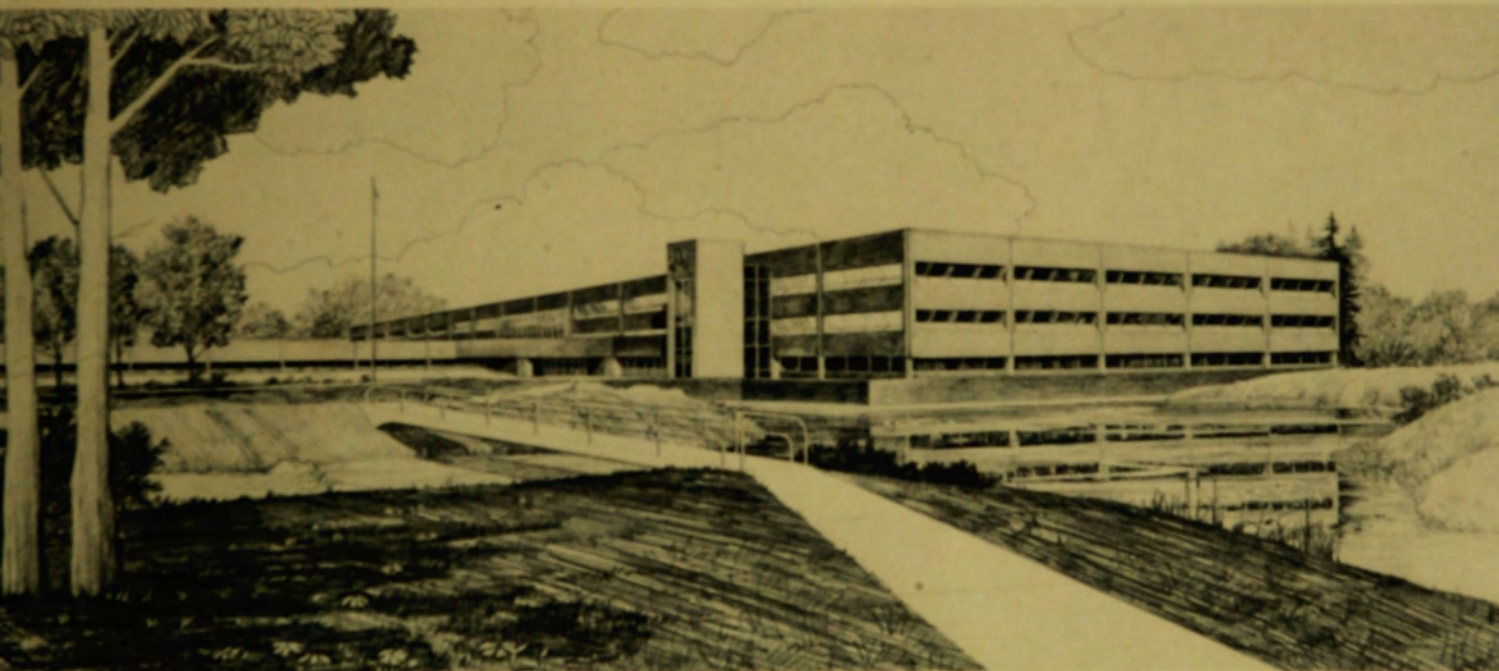


REQUIREMENTS FOR TRANSPORTING THE TMI-2 CORE

David E. Wilkins

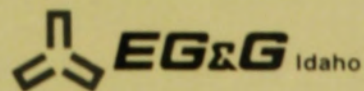
Idaho National Engineering Laboratory

Operated by the U.S. Department of Energy



This is an informal report intended for use as a preliminary or working document

Prepared for the
U.S. DEPARTMENT OF ENERGY
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-76ID01570



REQUIREMENTS FOR TRANSPORTING THE TMI-2 CORE

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ABSTRACT

This report summarizes the requirements associated with the actual transport of core debris from the damaged Three Mile Island Unit 2 reactor to the Idaho National Engineering Laboratory. The requirements are discussed under six headings: accountability, security, quality, safety, environment, and transportation.

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REQUIREMENTS FOR TRANSPORTING THE TMI-2 CORE

INTRODUCTION

Core debris from the damaged TMI-2 reactor will be transported to the Test Area North (TAN) Hot Shop at the Idaho National Engineering Laboratory (INEL) for interim storage, examination, and preparation for final disposal. Under the TMI-2 Core Examination Program, the debris will be analyzed to understand the reactor accident sequence and to aid in prediction and control of nuclear fuel behavior during degraded core cooling situations. Interim storage at TAN will support the examination program and the preparation for final disposal of the core debris at a government repository.

The core debris will be contained in a canister transported to INEL in a fuel shipping cask. Although several casks are under evaluation, the likely choice will be a legal-weight truck cask such as the NLI 1/2.

A study was performed to identify requirements applicable to shipping the core debris from TMI-2 to INEL. The areas evaluated are as follows:

Accountability--Safeguard requirements for accountability of fissile material during shipment

Security--Security requirements associated with shipping the core

Quality--Quality assurance and inspection requirements

Safety--Regulations governing safety, including supporting documentation, and studies required for shipping the core

Environmental--Regulations governing the environmental evaluation requirements for shipping the core

Transportation--Requirements necessary to make a cask procurement commitment necessary for shipping the core.

This report is a product of that study, and it summarizes the requirements in each area for shipment of the core debris, and lists required studies and documentation. The two subsequent major sections of this report present (a) a summary of requirements, and (b) a list of supporting studies and documentation that must be completed prior to shipment.

REQUIREMENTS

Requirements for shipment of the TMI-2 core debris have been determined from appropriate documentation listed in the References section of this report. The transport requirements summarized herein are extracted from them; consequently, the reader need not obtain the documentation. It is assumed throughout the study that EG&G Idaho, Inc., functioning as the operating subcontractor for the U.S. Department of Energy, will accept title to the nuclear fuel outside the main gate of TMI and become the shipper of record at TMI for transport of the fuel from TMI to INEL.

Accountability

The EG&G Idaho, Inc. Safeguards and Security Branch requires the following information to meet shipping accountability or safeguard requirements (see Reference 1) and should be on or attached to the DOE/NRC-741 document:

1. Gross weight of each container
2. Net weight of material contained in each container
3. Description of contents of each container (e.g., whole fuel rods, damaged fuel rods, structural material, slag, residue, etc.)
4. Estimated total quantity (expressed in grams) of uranium and plutonium per container
5. Estimated quantities (expressed in grams) of ^{235}U and $^{239,241}\text{Pu}$ per container
6. Percent enrichment of ^{235}U and ^{240}Pu after burnup
7. Individual identification number for each container
8. DOE/NRC-741 Transfer Document for each shipment.

Items 4 and 5 should be best engineering estimates based on the description of the contents of each canister. For example, a canister that contains part broken fuel elements, part structural material, and part loose debris would be estimated, as follows:

- o Fuel elements--uranium and plutonium content based on original fuel loading and modified for burnup
- o Structural Material--10% of canister contents
- o Loose Debris--uranium and plutonium content based on analysis of samples and engineering judgments.

Security

Physical protection of the TMI-2 core debris shall comply with DOE Order 5632.2 (see Reference 2). The Idaho Safeguards and Security Branch of EG&G Idaho, Inc. requires the following:

1. Each shipment shall be accompanied by a driver and escort in the transport vehicle (the escort may be a second driver) or a driver in the transport vehicle and a separate vehicle occupied by two escorts. A driver or escort will remain with the shipment at all times, for example, rest stop, telephone check.
2. The shipment shall be equipped with a communications device that will permit contact with a central communications center, a state or local law enforcement agency, or other reliable contacts to permit timely response to a security incident involving the shipment. If an escort vehicle is used, it shall be equipped similarly with a reliable communications device.
3. Carrier personnel shall initiate communication approximately every two hours--no longer than four hours unless unfavorable communication conditions exist--with a central control station that can direct any required emergency response.
4. A communications center or response force shall have enhanced ability to locate the position of the transport vehicle if an incident occurs.
5. To effect unimpeded travel, periodic contact will be coordinated through the office of the Director, Transportation Operations Staff, NE, with appropriate state law enforcement officials [or, where jurisdiction requires, appropriate local law enforcement agencies (LLEAs)] through whose jurisdiction irradiated spent fuel is routed. Information will be provided about (a) the nature of irradiated spent fuel shipments, and (b) appropriate emergency procedures.

The responsible shipping and receiving operations office within each region shall maintain a list of emergency coordinators, telephone numbers, and both organizational and individual contact

points, including, where appropriate, those of selected LLEAs. This list will be coordinated and made available by the Director, Transportation Operations Staff, NE, to each field organization. These emergency numbers and contact points shall be reconfirmed every six months through the Director, Transportation Operations Staff, NE.

6. All routes should be by interstate or limited access, divided, state highways to the maximum practicable extent. Urban routing should avoid high-density areas where feasible. Circumferential, interstate-quality highways should be used to avoid travel through the most highly populated portion of urban areas.
7. The carrier will keep appropriate Department of Transportation officials informed of intended routes and pertinent routing information that could impact security or safety.
8. Before the shipment is tendered to the carrier, the shipper shall check both the package and the transport vehicle to ensure that no conditions exist that could compromise the security of the equipment.
9. The shipping container will be checked to determine whether all labels were properly affixed by General Public Utilities Nuclear Corporation (GPUNC) and verify whether all tie downs are properly secured to prevent shifting enroute.
10. All documentation will be checked to verify that it is complete in every detail: 1) bill of lading, 2) radioactive shipping record (RSR) (similar to DOE form 5480.1A), and 3) vehicle inspection list. (All of these documents are to be properly completed and signed off by the responsible parties.)
11. Notifications are made to the consignee and the Warning Communications Center.

Quality

There are no specific additional quality assurance requirements for shipment of the TMI-2 core to the INEL (see Reference 3); however, the Quality Division of EG&G Idaho, Inc. would continue to perform its normal reviews, which would include the following:

1. Review of Bechtel/GPUNC activities requested by the Program
2. Review of shipping cask certifications for licensing by the Nuclear Regulatory Commission (NRC)
3. Review of EG&G Idaho, Inc. procurement activities associated with lease or procurement of the shipping cask.

Quality activities of EG&G Idaho, Inc. at TMI are covered by the TMI/TIO Quality Program Plan. Receipt activities at INEL are covered by TAN Hot Cell Quality Plan 012.1C. These Quality Program Plans invoke the

EG&G Idaho, Inc. Quality Manual, which satisfies the applicable requirements of ANSI/ASME NQA-A1 and 10 CFR 71, Appendix E, Quality Assurance Criteria for Shipping Packages for Radioactive Material.

Safety

Transportation of radioactive material within the United States is regulated by the NRC and the Department of Transportation (DOT). The Technical Safety Support Branch, Health and Safety Division, of EG&G Idaho, Inc. has excerpted the following section of 10 CFR 71 as applicable to the proposed shipment of the TMI-2 core debris. In keeping with the definitions used in 10 CFR 71, the term package means packaging and its radioactive contents (i.e., canister and shipping cask).

71.31 General Standards

- a) The shipping canister shall be constructed from materials which will not react chemically or galvanically with the contents or with other components
- b) The canister shall be equipped with a positive closure which will prevent inadvertent opening
- c) Lifting devices
 - 1) Any lifting device on the package shall be capable of supporting three times the weight of the package
 - 2) Any lifting device on the lid shall be capable of supporting three times the weight of the lid alone
 - 3) Any other projections or devices which are not capable of supporting three times the weight of the canister and contents must be covered during transport to prevent their possible use as a lifting device
- d) Tie-down devices
 - 1) Any tie-down device must be capable of supporting twice the weight of the package and contents as a vertical component, ten times the weight of the package as a horizontal component in the direction of travel, and five times the weight of the package as a horizontal component transverse to the direction of travel
 - 2) Any structural part of the package which does not meet the above criteria and which might be used as a tie-down must be covered securely during transport to prevent its use as a tie-down
 - 3) All tie-down devices must be designed such that individual or corporate failure will not impair the structural integrity of the package.

71.32 Structural standards for large quantity packaging

- a) Regarded as a simple beam supported at the ends only, the package must be capable of supporting a load equal to five times the fully loaded weight of the package if the load is distributed uniformly along the length of the package.
- b) The package must be capable of supporting an external gauge pressure of 25 pounds per square inch without failure or loss of contents.

71.33 Criticality Standards

- a) The contents must remain subcritical if it is assumed that water leaks into the canister, water moderation of the contents occurs to the most reactive credible extent consistent with the chemical and physical form of the contents, and the canister is fully reflected on all sides by the most reactive credible reflector (water, lead in cask wall, etc.)
- b) The contents must remain subcritical if it is assumed any liquid in the canister leaks out and the fissile material in the canister is in the most reactive credible configuration consistent with its chemical and physical form and is moderated by water outside of the canister to the most reactive credible extent and is fully reflected on all sides by the most reactive credible reflector (water, lead in cask wall, etc.)

71.35 Standards for Normal Conditions of Transport

The normal conditions of transport are listed in Appendix A of 10 CFR 71. The canister shall be designed and constructed such that under the normal conditions of transport, the following criteria will be met:

- a) No release of radioactive material
- b) The effectiveness of the package will not be reduced
- c) The geometric volume and spacing of the package and its contents will not be reduced by more than 5% below the values on which criticality safety was assessed
- d) No occurrence of holes or apertures which will permit the entry of a 4-in. cube
- e) No leakage of water into the radioactive containment volume
- f) No mixture of gases or vapors must accumulate inside the package which, through any credible increase in pressure or an explosion, could significantly reduce the effectiveness of the package.

71.36 Standards for Hypothetical Accidents

The standards for hypothetical accidents are listed in Appendix B of 10 CFR 71 and are much more severe than the normal transport standards. They include a free drop of the loaded package from a height of 30 feet to an unyielding surface, puncture resistance evidenced by a free drop of 40 inches on a 6-inch-diameter cylinder, thermal resistance equivalent to exposure to a radiant source at 1475°F for 30 minutes, and resistance to water immersion for 8 hours. Under these hypothetical accident conditions, the package must meet the following requirements:

- a) No loss of radioactive materials exceeding 0.1% of the contents and not more than 0.01 curies of Group I radionuclides, 0.5 curies of Group II radionuclides, or 10 curies of Groups III and IV radionuclides.
- b) The contents will remain in a subcritical configuration in the most reactive possible condition consistent with the damaged form of the package, and with the maximum possible water moderation and reflection by homogeneous materials.
- c) No reduction in shielding which would result in an external radiation exposure greater than 1 rem/hr at a distance of 3 feet from the surface of the package.

71.40 Specific Standards for a Fissile Class III Shipment

Fissile Class III shipments are defined as those which are controlled during transportation by special arrangements between the shipper and carrier for criticality safety. The number of canisters and contents must be limited such that:

- a) The undamaged canister and contents must remain subcritical with an identical shipment in contact with it.
- b) When subjected to damage by the hypothetical accident standards any combination of canisters in the most reactive configuration would remain subcritical

71.42 Special Requirement for Plutonium Shipments

Solid plutonium in the form of reactor fuel elements or metal alloys are normally exempted from the special requirements of paragraph 71.42, and the NRC can provide special exemptions for other plutonium bearing materials. Otherwise all shipments containing in excess of 20 curies of plutonium require separate inner and outer packaging with no release of plutonium from the inner container when the entire package is subjected to the hypothetical accident conditions of 10 CFR 71, Appendix B.

The TMI-2 core contains about 10^5 curies of plutonium and it can be assumed that any shipment will contain more than 20 curies.

Other shipping requirements possibly applicable to the TMI-2 core debris are found in 49 CFR 173.

Section 173.214 describes the packaging specifications required for shipping zirconium metal that is in the form of finely divided particles. In general this section would be considered only if pyrophoric zirconium is present in the debris. If the zirconium has oxidized or still in the form

of zircaloy, Section 173.214 does not apply. A study of sample core material will be performed by EG&G Idaho, Inc. to determine whether there are potential pyrophoric material hazards.

In addition to the regulations stated in the Code of Federal Regulations, there are shipping requirements in DOE Order 5480.1A, Chapter III; ID Order 5480.1, Chapter III; and in the EG&G Idaho, Inc. Safety Manual. The shipments of TMI-2 core materials will have to meet the NRC (10 CFR 71) and DOT (49 CFR 173) requirements. Compliance with these regulations will ensure that the standards of DOE Order 5480.1, Chapter III, are met and that no specific DOE certificates of compliance will be required. The DOE packaging requirements are the same as those found in 10 CFR and 49 CFR. ID Order 5480.1, Chapter III, requires EG&G Idaho, Inc. to do the following:

- o Implement internal procedures to ensure that all off-site shipments of fissile and other radioactive materials are made in accordance with this order, 49 CFR 100-199, IAEA Shipping Regulations, and other regulations, as appropriate.
- o Implement internal procedures to ensure that all on-site shipments of fissile and radioactive materials are made in accordance with this order.
- o Issue management directives assigning responsibilities for fissile and other radioactive shipments program.
- o Maintain a thorough and comprehensive internal audit program to ensure compliance with applicable shipping regulations.

- o Submit requests for approval of on-site containers (with three copies of supporting technical data) to programmatic directors.
- o Provide training that will certify all personnel engaged in shipment activities to be in compliance with off-site or on-site shipping regulations, as appropriate. Provide recertification training annually.
- o Submit requests for alternatives, waivers, and exemptions to DOE, DOT, or IAEA shipping regulations to the ID Manager on a case-by-case basis. Requests should be presented on a timely basis accompanied by adequate data supporting and justifying the alternative.
- o Prepare a safety analysis report for packaging (SARP) for packages of fissile and radioactive materials. Requests for approval shall be submitted to the ID Manager. The SARP is prepared by the vendor for the shipping cask.
- o Maintain a Quality Assurance program for new containers and an auditable inspection and maintenance program for all reusable off-site and on-site shipping containers.
- o Ensure that off-site and on-site shipping containers owned or approved by other organizations have had current maintenance and inspection, are appropriate for the intended use, have current authorization for use, and approval documents have been reviewed by users prior to loading the container.
- o Submit requests for alternatives or exceptions to on-site shipping regulations by ID contractors to the appropriate ID programmatic manager. Requests should be accompanied by data justifying the alternative.

DOE Order 5481.1 Chapter II (9)(d) requires a Safety Analysis for Transport of nuclear material. The Safety Analysis should include the following:

- o A summary description of the shipping cask and canister.
- o A summary description of the contents to include maximum radiological activity, water, and decay heat.
- o Requirements for preparing a safe shipment and descriptions of any special procedures if required, such as inerting the canister.
- o Description of the transportation route(s).

- o Documentation required for transport. This would include Form ID-F-5480.1A, rev. 11/82 (INEL Off-Site Radioactive Material Shipment Record) and DOE/NRC Form 741 with the following supporting documentation: radioactive material shipment and receipt record, radioactive material shipment checklist, radioactive waste shipment and disposal form, isotopic percent worksheet, preload and postload vehicle survey records, combustible gas worksheet, vehicle inspection checklist, and a straight bill of lading short form (Form EG&G-397).
- o Criteria required for a safe shipment. An example would be an acceptable combustible gas generation rate during shipment.
- o Accident analysis for the maximum credible accident during transport.

Environment

The Earth and Life Sciences Branch of EG&G Idaho, Inc. administers environmental matters, and reports that the Environmental Impact Statement for the TMI-2 Accident, NUREG-0683, is adequate to cover environmental concerns regarding shipping the TMI-2 core to the INEL, and a separate environmental document for transport is not required by NEPA or DOE-ID (see Reference 4). However, because of the sensitivity of the TMI issue, an environmental synopsis for transporting the core from TMI to INEL will be included in the safety analysis report.

Transportation

Department of Transportation requirements are covered in the Safety Requirements section of this report.

The Traffic and Receiving Branch of EG&G Idaho, Inc. administers transportation matters, and requires the following:

- o If the shipment is overweight, it will be the carrier's responsibility to obtain overweight permits through all states traveled.
- o The drivers will have in their possession a complete current card signed by a certified instructor, verifying that they are qualified to transport radioactive materials in accordance with 49 CFR 177.825.

- a. The drivers must have received, within the preceding two years, written training on
 - 1. Requirements in parts 172, 173, and 177 of this subchapter pertaining to the radioactive materials transported
 - 2. The properties and hazards of the radioactive materials being transported
 - 3. Procedures to be followed in case of an accident or other emergency.
- b. The drivers will have in their immediate possession a certificate of training as evidence of training required and a copy placed in his qualification file that shows
 - 1. The driver's name and operator's license number
 - 2. The dates training was provided
 - 3. The name and address of the person providing the training
 - 4. The driver has been trained in the hazards and characteristics of large quantities of radioactive materials
 - 5. A statement by the person providing the training that information on the certificate is accurate.
- c. The drivers have in their possession the route plan required by paragraph (6) of this section and operate the vehicle in accordance with the route plan. Any variation to the route plan must be reported as soon as possible to WCC.
- o The drivers will receive an emergency plan and instructions pertaining to any accident or incident with instructions to notify WCC, 208-526-1515 immediately.

REQUIRED STUDY, DOCUMENTS, AND REVIEWS

Study

The following study is required to support the safety analysis report for transport.

Pyrophoric Material Study

Pyrophoricity tests will be performed by EG&G Idaho, Inc. on selected samples from the TMI-2 grab sample collection. Sixteen samples from the four bulk samples being received at the INEL will be subjected to differential thermal analysis. The procedures used for testing will be selected so that the data obtained can be correlated with both the testing performed at Pacific Northwest Laboratories on debris removed from the H-8 leadscrew and the work performed at TMI.

Documents and Reviews

The documents and reviews required before shipment of the TMI-2 core are presented in the documentation responsibilities flowsheet (Figure 1) and are summarized below.

Safety Analysis for Transport

The Technical Support Branch of EG&G Idaho, Inc. will prepare the Safety Analysis Report outlined in the Safety Section.

Combustible Gas Generation Study

Radiolysis of water produces combustible gases which, if recombining, may produce canister damage from over pressure. A study to determine the extent of this problem will be performed by Rockwell Hanford (Washington) and will be verified by the Technical Safety Support Branch of EG&G Idaho, Inc..

Criticality Review

The Technical Safety Support Branch of EG&G Idaho, Inc. must review and approve the criticality analysis performed by the canister designer (see EG&G Idaho, Inc. Safety Manual, SM-9010 Rev. 3, Administrative Requirements for Fissile Material, 2-12-83).

Material Accountability

A calculational method to estimate the quantities of fissile material in each canister must be established and approved. This information is reported using form DOE/NRC-741.

Emergency Procedures

The Traffic Branch of EG&G Idaho, Inc. will write the emergency procedures required by DOE Order 5632.2.

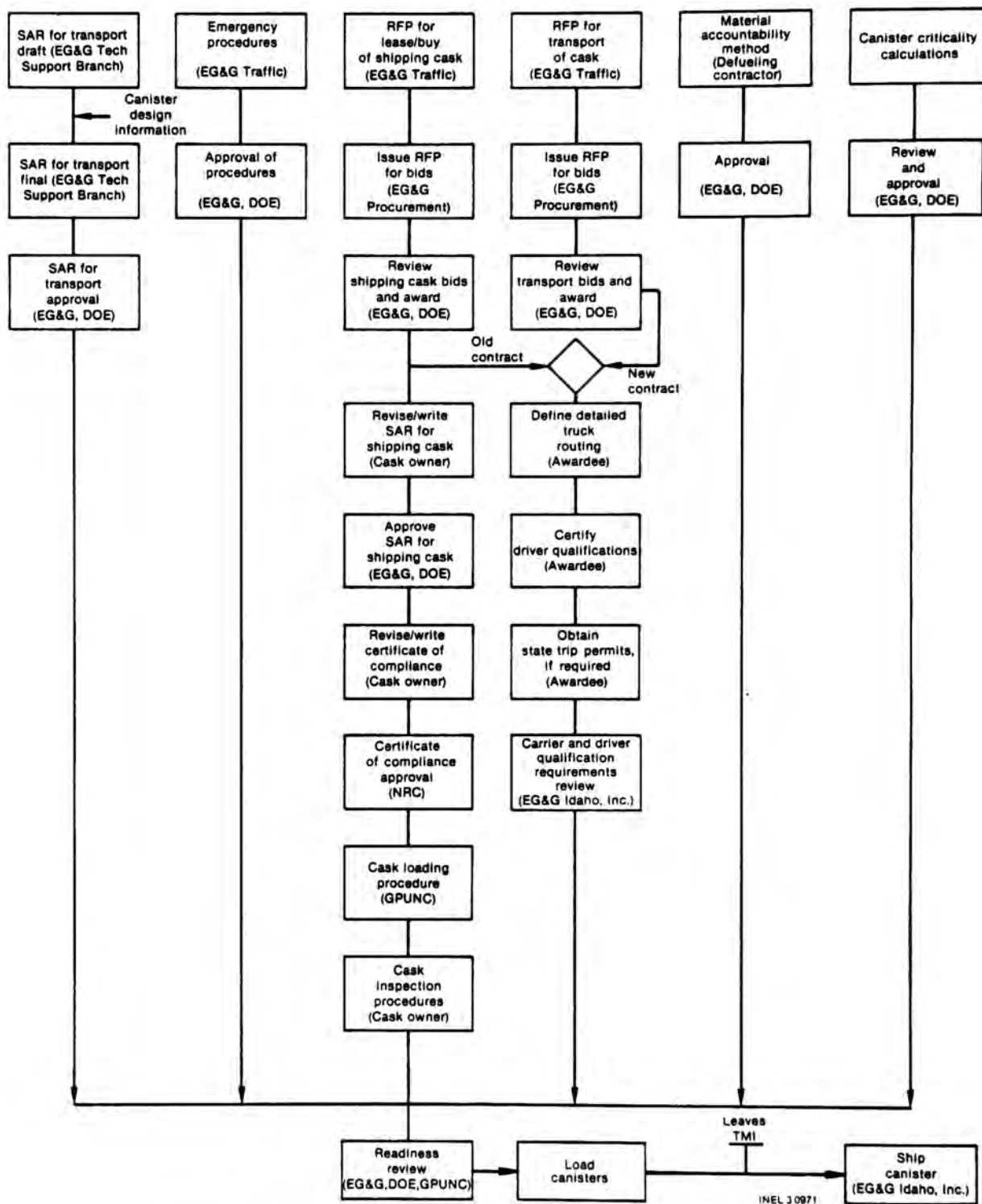


Figure 1. Documentation-responsibility flowsheet.

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2. A. A. Anselmo letter to K. C. Sumpter, AAA-214-82, Requirements for Physical Protection of Irradiated Reactor Fuel in Transit, July 12, 1982.
3. D. D. Patterson letter to D. E. Wilkins, DDP-2-83, Quality Requirements for Shipping TMI Fuel, March 21, 1983.
4. M. K. Martz letter to D. E. Wilkins, MKM-3-83, Environmental Requirements for Transport of the TMI-2 Spent Fuel and Core, April 14, 1983.

