interstate or foreign commerce by water. These definitions are accepted and adopted and form part of the regulations in this subchapter and apply to all shippers making shipments of poisonous articles by any vessel and shall apply to owners, charterers, agents, master or other person in charge of a vessel and to other persons, transporting, carrying, conveying, storing, stowing, or using poisonous articles on board vessels subject to R.S. 4472, as amended (46 U.S.C. 170) and the regulations in this subchapter.

Sec. 146.25-20 Radioactive materials, Class D Poison.

(a) Radioactive material is any material or combination of materials that spontaneously emits ionizing radiation. For the purpose of the regulations in this part radioactive materials are divided into 3 groups according to the type of rays emitted at any time during transportation, as follows:

(1) Group I. Radioactive materials that emit gamma rays only or both gamma and electrically charged corpuscular rays.

(2) Group II. Radioactive materials that emit neutrons and either or both types of radiation characteristic of Group I materials.

(3) Group III. Radioactive materials that emit electrically charged corpuscular rays only, i. e., alpha or beta, etc., or any other radioactive material that is so shielded that the gamma radiation at the surface of the package does not exceed 10 milliroentgens per 24 hours at any time during transportation.

Sec. 146.25-25 Exemptions for radioactive materials.

(a) Radioactive materials are exempt from prescribed packaging, marking other than the name of the contents, and labeling requirements, provided they fulfill all of the following conditions:

(1) The package must be such that there can be no leakage of radioactive materials under conditions normally incident to transportation.

(2) The package must contain not more than 0.1 millicuries of radium or polonium, or that amount of strontium 89, strontium 90, or barium 140 which disintegrates at a rate of more than 5 million atoms per second; or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

(3) the package must be such that no significant alpha, beta or neutron radiation is emitted from the exterior of the package, and the gamma radiation at any surface of the package must be less than 10 milliroentgens per 24 hours.

Sec. 146.25 - 30 Packing and shielding of radioactive materials.

(a) (1) Not more than 2,000 millicuries of radium, polonium, or other members of the radium family of elements, and not more than 2,700 millicuries (disintegration rate of 100,000 million (10^{11}) atoms per second) of any other radioactive substance may be packed in one outside container for shipment by water except by special arrangements and under conditions approved by the Commandant of the Coast Guard, or except as provided in subparagraph (2) of this paragraph.

(2) Not more than 300 curies of solid cesium 137, cobalt 60, gold 198, or iridium 192 may be packed in one outside container for shipment by water except by special arrangements and under conditions approved by the Commandant of the Coast Guard.

(3) For the purposes of the regulations in this part, one millicurie is that amount of any radioactive material which disintegrates at the rate of 37 million atoms per second. One thousand millicuries is equal to one curie.

(b) Radioactive materials that present special hazards due to their tendency to remain fixed in the human body for long periods of time (i.e., radium, plutonium, and radioactive strontium, etc.) must, inaddition to the packing prescribed in Sec. 146.25-400, Table H, be packed in inside metal containers specification 2R, or other container approved by the Bureau of Explosives and authorized by the Commandant of the Coast Guard.

(c) All radioactive materials must be so packed and shielded that the degree of fogging of undeveloped film under conditions normally incident to transportation (24 hours at 15 feet from the package) will not exceed that produced by 11.5 milliroentgens of penetrating gamma rays of radium filtered by 1/2 inch of lead.

(d) The design and preparation of the package must be such that there will be no significant radioactive surface contamination of any part of the container.

(f) All outside shipping containers must be of such design that the gamma radiation will not exceed 200 milliroentgens per hour or equivalent at any point of readily accessible surface. Containers must be equipped with handles and protective devices when necessary in order to satisfy this requirement.

(g) Radioactive materials Group I, liquid, solid, or gaseous, must be packed in suitable inside containers completely surrounded by a shield of lead or other suitable material of such thickness that at any time during transportation the gamma radiation at one meter (39.3 inches) from any point on the radioactive source will not exceed 10 milliroentgens per hour. The shield must be so designed that it will not open or break under conditions incident to transportation. The minimum shielding must be sufficient to prevent the escape of any primary corpuscular radiation to the exterior of the outside shipping container.

(h) Radioactive materials Group II, liquid, solid, or gaseous, must be packed in suitable inside containers completely shielded so that at any time during transportation the radiation measured at right angles to any point on the long axis of the shipping container will not exceed the limits specified in subparagraphs (1) to (4) of this paragraph. The shielding must be designed so as to maintain its efficiency under conditions normally incident to transportation and must provide personnel protection against fast or slow neutrons and all other ionizing radiation originating in the radioactive materials or any part of the aggregate constituting the complete package.

(1) Gamma radiation of 10 mrhm.

(2) Electrically charged corpuscular radiation which is the physical equivalent (see note 1 of this paragraph) of 10 mrhm. of gamma radiation.

(3) Neutron radiation which is the physical equivalent (see note 1 of this paragraph) of 2 mrhm. of gamma radiation.

(4) If more than one of the types of radiation named in subparagraphs (1), (2), and/or (3) of this paragraph is present the radiation of each type must be reduced by shielding so that the total does not exceed the equivalent of subparagraphs (1), (2), or (3) of this paragraph.

Note 1: For purposes of the regulations in this section the "physical equivalent" of a roentgen is that amount of radiation that would be absorbed in tissue to the extent of approximately 100 ergs per gram (mrhm. is an abbreviation for milliroentgens per hour at 1 meter (39. 3 inches).

(k) Radioactive materials, Group III, liquid, solid or gaseous, must be packed in suitable inside containers completely wrapped and/or shielded with such material as will prevent the escape of primary corpuscular radiation to the exterior of the shipping container, and secondary radiation at the surface of the container must not exceed 10 milliroentgens per 24 hours, at any time during transportation.

Sec. 146.25-35 Stowage and handling of radioactive materials on board vessels.

(a) All containers of radioactive materials stowed on board a vessel must be efficiently lashed, chocked, or braced to prevent sifting or leakage by movement of the containers in any direction.

(b) No person shall remain unnecessarily in a hold or compartment or close to a hold, compartment, or deck cargo space, containing radioactive materials and the shipper must furnish the carrier with such information and equipment as is necessary for the protection of the carrier's employees, stevedores, or other persons engaged in the handling of such cargo. In no instance shall any person who must necessarily remain in a hold, compartment, or in the proximity of a hold, compartment, or deck cargo space, containing radioactive material be exposed to a total of more than 300 milliroentgens of gamma radiation or equivalent in any 7 day period.

(d) Enclosed compartments in which are stowed any extremely dangerous poisons, Class A, or radioactive materials, Class D, shall not be left open to entrance by persons unfamiliar with the type of cargo being transported.

(e) No radioactive materials, Groups I, II, or III, shall be stowed on board a vessel in any hold, compartment, or deck space so that the total gamma radiation or equivalent in any space or area continuously occupied by passengers, crew, or shipments of animals will exceed 40 milliroentgens per 24 hours at any time during transportation. Any hold, compartment, or enclosed deck space containing radioactive materials shall be so ventilated that there will be no accumulation of radioactive gases in that hold, compartment, or enclosed deck space.

(f) Not more than 40 units of radioactive materials, red label (Groups I and II), shall be stowed together in any 1 area or place. One unit equals 1 milliroentgen per hour at a distance of 1 meter (39.3 inches) for hard gamma radiation or the amount of radiation which has the same effect on film as 1 milliroentgen per hour per meter of hard gamma rays of radium filtered by 1/2 inch of lead. If the shipment exceeds 40 units, a distance of at least 60 feet must separate increments of not more than 40 units each.

Sec. 146.25-45 Stowage of poisonous articles with explosives and other dangerous articles.

(a) Containers of poisonous articles offered for transportation on board vessels shall, when taken on board a vessel, be stowed

in accordance with the provisions applying to the particular character of vessel as shown in Sec. 146.25-100 to 146.25-400, inclusive, and with the detailed regulations for stowage in this subpart.

(b) Poisonous articles shall not be stowed in the same hold or compartment with Class A or Class B explosives.

(c) Class D poisons shall not be stowed in the same hold or compartment with Class C explosives.

(d) Poisonous articles shall not be stowed in the same hold or compartment with inflammable liquids.

(e) Poisonous articles shall not be stowed in the same hold or compartment with inflammable solids.

(f) Poisonous articles shall not be stowed adjacent to or under containers of corrosive liquids. Cyanides, or cyanide mixtures shall not be stowed in the same hold or compartment with corrosive liquids.

(g) Poisonous articles shall not be stowed in the same hold or compartment over cylinders of non-inflammable compressed gases.

(h) Poisonous articles, Class A, Class C, and Class D shall not be stowed in the same hold or compartment with cotton.

(i) Containers of poisonous articles shall be stowed well away from living quarters, refrigerated cargo and foodstuffs not packed in hermetically sealed containers.

Sec. 146.25-400 TABLE H - Classification: Class D; radioactive materials.

Table H lists the allowable stowage of radioactive materials. Those listings of interest are as follows:

DESCRIPTIVE NAME OF ARTICLE	STOWAGE
Radioactive materials Groups I and II and N. O. S.	"On deck protected" "On deck under cover." "Tween decks readily accessible."
Radioactive materials Group III and N. O. S.	"On deck protected." "On deck under cover" "Tween decks readily accessible."
Radioactive materials as described under Sec. 146.25-25 (a) and (b)	"On deck protected." "On deck under cover." "Tween decks readily accessible." "Under deck."

SUBPART - DETAILED REGULATIONS GOVERNING HAZARDOUS ARTICLES

Sec. 146.27-10 Stowage on board vessels.

All hazardous articles permitted for transportation on board vessels shall, when taken on board a vessel, be stowed in accordance with the provisions applying to the particular character of vessel as shown in the tables forming Sec. 146.27-100 and with the general stowage requirements shown in this subpart.

Sec. 146.27-15 General stowage requirement.

Hazardous articles shall not be stowed in any compartment or hold in which explosives are stowed.

Sec. 146.27-20 Protection for "On deck" stowage.

Hazardous articles that are permitted stowage "on deck in open" or "on deck protected" may be protected by the use of structural erections, awnings, or tarpaulins.

Sec. 146.27-100 Table K
Classification: Hazardous articles

DESCRIPTIVE NAME OF ARTICLE	STOWAGE
Drums, empty	May be accepted without restriction on any character of vessel, provided: (1) The drums or barrels are completely drained (2) Bungs shall be securely in place (3) Open head type barrel or drums shall have the head securely in place.

APPENDIX B

INTERSTATE COMMERCE COMMISSION REGULATIONS GOVERNING THE TRANSPORTATION OF EXPLOSIVES AND OTHER DANGEROUS ARTICLES

Note: The information contained herein is based on the text and the interpretation of the regulations as they existed on January 1, 1962. Any person prior to using this appendix should bring this information up to date.

COMMENTARY

The Interstate Commerce Commission is charged by the Congressof the United States with the responsibility of formulating regulations for the safe transportation of explosives and other dangerous articles. The regulations of the Commission are applicable to all means of transportation used in interstate and foreign commerce and are binding on carriers and shippers alike.

The regulations of the Interstate Commerce Commission applicable to the shipment of radioactive materials were originally written for and are still primarily intended for low quantity or isotope shipments. The framework of the regulations is quite suitable, however, for the regulating of shipments of spent fuel.

The regulations can be broken down into four major subgroups:

(1) Those portions that apply specifically to administrative matters, such as marking and labeling.

(2) Those portions that state general regulations which set forth overall principles of performance.

(3) Those portions that detail the required and allowable levels of radiation, and

(4) Statements which are of a general information nature.

Within the area of administrative matters first and foremost is the matter of obtaining from the Interstate Commerce Commission permission to exceed the stated maximum allowable contained radioactivity. The shipment of spent fuel will always be in excess of the allowable maximum.

The Interstate Commerce Commission has authorized the Bureau of Explosives of the Association of American Railroads to act on its behalf with regard to the issuing of permits and determining the adequacy of the cask and all other arrangements.

Certifications are required on a great many of the documents and shipping papers associated with the shipment. This certification to the effect that the shipper certifies that packing, marking, labeling radiation levels and other requirements, have been complied with, can be made by any representative or agent of the shipper.

The regulations with regard to matters of labeling, marking, placarding, and certifying are for the most part clear and well written and appear to present no problems to successful compliance.

The general statements of policy and performance which are included in the regulations are clearly written and need no further clarification or discussion. These statements are entirely reasonable and are intended to guarantee the health and safety of the general public and all those involved in the shipment.

The regulations dealing with levels of radiation and surface contamination were written based on the recommended allowable exposure of persons to ionizing radiations. For this reason, these regulations are applicable to shipments of spent fuel.

In paragraph 73.393 (a) container specification 2R, which is called for, for long lived types of radioactive material, is not suitable for spent fuel because it is an extremely small standard type of container, 6 inches in diameter by 16 inches long. Whether or not the cask satisfies the requirements of 73.393 (a) will be determined by the Bureau of Explosives at the time the cask details are reviewed.

The regulations limit the amount of radiation to which undeveloped film is to be exposed by referring to an amount of penetrating gamma rays of radium. This regulation found in paragraph 73.393 (b) calls for the exposure of undeveloped film at a distance of 15 feet to be no more than 11.5 milliroentgen of penetrating gamma rays of radium filtered by 1/2 inch of lead over a period of 24 hours.

In the event the shipment is one of spent fuel in a large lead lined cask, the radiation emitting from the spent fuel after shielding by a substantial amount of lead will have the same photographic effectiveness as gamma radiation from radium which has been filtered by 1/2 inch of lead.

This limits the radiation level at 15 feet from a cask to 0.48 milliroentgens per hour.

If the "inverse square law" is applied then 0.48 milliroentgens per hour at 15 feet is equal to 10.16 milliroentgens per hour at one meter, and is in accordance with other regulations.

The "inverse square law" however, is not applicable to large casks such as used for spent fuel, and this allowed dose at 15 feet becomes less than 10 mr per hour at one meter.

It is expected that in the not too distant future this regulation will be modified to apply only in the case of mixed loading.

If carload shipments are to be made prior to the modification of this regulation then a waiver of this requirement must be obtained from the Interstate Commerce Commission. The Commission has indicated that this waiver could be obtained with relative ease.

Paragraph 73.393 (c) refers to "significant radioactive surface contamination". A "significant" amount is considered to be in excess of the following levels:

(a) alpha activity in excess of 500 disintegrations per minute per 100 square centimeters.

(b) beta-gamma activity at the surface which would exceed 10 milliroentgens per 24 hours.

It will be impossible to determine, after the cask is loaded, if the beta-gamma activity of the surface is less than 10 mr/24 hrs. This point has, as yet, not been clarified.

These are the same limits allowed by section 73.395 (a) which prescribes the level of contamination allowable on or within conveyances used for the carriage of radioactive materials.

Paragraphs 73.393 (g) and 73.393 (h) refer to radioactive materials of Group I and Group II and discuss the prescribed packaging and the allowable radiation level. These radiation levels are to be measured at a distance of one meter from the "source".

"Source" is defined to be the surface of the radioactive material, and not the surface of the container or cask.

Paragraph 73.393 (k) specifies the general efficiency level of the instruments used to measure radiation and determine compliance with the stated regulations. The instruments once considered by the U.S. Atomic Energy Commission as suitable for measuring radiation and as complying with the requirements of 73.393 (k) are found in the SIC series of the AEC Instruments Catalog.

The instruments in this list may still be considered suitable, however, this list is obsolete. The list was made obsolete not so much by technical advances as by the desire of the AEC to refrain from endorsing the instruments of any one particular manufacturer over those of another.

Any commercially available instrument which is recommended by a reputable manufacturer as suitable to take the desired readings is considered an instrument satisfying paragraph 73.393 (k).

The "Radioactive Material" label as prescribed in paragraph 73.394 (a) and as illustrated in paragraph 73.414 (a) is the one required on all containers loaded with spent fuel. This label provides a space in which to enter the name of the "Principal radioactive content". Since in the case of spent fuel it is not possible to attribute the radioactivity to any one radioisotope, it is considered satisfactory to enter, in the space provided, the words "Chemical N.O.S.".

Sub-paragraph 74.586 (h) (2) specifies the distance required between packages of undeveloped film and containers of radioactive material bearing a red label. (A shipment of spent fuel will always bear a red label). This list is included because shipments of spent research reactor fuel would most likely consist of more than one container.

The definition of the term "portable tank" given in paragraph 71.8 (g) seems to very well describe the casks normally used for the purpose of transporting spent fuel. The Interstate Commerce Commission has indicated, however, that it considers tanks to be containers generally used for the purpose of holding gases or liquids. On this basis they advise that casks used to carry spent fuel need not comply with the requirements applicable to "portable tanks".

Shipments of spent fuel will very often be made with a liquid acting as the primary coolant. During the course of the shipment the cask will be exposed to variations in environmental temperature which could be reflected in the thermal expansion and contraction of

primary coolant. This thermal expansion and contraction could very well cause a cask which had started out as a non-pressurized cask to arrive in a pressurized condition.

The Interstate Commerce Commission considered the question of pressurized casks and decided they need not meet the criteria or comply with the regulations applicable to compressed gases. It was decided that the safeguards taken to protect persons and property from the radiation hazard would exceed the normal requirements for non-flammable compressed gases.

Part 77 is included in Appendix B because shipments from research reactors could conceivably be transported by truck.

This commentary is provided for the purpose of clarifying certain portions of the regulations. It is not intended as a substitute for or summary of the regulations.

The Interstate Commerce Commission Regulations for Transportation of Explosives and Other Dangerous Articles are published in the Code of Federal Regulations, Title 49, Parts 71 - 78 (49 CFR 71 - 78).

The specific portions applicable to a shipment of radioactive material are not available except as a portion of the entire document; for this reason those applicable portions are reproduced.

INDEX

To aid in locating sections or paragraphs which are applicable to certain functions or interests, the following broad listings are provided.

A. Paper work, Marking, and Labeling

Section: 73.9 (a)
73.28 (b) and (c)
73.29 (f)
73.30 (a)
73.392 (a)
73.394 (a) and (b)
73.401 (a), (b) and (e)
73.402 (a)(8), (a)(9) and (a)(13)
73.404 (a), (b), (c), (d), (e), (f) and (g)
73.413 (a)
73.414 (a) and (b)
73.427 (a)
73.428 (a)
73.430 (a) and (b)
74.541 (b)
74.546 (a), (b), (c), (d), and (e)
74.548 (a)
74.549 (a)(1), (a)(3), (a)(4), (a)(5), (a)(6), (b), (e) and (f)
74.553 (a)
77.815 (a)
77.819 (a) and (b)
77.823 (a) and (f)

B. General Procedures and Regulations

Section: 73.9 (a)
73.21 (b) and (c)
73.23 (a)
73.24 (b)
73.28 (a) and (b)
73.29 (a)
73.393 (a), (c) and (k)
74.532 (j)(3)
74.548 (a)
74.554 (a)

C. Radiation Regulations

Section: 73.29 (e)
73.391 (a), (b) and (c)
73.392 (a)
73.393 (a), (b), (c), (e), (g), (h), (j) and (k)
73.395 (a)
74.532 (j)(2)
74.566 (d)
74.586 (h), (h)(2) and (h)(3)
77.841 (d)
77.860 (d)

D. General Information

Section: 73.11 (a)
73.395 (a)
74.532 (j)(1), (j)(2), and (j)(3)
74.538 (a)
74.562 (a)
74.566 (d)
74.586 (h), (h)(2) and (h)(3)
74.589 (n)
74.597 (e)
77.834 (a), (b) and (e)
77.848 (a)
77.853 (a)
77.860 (a), (c) and (d)

General information includes those sections that apply to stowage and handling and are to be complied with by the carrier. The information in these sections can be of value to a shipper and are therefore included.

PART 71

GENERAL INFORMATION AND REGULATIONS

This part discusses very briefly the areas of application of Parts 71 - 78 and the basis for the authority to formulate, issue, modify and enforce the published regulations.

Section 71.8 (a) points out that within the entire regulations; that is Parts 71 - 78, the word "must" or "shall" is used in mandatory regulations, and the word "should" indicates recommendatory provisions.

PART 72

COMMODITY LIST OF EXPLOSIVES AND OTHER DANGEROUS ARTICLES CONTAINING THE SHIPPING NAME OR DESCRIPTION OF ALL ARTICLES SUBJECT TO PARTS 71 - 78

Section 72.5 lists the proper shipping name to be used for various articles that are considered to be subject to the regulations of Parts 71 - 78. The prior sections describe the proper method of using the listing.

The listings of interest are as follows:

Article	Classed as -
Radioactive materials, n.o.s.	Poison D
Drums, empty	See Sec. 73.29

PART 73

RULES AND REGULATIONS APPLYING TO SHIPPERS

Sec. 73.9 Import and export shipments.

(a) Import shipments of explosives and other dangerous articles offered in the United States in original packages for transportation by carriers by rail freight, rail express, motor vehicle, or water must comply with all requirements of the regulations in Parts 71-78. The importer must furnish with the order to the foreign shipper, and also to the forwarding agent at the port of entry, full and complete information as to the packing, marking, labeling, and other requirements, as prescribed in Parts 71-78, and the forwarding agent must file with the initial carrier in the United States a properly certified shipping order or other shipping papers as prescribed in this part.

Sec. 73.11 Violations and accidents to be reported.

(a) Consignees must report promptly to the Bureau of Explosives all instances of improper staying and broken, leaking, or defective containers of explosives or other dangerous articles in shipments received by them.

Subpart A - Preparation of Articles for Transportation By Carriers By Rail Freight, Rail Express, Highway or Water

Sec. 73.21 Prohibited packing.

(a) The offering of packages of dangerous articles in outside packages containing in the same compartment interior packages the mixture of contents of which would be liable to cause a dangerous evolution of heat or gas or produce corrosive materials is prohibited for transportation by common carriers by rail freight, rail express, highway, or water, except as specified in sec. 73.152 (a), sec. 73.242 (a), (b) and sec. 73.301 (a).

(b) The offering for transportation of any package or container of any liquid, solid or gaseous material which under conditions incident to transportation may polymerize (combine or react with itself) or decompose so as to cause dangerous evolution of heat or gas is prohibited. Such materials may be offered for transportation when properly stabilized or inhibited. Refrigeration may be used as a means of stabilization only when approved by the Bureau of Explosives.

(c) The offering for transportation of any package or container of any material which will cause a dangerous evolution of heat or gas under conditions normally incident to transportation is forbidden.

Sec. 73.23 Closures for containers.

(a) ... Gasketed closures must be fitted with gaskets of efficient material which will not be deteriorated by the contents of the container.

Sec. 73.24 Design of containers.

(a) In addition to standing the tests prescribed, the design and construction of inside and outside containers must be such as to prevent the occurrence in individual packages of defects that permit leakage of their contents under ordinary conditions incident to transportation.

(b) Articles for which detailed specifications for packing are not given in this part must be securely packed in containers strong enough to stand, without rupture or leakage of contents, all shocks ordinarily incident to handling during transit.

Sec. 73.28 Reused containers.

(a) Containers used more than once (refilled and reshipped after having been previously emptied) must be in such condition including closing devices and cushioning materials, that they will protect their contents during transit as efficiently as new containers. Repairs must be made in an efficient manner and parts that are weak, broken, or otherwise deteriorated must be replaced....

(b) Markings applied as prescribed by the specifications must be maintained in a legible condition.

(c) If, on account of painting or any other reason, the markings as prescribed for any container cannot be kept plain and

legible, a metal plate, brazed or soldered, or otherwise securely fastened to the container, with a reproduction of the prescribed markings plainly stamped thereon, will be permitted.

Section 73.29 Empty containers.

(a) Empty cylinders, barrels, kegs, drums, or other containers except carboys ... previously used for the shipment of any explosive or other dangerous article, as defined in this part, if authorized for reuse must have all openings including removable heads, filling and vent holes, tightly closed before being offered for transportation. Small quantities of the material with which containers were loaded may remain in "empty" containers and when the vapors remaining therein are unstable, it is permissible to add sufficient inert gas to render the vapors stable.

(e) All containers and accessories which have been used for shipments of radioactive materials when shipped as empty must be sufficiently free of radioactive contamination so as to conform to the conditions of paragraph (a) (1), (2), and (3) of sec. 73.392.

(f) Containers shipped as "empty" must have the old labels prescribed by this part removed, obliterated, destroyed, or completely covered by a square white label as described in sec. 73.413 measuring not less than six inches on each side, and bearing thereon the word "EMPTY" in letters not less than one-inch high. This does not apply to carload or truckload shipments to be unloaded by consignee.

Section 73.30 Loading and placarding of cars by shippers and unloading of cars by consignees.

(a) When shipments of explosives or other dangerous articles are loaded into cars by shippers, or unloaded from cars by the consignee or his duly authorized agent, the applicable provisions of Part 74 must be complied with. See sec. 74.538 for loading and storage chart.

Subpart G --- Poisonous Articles; Definition and Preparation

Section 73.391 Radioactive materials class D Poison; definition.

(a) For the purpose of Parts 71-78, radioactive material is any material or combination of materials that spontaneously emits ionizing radiation. For the purpose of Parts 71-78, radioactive materials are divided into three groups according to the type of rays emitted at any time during transportation, as follows:

(1) Group I. Radioactive materials that emit gamma rays only or both gamma and electrically charged corpuscular rays.

(2) Group II. Radioactive materials that emit neutrons and either or both the types of radiation characteristic of Group materials.

(3) Group III. Radioactive materials that emit electrically charged corpuscular rays only, i.e., alpha or beta, etc., or any other that is so shielded that the gamma radiation at the surface of the package does not exceed 10 milliroentgens for 24 hours at any time during transportation.

(b) Not more than 2,000 millicuries or radium, polonium, or other members of the radium family of elements, and not more than 2,700 millicuries (disintegration rate of 100,000 million be packed in one outside container for shipment by rail freight, rail express, or highway, except by special arrangements and under conditions approved by the Bureau of Explosives or except as specifically provided in subparagraph (c) of this section.

Note 1: For purposes of Parts 71-78 one millicurie is that amount of any radioactive material which disintegrates at the rate of 37 million atoms per second. One thousand millicuries is equal to one curie.

(c) Not more than 300 curies of solid cesium 137, cobalt 60, gold 198, or iridium 192, may be packed in one outside container for shipment by rail freight, rail express, or highway, except by special arrangements and under conditions approved by the Bureau of Explosives.

Section 73.392 Exemptions for radioactive materials.

(a) Radioactive materials are exempt from prescribed packaging, marking, and labeling requirements provided they fulfill all of the conditions in subparagraphs (a) (1), (2), and (3). Shipments for transportation by highway carriers are exempt also from Part 77, except section 77.817 of these regulations, and Part 197 of the I.C.C. Motor Carrier Safety Regulations.

(1) The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation.

(2) The package must contain not more than 0.1 millicuries of radium, or polonium, or that amount of strontium 89, strontium 90, or barium 140 which disintegrates at a rate of more than 5 million atoms per second; or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

(3) The package must be such that no significant alpha, beta, or neutron radiation is emitted from the exterior of the package and the gamma radiation at any surface of the package must be less than 10 milliroentgens for 24 hours.

Section 73.393 Packing and shielding.

(a) Radioactive materials that present special hazards due to their tendency to remain fixed in the human body for long periods of time (i.e., radium, plutonium, and radioactive strontium, etc.) must, in addition to the packing hereinafter prescribed, be packed in inside metal containers specification 2R (sec. 78.34), or other container approved by the Bureau of Explosives.

(b) All radioactive materials must be so packed and shielded that the degree of fogging of undeveloped film under conditions normally incident to transportation (24 hours at 15 feet from the package) will not exceed that produced by 11.5 milliroentgens of penetrating gamma rays of radium filtered by 1/2 inch of lead.

(c) The design and preparation of the package must be such that there will be no significant radioactive surface contamination of any part of the container.

(e) All outside shipping containers must be of such design that the gamma radiation will not exceed 200 milliroentgens per hour or equivalent at any point of readily accessible surface. Containers must be equipped with handles and protective devices when necessary in order to satisfy this requirement.

(g) Radioactive materials Group I, liquid, solid, or gaseous, must be packed in suitable inside containers completely surrounded by a shield of lead or other suitable material of such thickness that at any time during transportation the gamma radiation at one meter (39.3 inches) from any point on the radioactive source will not exceed 10 milliroentgens per hour. The shield must be so designed that it will not open or break under conditions incident to transportation. The minimum shielding must be sufficient to prevent the escape of any primary corpuscular radiation to the exterior of the outside shipping container.

(h) Radioactive materials Group II, liquid, solid, or gaseous, must be packed in suitable inside containers completely shielded so that at any time during transportation the radiation measured at right angles to any point on the long axis of the shipping container will not exceed the limits specified in subparagraphs (1) to (4) of this paragraph. The shielding must be designed so as to maintain its efficiency under conditions normally incident to transportation and must provide personnel protection against fast or slow neutrons and all other ionizing radiation originating in the radioactive materials or any part of the aggregate constituting the complete package.

(1) Gamma radiation of 10 mrhm.

(2) Electrically charged corpuscular radiation which is the physical equivalent (see note 1 of this paragraph) of 10 mrhm. or gamma radiation.

(3) Neutron radiation which is the physical equivalent (see Note 1 of this paragraph) of 2 mrhm. of gamma radiation.

(4) If more than one of the types of radiation named in subparagraphs (1), (2), and/or (3) of this paragraph is present the radiation of each type must be reduced by shielding so that the total does not exceed the equivalent of subparagraphs (1), (2), or (3) of this paragraph.

Note 1: For purposes of Parts 71-78 the "physical equivalent" of a roentgen is that amount of radiation that would be absorbed in tissue to the extent of approximately 100 ergs per gram (mrhm. is an abbreviation for milliroentgens per hour at 1 meter (39.3 inches)).

(j) Radioactive materials Group III, liquid, solid, or gaseous, must be packed in suitable inside containers completely wrapped and/or shielded with such material as will prevent the escape of primary corpuscular radiation to the exterior of the shipping container, and secondary radiation at the surface of the container must not exceed 10 milliroentgens per 24 hours, at any time during transportation.

(k) In determining compliance with requirements of paragraphs (e), (g), (h) and (j) of this section measurements of radiation must be made with a Landsverk-Wollan Electrometer, Model L-100 or equally efficient standardized meter.

Section 73.394 Radioactive materials labels.

(a) Each outside container or radioactive material Group I or II, unless exempt by sec. 73.392, must be labeled with a properly executed label as described in sec. 73.414 (a).

(b) Each outside container of radioactive material Group III must unless exempt by sec. 73.392 be labeled with a properly executed label as described in sec. 73.414 (b).

Section 73.395 Cleaning cars and vehicles.

(a) Any box car or motor vehicle which, after use for the transportation of radioactive materials in carload or truckload lots, is contaminated with such materials to the extent that a survey of the interior surface shows that the beta-gamma radiation is greater than 10 milliroentgens physical equivalent in 24 hours or that the average alpha contamination is greater than 500 disintegrations per minute per 100 square centimeters shall be thoroughly cleaned in such a manner that a resurvey of the interior surface shows the contamination to be below these levels. A certificate to that effect must be furnished to the local agent of the carrier or to the driver of the motor vehicle. Cars and motor vehicles which are used solely for the transportation of radioactive materials are exempt from the provisions of this section.

Section 73.396 Radioactive materials handling.

(a) When radioactive materials are loaded into railroad cars or motor vehicles by the shipper, the shipper shall observe all applicable requirements of Parts 74, 75, or 77, as the case may be.

Subpart H - Marking and Labeling Explosives and Other Dangerous Articles

Note: The markings prescribed for containers should be as near together as possible.

Section 73.401 Dangerous articles.

(a) Packages containing flammable liquids, flammable solids, oxidizing materials, corrosive liquids, compressed gases, and poisons, as defined in this part must be marked, unless exempted, with the proper shipping name as shown in the commodity list (see sec. 72.5). . . .

(b) Each package of dangerous articles must show the name and address of the consignee except in carloads and truckloads or less-than-truckloads when handled by a motor vehicle not requiring transfer from one motor carrier to another.

(e) Additional shipping information not inconsistent with Parts 71-78 may be shown on a container if so desired but no such label or marking shall be of a design, or form, or size, as may be confused with the marking required by Parts 71-78.

Section 73.402 Labeling dangerous articles.

(a) Each package containing any dangerous article as defined by Parts 71-78, must be conspicuously labeled by the shipper as follows, except as otherwise provided. ...

(8) "Radioactive Materials" label as described in sec. 73.414 (a) on containers of class D poisons, Group I and II, except when exempted by sec. 73.392.

(9) "Radioactive Materials" label as described in sec. 73.414 (b) on containers of class D poisons, Group III, except when exempted by sec. 73.392.

(13) "Empty Label" as described in sec. 73.413 must be applied to containers which have been emptied and on which the old label has not been removed, obliterated or destroyed. It must be so placed on the container as to completely cover the old label.

Section 73.404 Labels

(a) Shippers must furnish and attach the labels prescribed for their packages. Labels should be applied to that part of the package bearing consignee's name and address.

(b) Labels must not be applied to packages containing articles which are not subject to Parts 71 or 78 or are exempted therefrom.

(c) Shippers must not use labels which by their size, shape, and color, may readily be confused with the standard caution labels prescribed in this part.

(d) Labels must conform to standards as to size, printing and color, and samples will be furnished, on request, by the Bureau of Explosives.

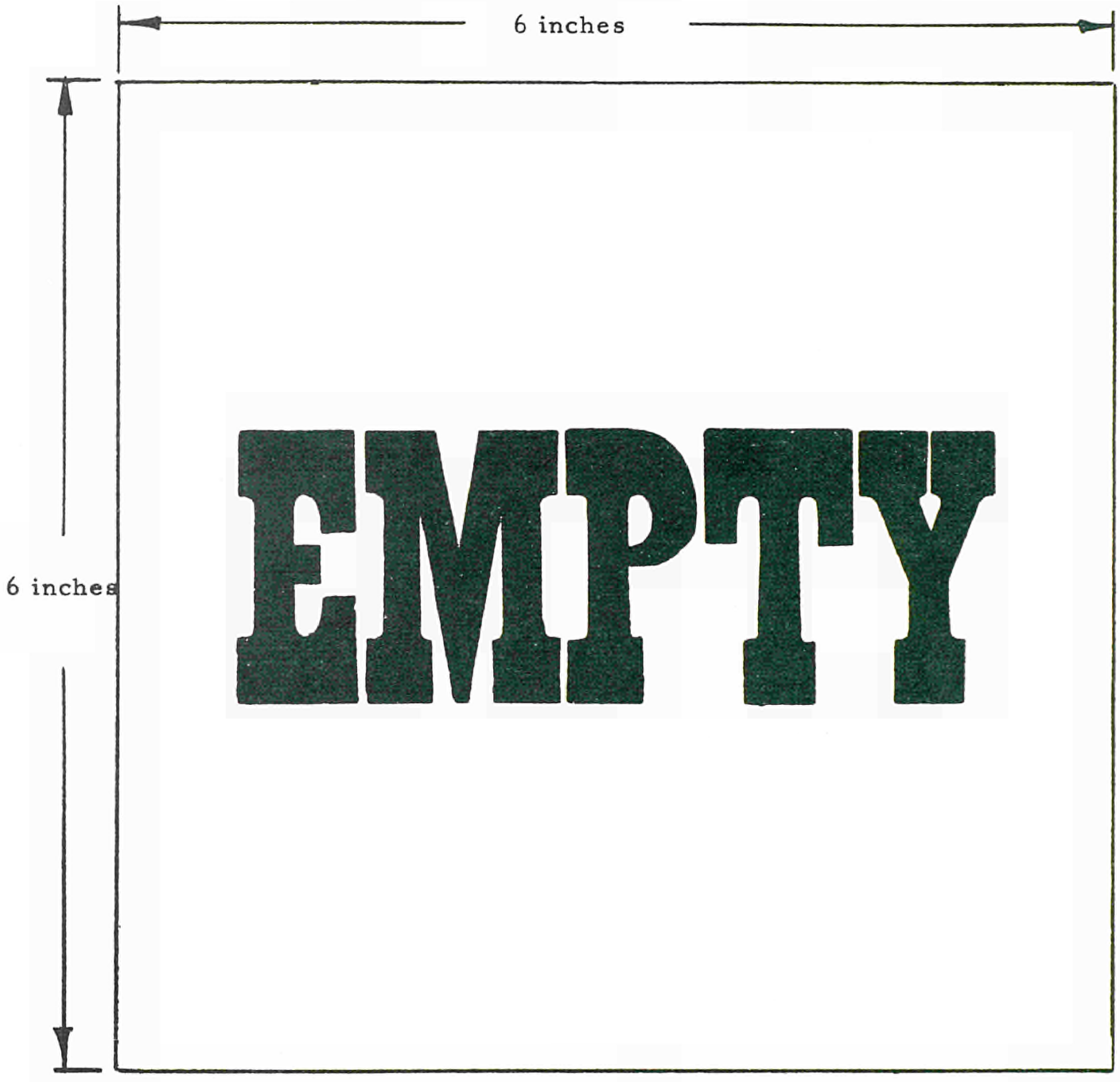
(e) A combination diamond-shaped label-tag of proper size and color, bearing on one side the shipping information and on the reverse side the wording prescribed in this part, will be permitted.

(f) As certification of compliance with regulations is also required by other Government agencies and to avoid multiplicity of certifications, there may be added to the certificate on labels "and the Commandant of the Coast Guard", or "and the Administrator of the Federal Aviation Agency" or "and the Post Office Department" as is necessary.

(g) The carrier's name and stationery form number, or the shipper's name and address, may be printed on the labels, in type not larger than 10 point, if placed within the black-line border and in the upper or lower corner of the diamond.

Section 73.413 Empty Container label.

(a) Labels for empty containers must be not less than 6 inches on each side, white in color, and printed in letters not less than 1 inch high in black ink and as shown in this section.



White Label For Empty Containers

Section 73.414 Radioactive Materials labels

(a) Labels for radioactive materials (class D poisons) Group I and Group II must be of diamond shape, white in color and with each side 4 inches long. Printing must be in red letters inside of a red-line border measuring 3-1/2 inches on each side, as shown in this section.

Note: This label must be duly executed by the shipper and the numer of radiation units must be shown. For purposes of these regulations 1 unit equals 1 milliroentgen per hour at 1 meter for hard gamma radiation or the amount of radiation which has the same effect on film as 1 mrhm or hard gamma rays of radium filtered by 1/2 inch of lead.

Label for Radioactive Materials

Group I or II

Section 73.414 Radioactive Materials Labels

(b) Labels for radioactive materials (class D poisons) Group III must be of diamond shape, white in color, and with each side 4 inches long. Printing must be in blue letters inside of a blue line border measuring 3-1/2 inches on each side, and as shown in this section.

Label for Radioactive Materials

Group III

Section 73.427 Shipping order and bill of lading description.

(a) The shipper when offering for transportation by carriers by rail freight, rail express, highway, or water any class A, class B or class C explosive, flammable liquid flammable solid, oxidizing material, corrosive liquid, compressed gas or poison as defined by this part, must describe such article in the shipping order, bill of lading or other shipping paper by the shipping name used in sec. 72.5 (see commodity list) and may add a further description not inconsistent therewith. Abbreviations must not be used.

Section 73.428 Label or placard notation

(a) The shipping order, bill of lading or other shipping paper must also show theron in connection with the entry of the article as prescribed in sec. 73.427, the color or kind of label applied, and for cars containing such articles loaded by the shipper, requiring placards the kind of placard applied to the car.

Section 73.430 Certificate

(a) The shipper offering for transportation by carriers by rail freight highway, water, or air, any class A or class B explosive and blasting caps ...or poison, requiring labels or carloads requiring placards, as prescribed by Parts 71-78, must show on the shipping order, bill of lading, or other shipping paper, in the lower left-hand corner, the following certificate over the written or stamped facsimile signature of the shipper or his duly authorized agent:

> This is to certify that the above named articles are properly described, and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission.

(b) For the relief of shippers from multiplicity of certifications required for packages which may move by various means of transportation, shipments may be certified for rail, motor vehicle, water, or air transportation by adding to the certificate required on the shipping document "and the Commandant of the Coast Guard" or the "Administrator of the Federal Aviation Agency", as the case may be.

PART 74

REGULATIONS APPLYING PARTICULARLY TO CARRIERS BY RAIL FREIGHT

Subpart A - Loading, Unloading, Placarding and Handling Cars; Loading Packages Into Cars

Section 74.532 Loading other dangerous articles.

(j) Radioactive materials and radioactive ores, residues, and similar material.

(2) The amount of radioactive materials, other than radioactive ores, residues, or similar materials, loaded in a freight car shall be limited so that the quantity does not exceed 40 units as determined by totaling the number of units, shown on the individual labels on the packages.

Note 1: For purposes of these regulations 1 unit equals 1 milliroentgen per hour at 1 meter for hard gamma radiation or the amount of radiation which has the same effect on film as 1 mrhm of hard gamma rays of radium filtered by 1/2 inch of lead.

(3) No persons shall remain in a car containing radioative material unnecessarily and the shipper must furnish the carrier with such information and equipment as is necessary for the protection of the carrier's employes.

Subpart B - Loading and Storage Chart of Explosives and Other Dangerous Articles

Section 74.538 Loading and storage chart of explosives and other dangerous articles.

(a) Explosives or other dangerous articles must not be loaded, transported, or stored together, except as provided in the Loading and Storage Chart of Explosives and Other Dangerous Articles shown in this section.

The following is a list of articles which must not be stored along with materials classified as "Radioactive materials (Class D Poisons)":

(1) Low explosives or black powder
(2) High explosives or propellant explosives, class A/
(3) Initiating or priming explosives, wet: Diazodinitrophenol fulminate of mercury, guanyl nitrosamino, guanylidene hydrasine, lead azide, lead styphnate, nitro mannite, nitrosoguanidine, pentaerythrite tetranitrate, tetrazene.
(4) Blasting caps, with or without safety fuse (including electric blasting caps), detonating primers.
(5) Ammunition for cannon with explosive projectiles, gas projectiles, smoke projectiles, incendiary projectiles, illuminating projectiles or shell, ammunition for small arms with explosive projectiles, or rocket ammunition with explosive projectiles, gas projectiles, smoke projectiles, incindiary projectiles and illuminating projectiles and boosters (explosive), bursters (explosive) or supplementary charges (explosive), without detonators
(6) Explosive projectiles, bombs, torpedoes, or mines, rifle or hand granades (explosive), jet thrust (jato) explosive class A
(7) Detonating fuzes, class A, with or without radioactive components

Subpart C - Placards on Cars

Section 74.541 "Dangerous" placards; "Dangerous - Radioactive material" placards; or "Caution - Residual phosphorus" placards.

(b) "Dangerous-Radioactive Material" placards, as prescribed in section 74.553, must be applied to cars containing shipments of class D poisons as prescribed by sections 73.392 (c) and 73.393 and bearing labels as described in sections 73.414 (a), (b) and (c).

Section 74.546 Placards must be standard.

(a) Placards must conform to standards as prescribed. Samples will be furnished by the Bureau of Explosives on request

(b) Tag-board placards must be printed on strong tag-board of quality and strength not less than that designated commercially as 100 percent sulphate, weighing 125 pounds per ream, of sheets 24 x 36 inches, and having a resistance of not less than 60 pounds per square inch Mullen test.

(c) Paper placards must be printed on strong white paper.

(d) Placards or car cards which by their shape, coloring, or printing may be readily confused with the standard placards prescribed in this part must not be used.

(e) Carrier's or shipper's name and stationery form number may be printed on placards in type not larger than 10 point, but must be printed thereon separate from any placard wording.

Section 74.548 Placarded cars.

(a) Shippers must have applied placards to cars loaded by them when cars are acceptable for transportation. (See § 74.549 for method of application)

Section 74.549 Application of Placards

(a) Placards must be securely applied one to each end and each side of car as follows:

(1) By tacking tag-board placards to each end and each side of cars or to placard boards of suitable size provided for the purpose.

(3) Tacks when used must have heads at least 1/4 inch across At least 5 tacks must be used, one at each corner and one in the center of the placard, or when stapling devices are used the staples should be made of flat metal not less than 19 gauge, and the space between the legs of the staples should be at least 3/8 inch and length of staples not less than 1/4 inch. At least 9 staples must be used, one at each corner, one along edge between each corner, and one in center. Tacks, nails, staples, or other devices used in previous application of placards must be removed when their presence interferes with proper application of placards.

(4) By insertion of tag-board placards in suitable placard holders affixed to cars.

(5) Paper placards must be securely pasted to metal or other smooth surfaces. Metal placard boards must be used when provided for the purpose. Grease or other substances which interfere with secure application must be removed from surfaces before pasting on placards.

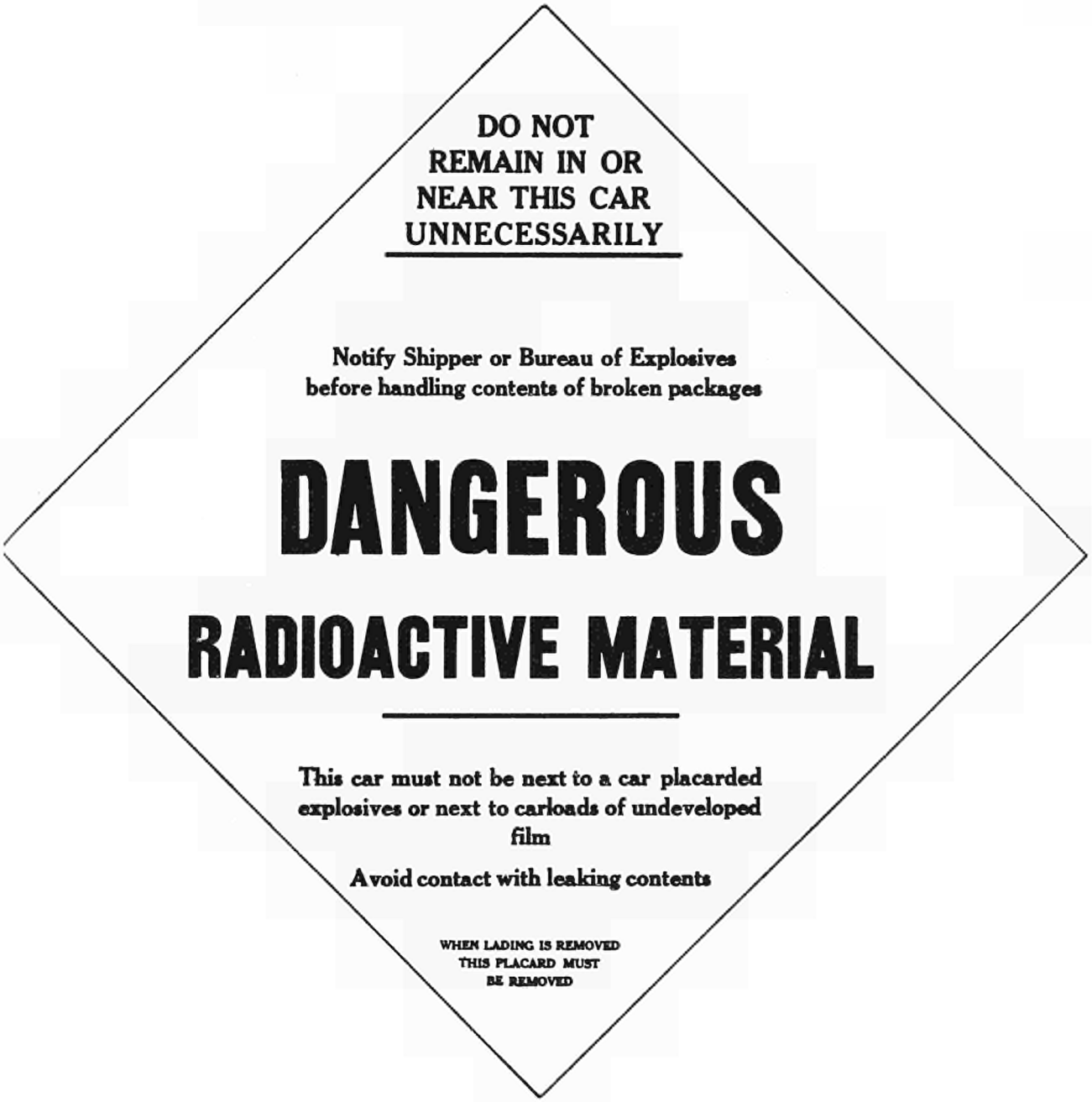
(b) Placards applied to cars must have the printing in horizontal position.

(e) Placard holders must be so constructed as not to obstruct the wording, change the shape of the placard, or reduce the exposed surface of the placard more than three-eighths of an inch on each side.

(f) Placards as required by sections 74.540, 74.541, and 74.542 must be securely applied to both sides and both ends of a container car on which a container or containers loaded with explosives, class A or B, or with dangerous articles requiring labels, are placed; or placards must be securely applied to both ends of such a car and to both sides of a container loaded with such articles.

Section: 74.553 Dangerous - Radioactive material placard.

(a) The "Dangerous-Radioactive material" placard for class D poisons must be of diamond shape, measuring 10-3/4 inches on each side, and must bear the wording in red letters as shown in the following cut:



Dangerous Placard For Radioactive Material

Section 74.554 Unauthorized use of placards

(a) Placards prescribed by this part must not be applied to cars containing articles not subject to Parts 71-78 or specifically exempted therefrom.

Section 74.562 Removal of placards and car certificate after unloading.

(a) When lading requiring placards or car certificates is removed from cars other than tank cars, placards and car certificates must be removed by the party unloading the car.

Section 74.566 Cleaning cars

(d) Any box car which, after use for the transportation of radioactive materials in carload lots, is contaminated with such materials to the extent that a survey of the interior surface shows that the beta-gamma radiation is greater than 10 milliroentgens physical equivalent in 24 hours or that the average alpha contamination is greater than 500 disintegrations per minute per 100 square centimeters shall be thoroughly cleaned in such a manner that a resurvey of the interior surface shows the contamination to be below these levels. A certificate to that effect must be furnished to the local agent of the carrier. Cars which are used solely for the transportation of radioactive materials are exempt from the provisions of this section.

ection 74.586 Handling explosives and other dangerous articles.

(h) A container of radioactive material bearing red label must not be placed in cars, depots or other places closer than 3 feet to an area which may be continuously occupied by passengers, employees, or shipments of animals. When more than one such container is present, the distance from occupied areas must be computed from the table in subparagraph (2) of this paragraph by adding the number of units shown on labels on the containers.

(2) A container of radioactive material, red label, must not be placed closer than 15 feet to any package containing undeveloped film. If more than one such container is present, the distance must be computed from the table in this subparagraph by adding the number of units shown on the labels on the packages.

TABLE

Total Number of Units	Minimum distances in feet to nearest undeveloped film.	Distance in feet to area that may be continuously occupied by passengers or employees	Distance in feet dividing partition of a combination car
1 to 10	15	3	3
11 to 20	20	4	4
21 to 30	25	5	5
31 to 40	30	6	6

Note 1: The distance in the table must be measured from the nearest point of the radioactive container or containers.

Note 2: 1 unit equals 1 milliroentgen per hour at 1 meter for hard gamma radiation or the amount of radiation which has the same effect on film as 1 mrhm. of hard gamma ryas of radium filtered by 1/2 inch of lead.

(3) Not more than 40 units of radioactive material (red label) shall be transported in any car or stored in any location at one time.

Section 74.589 Handling Cars

(n) Position in train of cars containing class D poisons. In a freight train or mixed train either standing or during transportation thereof, a car placarded "Dangerous - Radioactive material" must not be handled next to cars placarded "Explosives" or next to carload shipments of undeveloped film.

Section 74.597 Leaking packages of acid or poisons.

(e) Radioactive materials - Poison class D. In event of breakage of container, wreck, fire, or unusual delay involving cars placarded "Dangerous-Radioactive material" as prescribed in sec. 74.541 (b) the car and any loose radioactive material must be isolated as far as possible from danger of human contact and no persons must be allowed to remain close to the car or contents needlessly until qualified persons are available to supervise handling. The shipper and the Bureau of Explosives should be notified immediately. Details involving the handling of radioactive materials in the event of a wreck may be found in Bureau of Explosives' Pamphlet No. 22 covering "Recommended Practice for Handling Collisions and Derailments involving Explosives, Gasoline and Other Dangerous Articles."

PART 77

REGULATIONS APPLYING TO SHIPMENTS MADE BY WAY OF COMMON CONTRACT, OR PRIVATE CARRIERS BY PUBLIC HIGHWAY

Subpart A - General Information and Regulations

Section 77.815 Labels (See sec. 73.405 to section 73.414 for description of labels)

(a) Labels prescribed by the Commission's regulations, Part 73, must have been applied to shipments, unless exempt from Parts 71-78 and in addition the shipper must have certified to compliance with the regulations by writing, stamping, or printing his name underneath the certificate printed, thereon or on the shipping papers.

Section 77.819 Certificate

(a) Except as provided in this section, no motor carrier may accept for transportation or transport any class A or class B explosives, blasting caps or electric blastingcaps in any quantity, or any dangerous articles requiring labels as prescribed by Part 73, unless it be certified to him by the shipper's name inserted in the certificate on the label or by the following certificate over the written or stamped facsimile signature of the shipper or his duly authorized agent in the lower left-hand corner of the manifest, memorandum receipt, bill of lading, shipping order, shipping paper, or other memorandum; This is to certify that the above named articles are properly described, and are packed and marked and are in proper condition for transportation according to the regulations prescribed by the Interstate Commerce Commission.

(b) For the relief of shippers from multiplicity of certifications required for packages which may move by various means of transportation, shipments may be certified for rail, motor vehicle, water, or air transportation by adding to the certificate required on the shipping document "and the Commandant of the Coast Guard", or "and the Administrator of the Federal Aviation Agency," as the case may be.

ection 77.823 Marking on motor vehicles and trailers

(a) Every motor vehicle, other than tank motor vehicles, transporting any quantity of explosives, class A, poison gas, class A or radioactive material, poison class D requiring red radioactive materials label; . . . shall be marked or placarded on each side and rear with a placard or lettering in letters not less than 3 inches high on a contrasting background as follows:

(11) Dangerous, class D poison ...DANGEROUS-RADIO-ACTIVE MATERIAL

(f) Removal of signs or lettering. Every sign or lettering required by paragraph (a) of this section shall be removed from or covered on any motor vehicle to which it is attached or affixed when such motor vehicle is not transporting the article for which the sign is appropriate, except that no such sign or lettering is required to be removed or covered when such motor vehicle is used exclusively in the transportation of any article for which the sign or lettering is appropriate.

Subpart B - Loading and Unloading

ection 77.834 General Requirements

(a) Containers secured in vehicle. Any tank, barrel, drum or cylinder, not designed to be permanently attached to a motor vehicle containing any flammable liquid, compressed gas, corrosive liquid, or poisonous article, shall be reasonably secured against movement within the motor vehicle by which it is being transported.

(b) No explosives or other dangerous articles on pole trailers. No explosive or other dangerous article may be loaded into or on or transported in or on any pole trailer.

(e) Handbrake set while loading and unloading. No explosive or other dangerous article shall be loaded into or on, or unloaded from, any motor vehicle unless the handbrake be securely set and all other reasonable precautions be taken to prevent motion of the motor vehicle during such loading or unloading process.

Section 77.841 Poisons.

(d) Radioactive material.

A container of radioactive material, red lablel, must not be placed in vehicles, terminals, or other places closer than 3 feet to an area which may be continuously occupied by passengers, employees, or shipments of animals. When more than one such container is present, the distance from occupied areas must be computed from the table in subparagraph (1) of this paragraph by adding the number of units shown on labels on the containers.

(d) A container of radioactive material, red label, must not be placed closer than 15 feet to any package containing undeveloped film. If more than one such container is present the distance must be computed from the table in this subparagraph by adding the number of units shown on the labels on the packages.

TABLE

Total number of units	Minimum distance in feet to nearest underdeveloped film	Distance in feet to area that may be continuously occupied by passengers or employees for periods:	
		Up to 8 hours	Exceeding 8 hours
1 to 10 -----	15	3	5
11 to 20-----	20	4	7
21 to 30-----	25	5	9
31 to 40-----	30	6	10

Note 1: The distance in the table must be measured from the nearest point of the radioactive container or containers.

Note 2: 1 unit equals 1 milliroentgen per hour at 1 meter for hard gamma radiation or the amount of

radiation which has the same effect on film as 1 mrhm. of hard gamma rays of radium filtered by 1/2 inch of lead.

(2) Not more than 40 units of radioactive material, red label, shall be transported in any vehicle or stored in any location at one time. Packages must be so blocked or braced in vehicles as to prevent any shift of lading under conditions normally incident to transportation.

(4) Radioactive materials (class D poisons) must not be loaded in the same vehicle with Class A explosives.

(5) If for any reason, a package containing radioactive materials, red label, would otherwise remain in the same building for a period longer than 24 hours, it must be moved to a different location after each 24 hours.

Subpart C - Loading and Storage Chart of Explosives And Other Dangerous Articles

Section 77.848 Loading and storage chart of explosives and other dangerous articles. The restrictions found in this action on the loading and storage of explosives and other dangerous articles are identical with Section 74.538

Subpart D - Vehicles and Shipment in Transit; Accidents

Section 77.853 Transportation and delivery of shipments

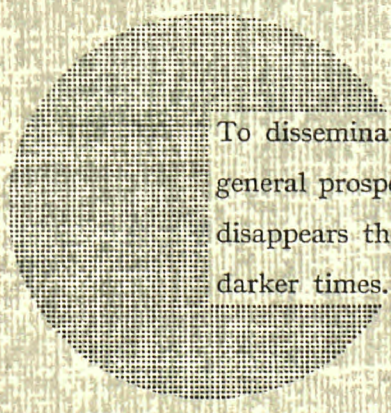
(a) No unnecessary delay in movement of shipments. All shipments of explosives or other dangerous articles shall be transported without unnecessary delay, from and including the time of commencement of the loading of the cargo until its final discharge at destination.

Section 77.860 Accidents; poisons

(a) Accident to vehicle; warnings; no sparks or flame. In the event of an accident involving any motor vehicle transporting any poison which is flammable, noxious, or toxic, every availabel means shall be employed in the protection of persons or property or in the removal of hazards or wreckage, from congregating in the vacinity; such means shall also be employed to prevent smoking, to keep flame away, to safeguard against the aggravation of the hazard present, and to warn other users of the highway. Care shall also be taken to prevent any poison, whether flammable or nonflammable, from contaminating streams or flowing or being spilled into sewers, and poison in powdered form from being scattered by wind. (See also sec. 77.814)

(c) Radioactive materials; poison D. In case of accident to vehicle resulting in breakage of, or unusual delay to any shipment of radioactive material the package or material should be segregated as far as possible from human contact. The shipper and the Bureau of Explosives should be immediately notified. In case of breakage of a package containing radicactive material and when it appears likely that the inside container may have been damaged, great care must be exercised to prevent contact with or inhalation of radioactive material by any person.

(d) Cleaning vehicles. Any motor vehicle which, after use for the transportation of radioactive materials in truckload lots, is contaminated with such materials to the extent that a survey of the interior surface shows that the beta-gamma radiation is greater than 10 milliroentgens physical equivalent in 24 hours or that the average alpha contamination is greater than 500 disintegrations per minute per 100 square centimeters shall be thoroughly cleaned in such a manner that a resurvey of the interior surface shows the contamination to be below these levels. A certificate to that effect must be furnished the carrier or to the driver of the motor vehicle. Motor vehicles which are used solely for the transportation of radioactive materials are exempt from the provisions of this section.



To disseminate knowledge is to disseminate prosperity — I mean general prosperity and not individual riches — and with prosperity disappears the greater part of the evil which is our heritage from darker times.

Alfred Nobel

SALES OFFICES

All Euratom reports are on sale at the offices listed below, at the prices given on the back of the front cover (when ordering, specify clearly the EUR number and the title of the report, wich are shown on the front cover).

PRESSES ACADEMIQUES EUROPEENNES
98, Chaussée de Charleroi, Bruxelles 6

Banque de la Société Générale - Bruxelles
compte N° 964.558,

Banque Belgo Congolaise - Bruxelles
compte N° 2444.141,

Compte chèque postal - Bruxelles - N° 167.37,

Belgian American Bank and Trust Company - New York
compte No. 22.186,

Lloyds Bank (Europe) Ltd. - 10 Moorgate, London E.C.2,

Postcheckkonto - Köln - Nr. 160.861.

OFFICE CENTRAL DE VENTE DES PUBLICATIONS DES COMMUNAUTES EUROPEENNES
2, place de Metz, Luxembourg (Compte chéque postal N° 191-90)

BELGIQUE — BELGIË
MONITEUR BELGE
40-42, rue de Louvain - Bruxelles
BELGISCH STAATSBLAD
Leuvenseweg 40-42 - Brussel

DEUTSCHLAND
BUNDESANZEIGER
Postfach - Köln 1

FRANCE
SERVICE DE VENTE EN FRANCE
DES PUBLICATIONS DES
COMMUNAUTES EUROPEENNES
26, rue Desaix - Paris 15e

GRAND-DUCHE DE LUXEMBOURG
OFFICE CENTRAL DE VENTE
DES PUBLICATIONS DES
COMMUNAUTES EUROPEENNES
9, rue Goethe - Luxembourg

ITALIA
LIBRERIA DELLO STATO
Piazza G. Verdi, 10 - Roma

NEDERLAND
STAATSDRUKKERIJ
Christoffel Plantijnstraat - Den Haag

EURATOM — C.I.D.
51-53, rue Belliard
Bruxelles (Belgique)