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MANAGEMENT PLAN FOR THE PROCUREMENT OF SHIPPING CASKS REQUIRED TO SERVICE PROPOSED FEDERAL WASTE REPOSITORIES

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ABSTRACT

Development of transportation systems to move radioactive waste and unreprocessed spent fuel to proposed federal waste repositories is an integral part of the National Waste Terminal Storage Program. To meet this requirement, shipping casks must be designed, licensed, and fabricated. To assist the manager charged with this responsibility, a Cask Procurement Plan has been formulated. This plan is presented as a logic diagram that is suitable for computer analysis. In addition to the diagram, narrative material that describes various activities in the plan is also included.

A preliminary computer analysis of the logic diagram indicates that, depending on the result of several decisions which must be made during the course of the work, the latest start dates which will allow prototype delivery of all types of casks by December 1985, range from November 1977 to March 1982.

ACKNOWLEDGMENTS

The assistance offered by M. J. Becktell and B. J. Mathis during the preparation of the logic diagram has been invaluable.

FOREWORD

In February 1976, the US Energy Research and Development Administration (now US Department of Energy - DOE) announced an expanded waste management program for defense and commercial radioactive waste. The commercial radioactive waste disposal program, which was designated the National Waste Terminal Storage (NWTS) Program, represented the principal programmatic effort of DOE for ultimate and final disposal of commercial radioactive waste. Management and technical direction for the NWTS Program was assigned to the Office of Waste Isolation (OWI), Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennessee. This report describes work performed at Sandia Laboratories under Contract No. E(29-1)-789 for the Office of Waste Isolation.

TABLE OF CONTENTS

List of Tables

List of Figures

I. INTRODUCTION

It is necessary that an adequate transportation system be developed to move the spent fuel and radioactive waste generated by the nuclear power industry. For this reason, the Department of Energy (DOE), through the Office of Waste Isolation (OWI), has sponsored several studies to determine what activities and time schedules are necessary to ensure that waste-transportation systems will be available when needed to service federal waste repositories.

At the present time, it is uncertain when a final decision will be made concerning a disposal method for radioactive waste from the commercial light water reactor (LWR) nuclear power industry of the United States. In this report it is assumed that an acceptable technology for the geologic disposal of such waste will be developed. Recycling of reactor spent fuel--the chemical recovery of uranium and plutonium from the discharged fuel elements prior to the waste disposal--is considered to be a possible eventuality. However, the so-called "throw-away" fuel cycle, with or without a design contingency for future recovery and recycle, will probably establish the initial time constraints for cask procurement activities.

A plan has been developed that is suitable for use by a program manager who is charged with the responsibility of insuring that an appropriate number of casks be available when needed. This plan considers all relevant activities starting from a determination of the optimum inventory of cask types and ending with provisions for ultimate disposal of casks which are no longer serviceable. Waste forms which are considered in this plan are defined in the Glossary, Appendix A.

The procurement plan is presented as a logic diagram (PERT chart[1]) with supporting narrative material to clarify the nature, intent, and relevance of the identified activities. This type of management tool has been found to be invaluable for the successful management of complex engineering projects. For this reason, a considerable body of computer software has been developed that accepts information in logic-diagram form and provides management-oriented project-status information during the course of the project.

The plan is based on the requirement that shipment of spent fuel from its present storage locations to a geologic storage site will commence in late 1985. Current DOE policy for placing unreprocessed spent fuel in geologic repositories will establish critical path time constraints for this program plan. Time constraints for shipping high-level waste (HLW) from a recycle plant to repositories are also considered. Although this 1985 date may slip, for the purpose of initial computer analysis of the program plan a program start date of April 1978 and an initial delivery date for prototype casks of December 1985 was assumed. A reevaluation of the plan with any other start and finish dates is possible.

Not all issues involved in transportation of radioactive waste have been resolved. Therefore, the plan presently includes a decision point and related contingencies in several tasks.

Information on which decisions are made will be based on results of plan activities and national policy decisions.

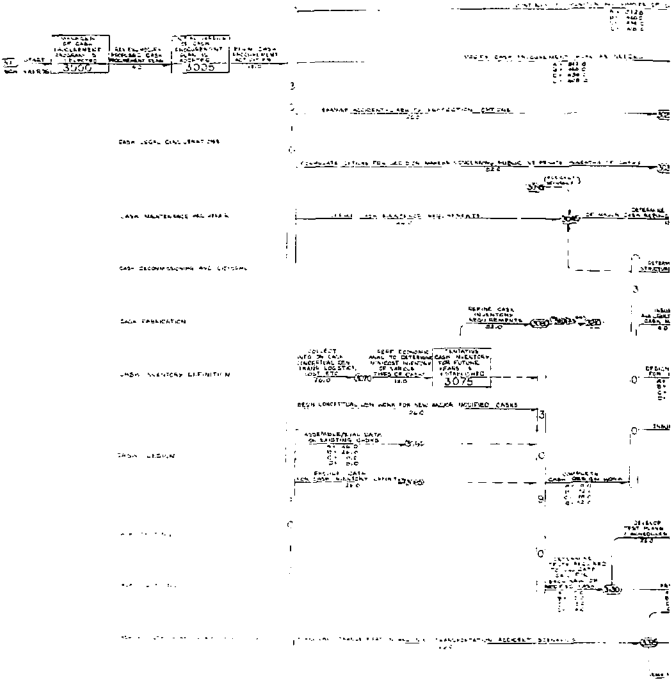
Following the logic diagram and the narrative material, several points concerning time scheduling that result from the initial analysis of the diagram are discussed. This information shows the importance of an early start on the procurement activities if the desired operational date is to be met.

II. THE PROCUREMENT PLAN

The Cask Procurement Plan is shown in Figure 1. This plan is presented as a logic diagram which can be analyzed by available computer software. Several options presented in the plan are defined in Table I. Since this diagram is a proposed plan, it has been subjected to a minimal computer analysis. An example of the type of information that can be generated is shown in Appendix B.

An important result that can be determined from the logic diagram is the duration of the critical path. This is the expected time that will be required to complete the program. Depending upon eventual decisions to use existing casks or design new casks, different times for some activities of the program plan will be required. These options produce different lengths for the critical path with the result that the latest start dates for the present plan range from November 1977, to March 1982.

Although it is useful to have the complete overview of the plan which Figure 1 provides, the plan is easier to comprehend if it is divided into program activities. Therefore, in the following sections the activities that constitute the ten major tasks in the plan are described.


START
3000
REVIEW/REVISE PROPOSED CASK PROCUREMENT PLAN
3005
PLAN CASK PROCUREMENT ACTIVITIES
REVIEW CASK PROCUREMENT PLAN AS NEEDED
CASK LEGAL CONCURRENCES
CASK MAINTENANCE AND REPAIR
DETERMINE
CASK DECOMMISSIONING AND DISPOSAL
CASK FABRICATION
REFINE CASK INVENTORY REQUIREMENTS
3080
CASK INVENTORY DEFINITION
COLLECT INFO ON CASK CONCEPTUAL DSN TRANS LOGISTICS, COST, ETC
3070
PERF ECONOMIC ANAL TO DETERMINE MIN COST INVENTORY OF VARIOUS TYPES OF CASKS
TENTATIVE CASK INVENTORY FOR FUTURE YEARS ESTABLISHED
3075
DESIGN FOR
BEGIN CONCEPTUAL DSN WORK FOR NEW AND/OR MODIFIED CASKS
CASK DESIGN
ASSEMBLE/EVAL DATA ON EXISTING CASKS
PROVIDE DATA FOR CASK INVENTORY DEFINITION
COMPLETE CASK DESIGN WORK
DEVELOP TEST PLANS / PROCEDURES
3130

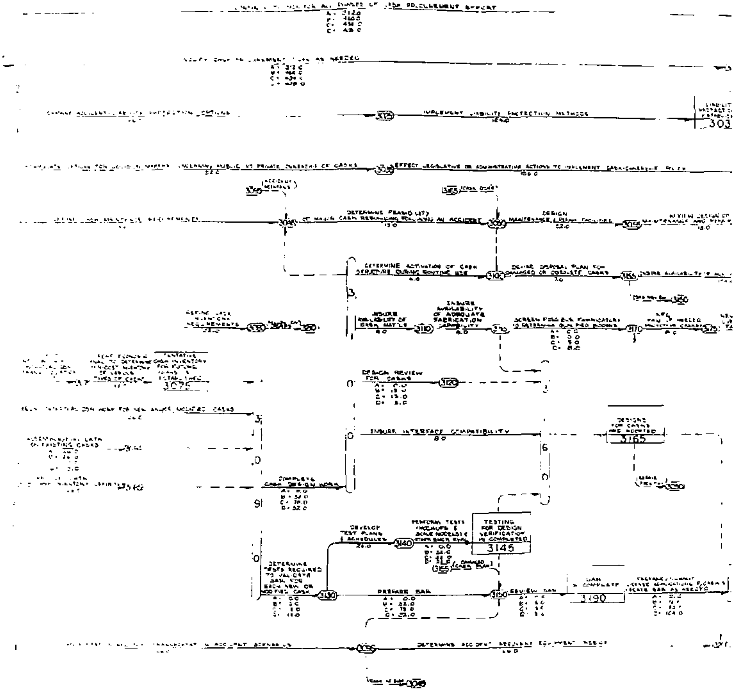


Figure 1. Cask Procurement

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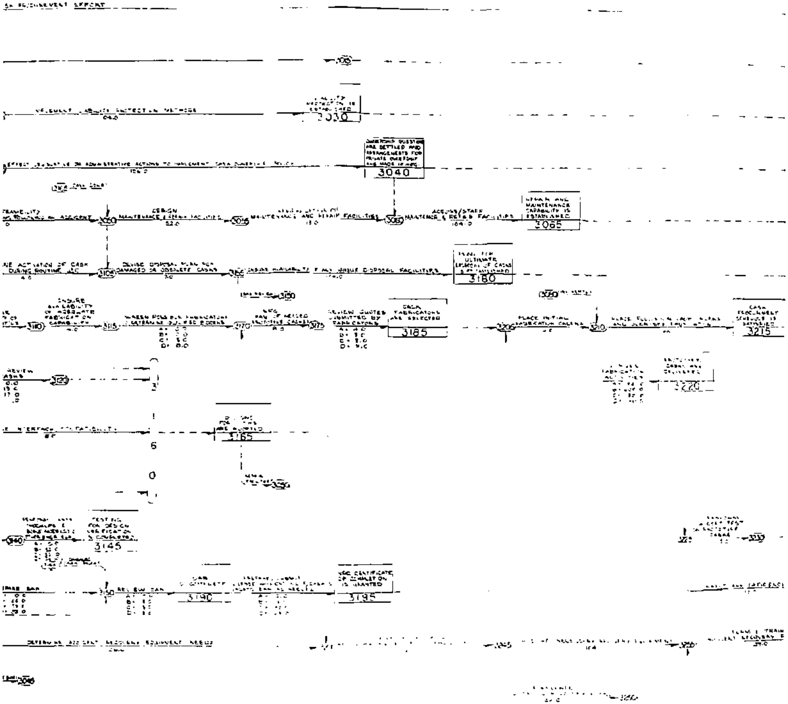
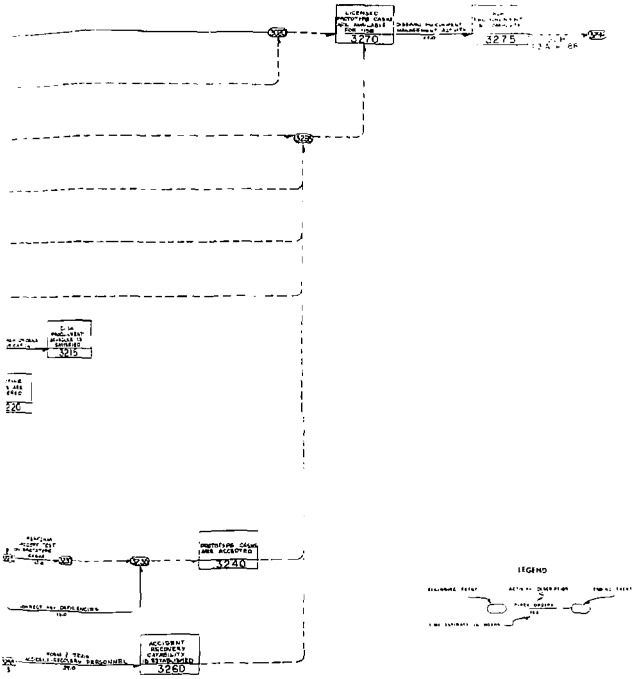


Figure 1. Cask Procurement Plan



NOTE:
PROCUREMENT PLAN OPTIONS
A. USE EXISTING LWR SPENT FUEL SHIPPING CASK
B. MODIFY EXISTING LWR SPENT FUEL SHIPPING CASK
C. DESIGN NEW SHIPPING CASK FOR LWR SPENT FUEL CR
D. DESIGN NEW SHIPPING CASK FOR CW

4

Table I

PROCUREMENT PLAN OPTIONS

a: Use existing LWR spent fuel shipping cask

b: Modify existing LWR spent fuel shipping cask

c: Design new shipping casks for LWR spent fuel or high-level waste (HLW)

d: Design new shipping cask for clad waste (CW)

III. CASK PROCUREMENT MANAGEMENT TASK

Task Activity

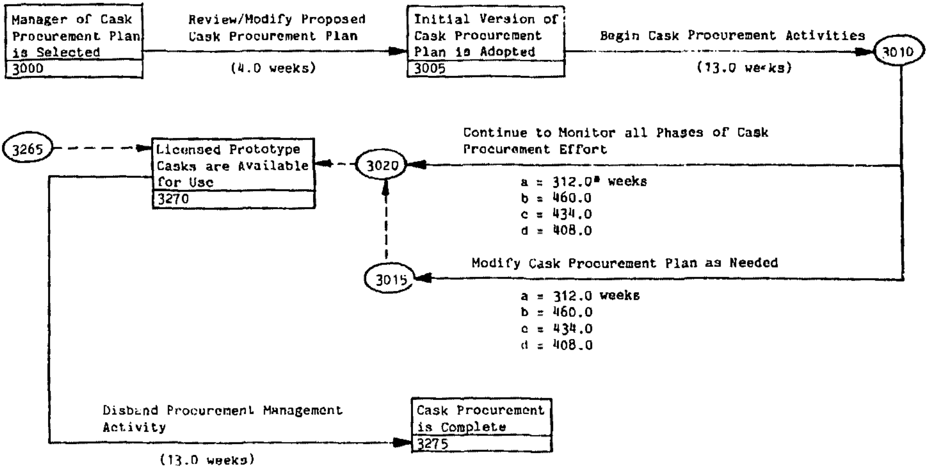
The purpose of this task is to provide management direction, coordination, and control of the individual tasks that constitute the cask procurement effort. The portion of this procurement plan that represents this task is reproduced in Figure 2.

The organization and responsible individual selected as manager of Cask Procurement would administer the plan, have authority to modify it as national policy changes, and interact with the funding agency to insure that the appropriate resources are available to accomplish the procurement effort.

Initiation of the plan would occur through selection of principal investigators for each of the tasks and formulation of their respective scopes of work. After the prototype casks have been delivered and accepted, the program is assumed to be complete. However, fabrication of production casks would continue beyond the duration of this program. One of the last management activities in this program would be to arrange for a cask-inventory production schedule.

Technical Expertise

The Manager of Cask Procurement activities should have knowledge of shipping cask technology and experience in the management of technology programs. The program manager should have a staff of persons who are technically qualified to provide liaison with the principal investigators of each task. Since the logic



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*See Table I for definition of options

Figure 2. Cask Procurement Management Task

diagram would serve as the primary scheduling tool, the services of an individual qualified to update the diagram as needed and obtain computer-generated project-status information from it would be required. Also, individuals qualified in financial and budget matters will be needed to oversee the budgeting and control processes for the program.

Time Schedule

The duration of the management task is determined by the time required to complete the procurement program.

Critical Program Interactions

The management function involves interaction with all other tasks.

IV. CASK INVENTORY DEFINITION TASK

Task Activity

In this task, the types and number of shipping casks that must be available in future years to transport radioactive waste generated by LWR power plants to final disposal sites will be determined. The optimum inventory of shipping casks and the associated transportation strategy must be determined by an economic analysis which examines all relevant cost factors. Figure 3 represents the portion of the program plan which depicts this task.

An appropriate methodology for solving the problem posed here is the discounted-cash-flow technique. This approach provides a means of comparing cost streams when expenditures are made at different future times. Simply stated, this analysis proceeds as if funds for all future costs were available and start to earn interest at the present time. Then, as expenses are incurred, they are paid from this reserve fund. Any strategy which either reduces or postpones costs is desirable because the required initial size of the reserve fund (present value of costs) is reduced. The optimum transportation strategy is that which minimizes the present value of all future costs. The effect of inflation, insofar as it is predictable, can be included as negative interest.

To perform the proposed cash-flow analysis, information about possible shipping systems must be known or assumed. Examples of the data required are:

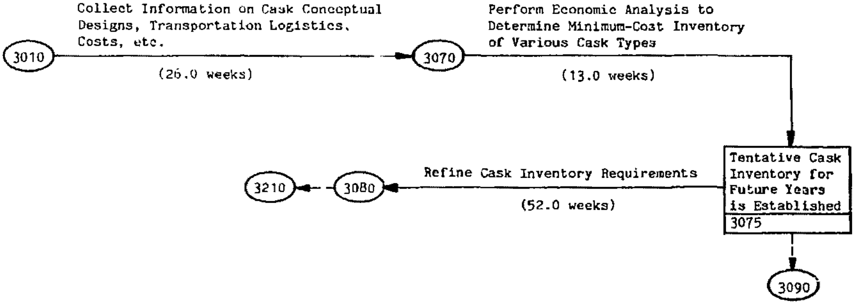


Figure 3. Cask Inventory Definition Task

1. A schedule of the quantity of each type of waste that must be shipped in future years,
2. Average shipping distances,
3. Average shipping speeds for various transportation modes,
4. Base-line waste cooling times,
5. Shipping capacities of various new and existing casks,
6. Total additional costs for design, testing, and licensing of each possible new or existing cask type,
7. Fabrication costs for each cask type,
8. Expected cask lifetimes,
9. Estimates of when various costs would be incurred,
10. The weight and resulting shipping charges for each cask type,
11. The average cask turnaround time and maintenance down time,
12. The maintenance costs for each cask type,
13. The overhead costs for the transportation system if they are a sensitive function of the cask inventory, and
14. Possible noneconomic constraints such as limited access to transportation facilities at particular plants, etc.

This list is not exhaustive, and it is clear that definitive information in many areas will be lacking during the early phases of the cask procurement program.

The initial output from this task would be a tentative identification of casks which are not essential in an optimum transportation strategy. This information would allow early identification of those cask types for which design efforts may be eliminated. After this milestone is completed, the cask inventory definition can be periodically updated as more reliable information is obtained.

Finally, late in the procurement program, the latest inventory definition would be used when placing orders for production casks.

Technical Expertise

The principal investigator for this task should have experience in detailed economic analyses of complex engineering projects. Other investigators will be required to assist in the gathering and processing of input data discussed above and must have or acquire information about characteristics of barge, rail, and truck transportation, characteristics of existing and conceptual shipping casks, engineering-development procedures, and waste inventory and logistics matters.

Time Schedule

It is anticipated that this task is to be a part of the Transportation Logistics Study being performed at Oak Ridge National Laboratory [2]. Assuming that no serious delays are encountered in the gathering of input data, it is estimated in this program plan that the analysis needed to obtain the tentative cask inventory can be completed in 39 weeks. The task could then be suspended. However, it is recommended that the task be continued at a low level of effort until 52 weeks before the anticipated date for ordering follow-on casks. At that time, improved input data will be available, and an updated inventory requirement can be generated to assist in defining the size of the production-cask orders.

Critical Program Interactions

Much of the information required as input for this task should be available from the Cask Design Task. Therefore, extensive interaction with that task should be anticipated. Preliminary inventory results should be communicated to the Cask Design Task as soon as they become available.

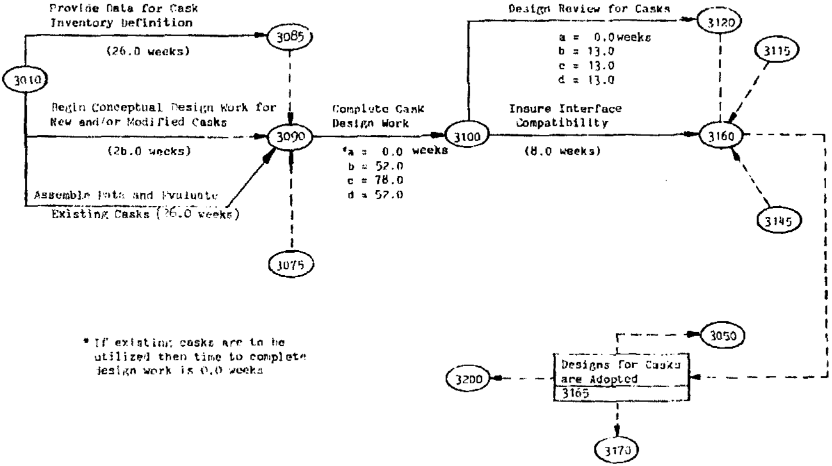
V. CASK DESIGN TASK

Task Activity

In this task, designs for new waste shipping casks will be prepared and/or desirable modifications of existing casks defined so that movement of LWR radioactive waste can be accomplished in the safest and most efficient way possible. Detailed design drawings and purchase specifications for prototype casks will result from completion of this task. Casks for shipment of three types of waste are considered:

1. LWR spent fuel, either uncanistered or canistered,
2. High-level waste, and
3. Clad waste.

In general, this task involves the evaluation of existing casks from the standpoint of the DOE/OWI transportation and economic requirements, identification of any existing casks that meet these requirements, and development of new cask designs to meet any unsatisfied shipping needs. There are numerous decision points that must be passed prior to completion of the task. The licensing, fabrication, and testing associated with the development of a new cask design, or modification of existing casks, are discussed separately in Sections VI, VII and VIII respectively. Figure 4 shows that portion of the program plan which outlines the activities in this task.



* If existing casks are to be utilized then time to complete design work is 0.0 weeks

Figure 8. Cask Design Task

The large number of possible alternatives that must be considered in this task make a complete logic diagram of its activities quite complicated. Instead of including all known details in the program plan, diagrams of portions of the Cask Design Task have been prepared that more fully show the many activities and decisions that have been identified. The detailed diagrams are elaborations on activities shown in the overall program plan.

<u>LWR Spent-Fuel Shipping Casks</u>. At the present time, several licensed LWR spent-fuel shipping casks are available for use. Table II lists these existing casks. Certain details concerning each of the casks are given, including payload, gross weight, costs, and estimated fabrication times. An assessment would be made to determine whether to use or modify one or more of these existing designs and/or to develop new ones.

Depending on logistics and economics, use of several different casks will probably be desirable. For example, rail casks in general will offer the advantages of larger payloads and lower freight charges per ton-mile compared with truck casks.* However, many existing and planned nuclear power plants do not have rail access. Therefore, in the short-term, at least some truck casks will be required. For the long term, the relative economic

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*Reluctance of the domestic rail industry to accept spent-fuel shipments, and state and local restrictions on truck and rail shipments, must be monitored and adjustments made in the program plan as required.

TABLE II

Existing LWR Spent-Fuel Shipping Casks

Cask Identification	Owner/Supplier	Payload (#Assemblies) PWR	Payload (#Assemblies) BWR	Mode of Transportation	Gross Weight (short tons)
NLI-1/2	NL Industries Barnwell, SC	1	2	Truck	22
NAC-1[a]	Nuclear Assurance Corp Atlanta, GA	1	2	Truck	24
NFS-5	Nuclear Assurance Corp Atlanta, GA	2	4	Truck	25
TN-8[b]	Transnuclear	3	0	Overweight	36
TN-9[b]	White Plains, NY	0	7	Truck[c]	
IF-300	General Electric Co Nuclear Energy Div San Jose, CA	7	18	Rail	74
NLI-10/24	NL Industries Barnwell, SC	10	24	Rail	98
TN-12[d]	Transnuclear White Plains, NY	12	32	Rail	97
NAC-2[e]	Nuclear Assurance Corp	7	12	Rail	80
NAC-3	Atlanta, GA	12	32	Rail	100

Cost and Fabrication

Rental, leasing, or purchase prices depend on cask capacity and whether or not technical services are provided by the supplier. Some suppliers require a maintenance or service contract with lease or purchase. Some suppliers offer a lease with option to buy. Prices range approximately as follows:[f]

Cask Type	Purchase Price ($M)	Lease or Rental Prices[g]	Fabrication Lead Times (mo)
Truck	0.5 to 1.25	$500 to $1600 per day or $200K to $500K per year	12 to 24
Rail	2.0 to 4.0	$2K to $4K per day or $0.7M to $1M per year	24 to 42

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[a] Formerly Nuclear Fuel Services NFS-4.

[b] The TN-8 and TN-9 are versions of the same cask designed exclusively for PWR and BWR fuel, respectively.

[c] Overweight permits are required resulting in an increased freight cost which must be amortized by the increased payload compared with legal weight trucks. The permit requirement introduces uncertainties in obtaining permission to ship along certain routes.

[d] The TN-12 is not yet licensed for use in the United States.

[e] The NAC-2 and NAC-3 are currently under design.

[f] The cost ranges quoted are believed to be reasonably accurate. Firm quotes are available only from the manufacturers.

[g] Some suppliers may require a long-term lease. Some prices include full technical services.

merits of rail casks versus the cost of installing railheads must be examined.* It is expected that truck casks will continue to be a necessary part of any LWR spent-fuel shipping system in the foreseeable future.

Three specific applications of LWR spent-fuel shipping casks are envisioned in the waste disposal program:

1. Spent fuel is shipped uncanistered from a reactor or interim storage site to a reprocessor or disposal site.
2. Spent fuel is shipped uncanistered from a reactor site to an interim storage site. There the fuel is canistered and then shipped to a geologic disposal site for temporary or permanent disposal.
3. Spent fuel is canistered at the reactor plant and shipped directly to a geologic disposal site.

The first option will require no canistering of the fuel unless isolation of leaking elements is required. The second option will require double handling of the fuel, which will increase transportation costs, but will avoid the duplication of canistering facilities inherent in the third option. The second option may also require two types of cask internal structures, or interchangeable baskets, to accommodate canistered and uncanistered fuel elements. in any case, because of the expected saturation of on-site spent-fuel storage at many reactor plants, transport of uncanistered fuel will probably be required for some time. Of the casks listed in Table

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*It is possible to establish an intermediate loading point at which truck-cask payloads may be transferred to a rail cask, or at which truck casks may be mounted on rail cars, for long-distance hauling.

II, the only one for which a specific claim is made of its suitability to transport canistered fuel is the NLI-10/24. Depending on the canister design, the other casks listed may or may not accommodate canistered spent fuel.

Figure 5 shows schematically the interactions and decisions that are required before selection of designs for LWR spent-fuel shipping casks can be made. There are three possible alternatives: (1) use of one or more existing cask models, (2) modification of one or more existing cask models, and (3) design of one or more new casks. In fact, it is possible that the cask fleet will consist of casks from a combination of these alternatives.

Although design of a new cask or modification of an existing cask can begin as soon as possible, such efforts will have little guidance until several fundamental questions are answered. Development of an efficient shipping system will depend on early coordination between persons performing economics and logistics studies and persons knowledgeable about the characteristics and availability of existing casks and the state-of-the-art of cask-design technology. Only by such interactions can comprehensive decisions be made regarding the most economic approach to the final shipping system.

Policy direction is another area of primary importance in determining the direction of this task. The Cask Program Manager must remain in close contact with DOE and/or OWI in order to incorporate any program changes caused by revisions in fuel-cycle policy direction. An example of this is the recent decision to ship

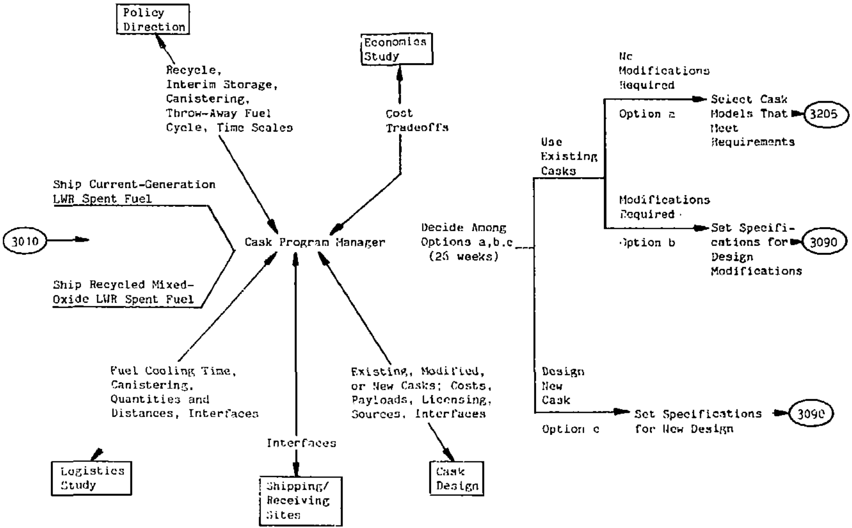

Figure 5. LWR Spent-Fuel Shipping Cask Procurement - Interactions and Decisions Pertaining to Cask Selection

LWR spent fuel to repositories and indefinitely delay reprocessing. This policy would delay the generation of HLW and CW materials.

If relicensing and interface problems do not become intractable, then LWR spent fuel cask designs which are now available or under development by private industry are expected to be adequate to meet foreseeable needs. The path in Figure 5 involving design of a new LWR spent-fuel shipping cask is included because, although feasible, sole use of existing cask designs has not yet been shown to be an optimum solution.

There are two additional factors which may justify the need for a new cask design. First, the casks listed in Table II are designed to carry relatively short-cooled fuel. Since there is a sizable backlog of long-cooled fuel presently in storage, the need for shipping short-cooled fuel may never arise. The existing casks are overdesigned when used to transport long-cooled fuel, and an economic penalty in the form of a lower payload-to-gross-weight ratio will be incurred relative to casks designed specifically for long-cooled fuel. A detailed economic/logistic analysis may well indicate an advantage in designing a new cask for such applications.

Second, if fuel recycle is initiated at some time in the future and LWRs use mixed U-Pu oxide fuels, the neutron source strength in the spent fuel for projected cooling times prior to shipment will be considerably greater than current U-oxide (non-recycle) spent fuel. The decay thermal source also will be greater for mixed-oxide fuel than for U-oxide fuel. Thus, to ship mixed-oxide spent fuel in existing casks, the required cooling time of the spent fuel must be increased from that currently specified.

Again, a detailed economic/logistic analysis may indicate an advantage in designing a new cask if such applications arise in the future.

The schematic plan shown in Figure 5 does not provide details associated with the design of a new cask. There are numerous tasks associated with cask design which are common to all design efforts. Therefore, shipping-cask design is discussed separately in this section under "Technical Disciplines Associated with Cask Design."

<u>High-Level Waste Shipping Cask</u>. No existing casks have been identified which are capable of transporting HLW from a fuel recycle plant to a repository in the form and concentration that is presently envisioned. Figure 6 shows a schematic diagram of the steps necessary to procure a HLW cask.

One area of uncertainty in HLW cask design involves the fission-product and actinide concentrations achieved in the recycle-plant end product. Interactions with recycle plant projects should be used to update the waste geometry and source characteristics as necessary. Another area of uncertainty involves the problem of mixed-oxide-fueled LWRs after initiation of recycling. High-level waste from mixed-oxide spent fuel will have a considerably greater neutron source strength and a larger thermal source than similar HLW from current-generation fuel. Considering the existing backlog of spent fuel, design of a cask for recycled-fuel HLW in the near future appears unnecessary. However, a cask designed for current-generation HLW would not be adequate for transporting HLW resulting from recycled fuel unless the cooling time for the latter were

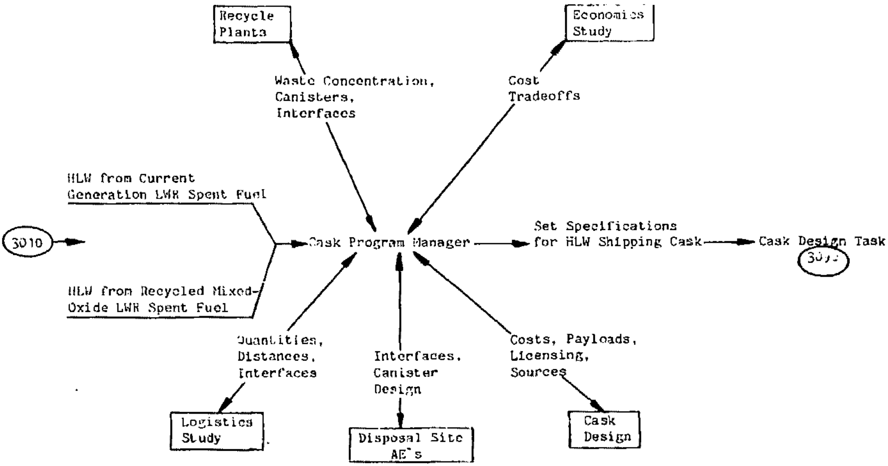

Figure 6. High-Level Waste Shipping Cask Procurement - Interactions and Decisions Pertaining to Design

increased relative to the former. This is analogous to the spent-fuel shipping cask recycle-fuel problem. If a spent-fuel shipping cask is designed for short-cooled recycled spent fuel, then a special HLW cask would probably be required also. If the recycled spent fuel is allowed to cool until current-generation spent-fuel shipping casks can transport it, then a HLW cask designed for current-generation waste could probably serve to transport the HLW from the long-cooled recycled spent fuel.

In order to retain the option to service reprocessing facilities, conceptual design of a shipping cask for transporting HLW should be developed. However, there is no immediate need to initiate detailed design.

Clad-Waste Shipping Cask. Clad waste from LWR spent-fuel recycling is included in the "large quantity" category as defined in 10 CFR 71[3]. Unlike spent fuel and HLW, however, CW is a relatively low-intensity radiation source, and the shielding required for a CW shipping cask should not exceed the equivalent of a few inches of lead.

A decision concerning the design of a CW shipping cask can be made only after an examination of the available alternatives that satisfy the logistics and economics of a recycle/repository plan. The interactions and decisions regarding a CW shipping cask are identical with those required for the HLW cask. Figure 6 shows schematically the alternatives available to a Cask Program Manager for a HLW and, also, a CW shipping cask. However, the design effort and cost of a CW shipping cask should be considerably less than that for a HLW cask. Conceptual designs of a shipping cask for transporting CW from current-generation spent fuel should be developed. Conceptual designs of HLW and CW casks would serve as input for the design of receiving/shipping facilities.

Technical Disciplines Associated with Cask Design. The preceding discussions have referred to the need to design various shipping casks or containers without providing any details as to what such an effort entails. The actual level of effort will depend on the particular cask requirements. For those casks under consideration here, the following technical areas are relevant: heat transfer, structures and containment, source characterization, and radiation shielding.

Particular points to be considered in each of these areas are shown schematically in Figure 7. A high level of interaction among persons working in the various technical disciplines is essential. Guidance from economics and logistics studies during early conceptual design phases, along with policy direction, should be available to provide reasonably well-defined objectives for the designers. These objectives should include information on desired cask characteristics and operational constraints such as:

1. Mode of transportation;
2. Payload, size, and weight contraints;
3. Fuel characteristics (e.g., cooling time, fuel-element elongation, bow, twist, etc.);
4. Interface requirements;
5. Maximum allowable temperatures in normal and accident conditions;

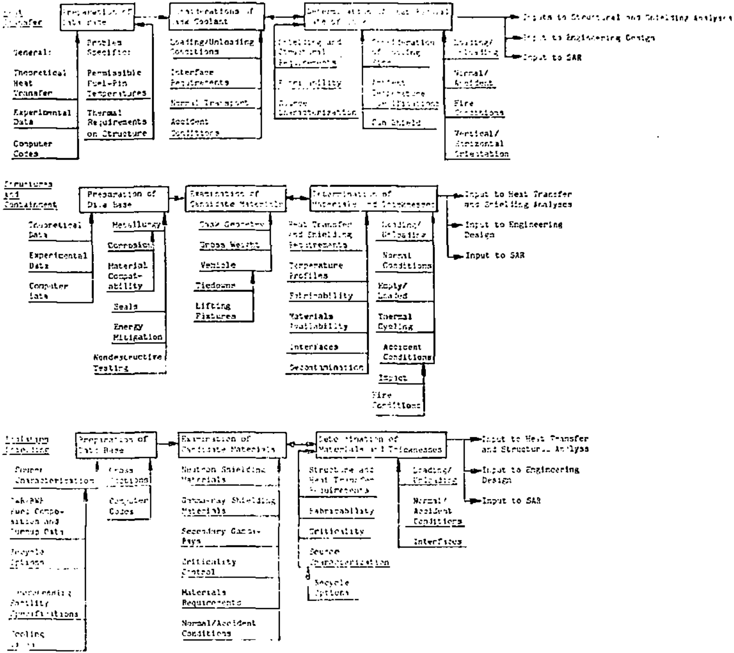

Figure 7. Technical Disciplines and Interactions Involved in Shipping-Cask Design

6. Whether or not canistering of spent fuel is allowed or required; and

7. Loading and unloading constraints (e.g., under water, in air).

Cost minimization, preparation of a Safety Analysis Report for Packaging (SARP), and possible test procedures and requirements should be considered during the design phase. A secondary responsibility of the design team is to verify the fabricability of their designs including availability of raw materials, manufacturing capacity, and special assembly techniques.

Technical Expertise

The personnel needed to perform the Cask Design Task must include individuals who are knowledgeable about the characteristics of existing casks and containers and the technology of cask design. The principal investigator should have comprehensive knowledge of shipping casks and/or cask-design technology.

During the design phase the task personnel should include:

1. Heat transfer specialists,
2. Radiation transport specialists,
3. Structural/mechanical engineers, and
4. Design engineers.

These individuals should be knowledgeable, or have access to consultants in the fields of metallurgy, nuclear-fuel and nuclear-waste source characterization, and design definition.

Time Schedule

The estimated time required to design shipping casks is affected by the decisions pertaining to cask selection. Licensing and fabrication times are similarly affected. Table III shows the range of fabrication times for existing LWR spent-fuel shipping casks. These ranges indicate a variation both with the cask size and model.

An estimate of the time required to complete specific tasks in the procurement plan (Figure 1) as a function of the option selected are shown in Table III. Four options, labeled a, b, c, and d, are defined in this table. To some extent the times shown in Table III depend on the level of effort devoted to each task; the present time estimates are believed to be realistic minima. The assumption has been made that there will be a reasonably high incentive to complete this program. Additional funding might reduce some of the times slightly, but at a rapidly diminishing amount of time saved per additional dollar invested.

The area of greatest uncertainty in the time schedule for cask procurement is the licensing procedure. Although this should not deter the cask procurement program, the regulatory uncertainty must be considered and the program plan updated as required.

Critical Program Interactions

Interactions will occur between activities of the Cask Design Task and other program tasks. In the early phases of the Design Task, information will be provided for the Inventory Definition Task. During the detailed design or modification of a cask, infor-

TABLE III

Time Required to Complete Selected Program Tasks

Option[*]	Description	Approximate Time (weeks) Required to Complete Task: Cask Design (3090→3100)[**] and SAR Preparation (3130→3150)	Design Review (3100→3120)	SAR Review (3150→3190)	Obtain License (3190→3195)	Evaluate Fabricators, Requests and Analyze Bids (3115→3185)	Fabricate Cask[***] (3210→3220)
(a)	Use Existing LWR Spent Fuel Shipping Cask	0	0	0	0	12	52-182
(b)	Modify Existing LWR Spent Fuel Shipping Cask	52	13	8	78	16	69-208
(c)	Design New Shipping Cask for LWR Spent Fuel or HLW	73	13	8	130	24	104-130
(d)	Design New Shipping Cask for CW	52	13	8	104	24	104-130

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[*] See Figure 5 for a diagram of the options related to spent fuel shipping casks.

[**] Task numbers refer to the program plan, Figure 1.

[***] Fabrication time varies with fabricator, type of cask (truck or rail) and details of design.

mation must be generated to support the areas of testing, licensing, and fabrication. At various steps in the design phase, information must be provided to support the Maintenance and Repair, the Decommissioning and Disposal, and the Accident-Recovery Capability Tasks. Following receipt of bids for the fabrication of prototype new casks, design-team personnel should be available for consultation with fabrication-task personnel.

VI. CASK LICENSING TASK

Task Activity

The timely and complete preparation of the Safety Analysis Report for Packaging (SARP) associated with new cask designs or modification of existing casks is provided for in the Cask Licensing Task. This effort entails the assembly of all data pertinent to the NRC license applications, proper execution of all forms and requirements associated with such license applications, and follow up on any questions or comments from NRC during review of the application. The effort should result in the issuance of Certificates of Compliance by NRC at the end of the task.

When licensing a modified version of an existing cask, the time and effort required to accomplish this task will depend on the extent of such modifications. It is probable that an amended license may be granted without extensive delays. Therefore, the following comments apply mainly to the most time-consuming case in which a license is to be obtained for an entirely new cask design.

The portion of the Cask Procurement Plan associated with the licensing task is reproduced in Figure 8. Based on the decisions reached in the cask design/logistics/economics evaluation, the licensing effort may involve several designs. A SARP for each design should be prepared concurrently with the actual design effort. Special requirements, such as experiments to substantiate information presented in the SARP, should be coordinated with the design team(s) and the Cask Testing Task.

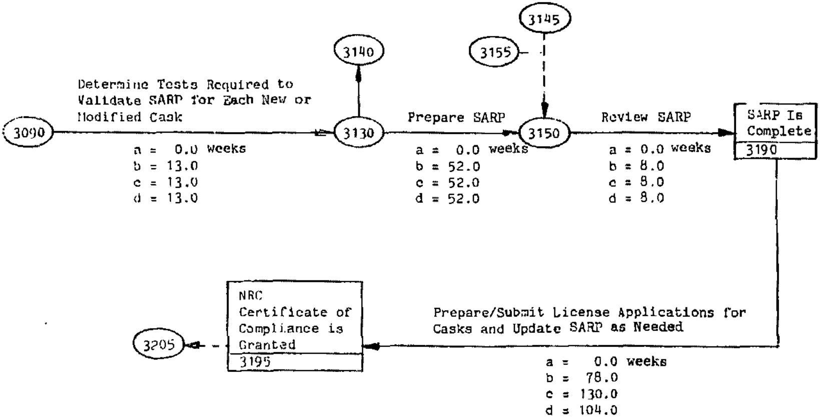

Figure 8. Cask Licensing Task

Technical Expertise

The principal investigator for the Cask Licensing Task should have a broad background in radioactive waste transportation. He should have assistance from someone experienced in regulatory activities, including SARP preparation and NRC licensing procedures. Documentation of the cask-design activities required for the license application should be performed with the assistance and consultation of the cask-design team and should utilize the services of a technical editor.

Time Schedule

The Cask Licensing Task should begin as soon as a decision to design a new or to modify an existing cask is made. The level of effort devoted to the task may vary considerably depending upon the number and type of designs being developed. The SARP for each cask design should be completed simultaneously with the design, and the license application should be submitted as soon as possible thereafter. The time required for licensing will depend on the design option selected (see Table III) and the completeness of the SARP.

Following submission of the license applications, the effort on this task should be reduced to a level consistent with monitoring the progress of the applications through the NRC review process and answering questions as required. The latter may necessitate short periods of increased activity. To ensure timely completion of the procurement program, fabrication of a cask should begin immediately following receipt of its Certificate of Compliance.

Critical Program Interactions

To minimize risk, fabrication of all new and modified casks should await issuance of Certificates of Compliance by NRC. Therefore, timely preparation and submission of the SARP is vital to the overall Cask Procurement Plan. Extensive interactions between the licensing team and the teams working on the Design, Maintenance and Repair, Decommissioning and Disposal, and Accident-Recovery Tasks are essential for the accomplishment of this goal. In addition, interactions between licensing and testing activities are necessary for identifying and performing any experiments needed to support the SARPs.

VII. CASK TESTING TASK

Task Activity

In this task, any tests deemed necessary to support the cask design effort, to verify manufacturing techniques, or to provide support for material submitted in a SARP will be performed. The tests include those required to verify that prototype casks meet the design and manufacturing specifications. Development of test plans and techniques; and scheduling laboratory space, personnel, and instrumentation (including recording devices and data reduction) are the responsibilities of the testing personnel. All test activities should include the preparation of supporting documentation and reporting of results in a form suitable for use by the design, or other procurement-plan, personnel. The portion of the program plan that describes this task is reproduced in Figure 9.

The number and types of tests which may be required by the various phases of the cask procurement plan cannot be delineated at present. However, they may include any of the following:

1. Thermal or mechanical life tests on components or material;
2. Shielding tests under normal and hypothetical accident conditions;
3. Structural tests under normal and hypothetical accident conditions;
4. Tests of fabrication techniques;
5. Tests of seal reliability under normal and hypothetical accident conditions;
6. Tests related to chemical reactions, metallurgical properties, or corrosion;

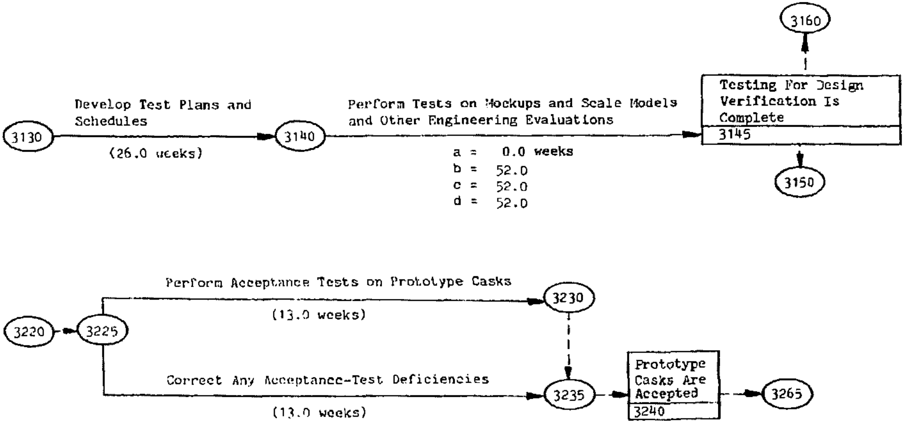

Figure 9. Cask Testing Task

7. Tests related to heat conduction and removal;

8. Tests related to radiation damage to components, structures, or coolants;

9. Tests of decontamination procedures or requirements;

10. Tests related to repair or maintenance; and

11. Tests related to residual activation of structures and components.

Much of the above information is known with confidence for common materials but may need experimental verification for less well known materials. Any features considered for new casks that are not used in existing casks may require experiments to confirm their validity and to provide supporting data for the SARP. Most of the tests listed pertain only to the design stage, but some types of shielding, heat transfer, and seal properties tests could also apply to nondestructive confirmatory tests performed on full-scale prototype casks.

Acquisition of test samples may require consultation with design personnel regarding suppliers and fabrication techniques. The design personnel will be responsible for preparing machine drawings or other documents necessary for acquisition or fabrication of the test samples, and will be responsible for specifying the precise quantities to be measured. The test personnel will be responsible for the actual purchase and/or construction of test samples.

Technical Expertise

The personnel required to perform the testing activity will vary from test to test. Generally, each test should be managed by an experimentalist who is knowledgeable in the relevant discipline. In each case, support should be available as required in the form of technicians, shop personnel, and purchasing and contracts personnel.

Time Schedule

There is no specific time schedule which applies to the entire cask testing activity. Once a specific test is identified, the time required to complete it will depend on both the nature of the test and the point reached in the design (i.e., the urgency with which the test results are needed). Figure 9 shows a nominal time for test planning and execution. This time is based on the assumption that a number of tests can be conducted in parallel.

After a prototype cask is delivered, the test personnel are responsible for performing acceptance testing according to requirements specified by the Design Task. Such tests should lead to the identification of deficiencies (if any) to be corrected by the manufacturer, and to acceptance of the prototype on the time scale shown in Figure 9.

Critical Program Interactions

The major interaction required in the test activity is with the Cask Design Task activities. The test personnel will perform measurements called for by the designers in support of the design and the SARP preparation. Additional interactions will be required with the Licensing Task to support the SARP, and with the Fabrication Task to prepare for receipt of prototype casks on which acceptance testing is required. After such testing is completed, the Program Manager can authorize transfer of the prototypes to DOE/OWI control.

VIII. CASK FABRICATION TASK

Task Activity

In this task, methods for overseeing the fabrication of a prototype unit of each existing, new, or modified cask design developed under the procurement plan are delineated. The portion of the Cask Procurement Plan pertaining to the Fabrication Task is reproduced as Figure 10. Most of the following applies only to new cask designs.

During the design phase of a new or modified cask, it is the responsibility of the design team leader to make certain that the design can be fabricated. Upon completion of a design, the fabrication task personnel will be responsible for determining sources for materials and fabrication capability from information and recommendations supplied by the design team. Contacts with potential suppliers and fabricators should be used to verify the availability of the various materials needed in the required quantities and for the desired delivery dates.

The fabrication-task personnel will be responsible for preparing and issuing Requests for Quotation (RFQ) for cask fabrication, reviewing bids (with consultation from design team members), and selecting a fabricator for each new design. Following receipt of a Certificate of Compliance from NRC for each design, the order for a prototype cask will be placed. Placement of this order and supervision of the prototype unit fabrication are the responsibilities of the fabrication-task personnel. Follow-on orders

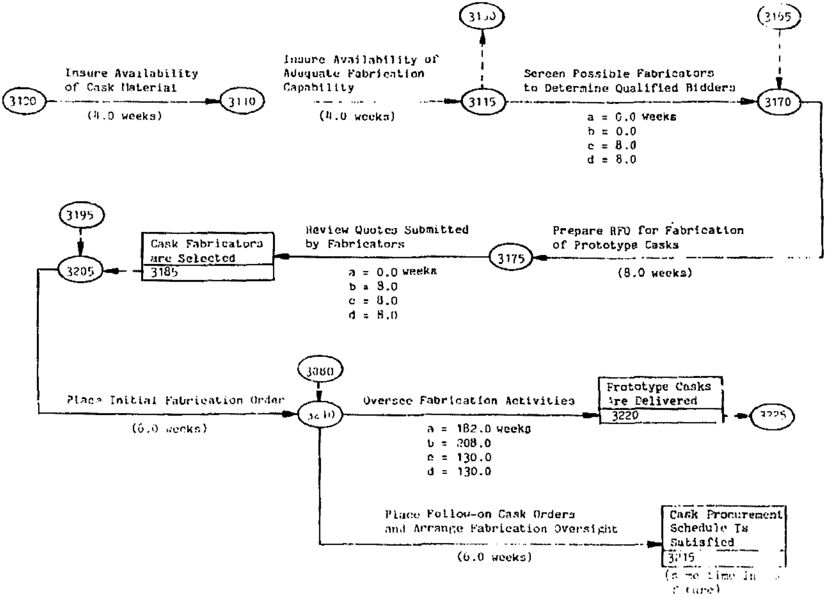

Figure 10. Cask Fabrication Task

may also be placed under this task. When the cask prototype is completed, it will be delivered to the cask-testing personnel.

Technical Expertise

The expertise required is in the fields of purchasing, contract management, and manufacturing procedures. The principal investigator should be an individual with a mechanical- or industrial-engineering background. Experience in contract management would also be desirable. Other team members needed during various phases of the program should include persons familiar with materials and industrial processes, in purchasing and RFQ preparation, and in contract management.

Time Schedule

Activities in the Cask Fabrication Task begin when an existing cask design is identified as adequate to meet a transportation need or when work on new or modified cask designs is completed. For the latter, the initial effort toward fabrication parallels the design review. The RFQ package is prepared following receipt of final drawings from the Design Task and may be issued at any time thereafter. Orders for prototypes of a new or modified cask should await receipt of a Certificate of Compliance from NRC. Following placement of such an order, fabrication time will depend on the specifics of each particular design and the options selected (see Table III).

Critical Program Interactions

Interactions will occur between activities in the Cask Fabrication Task and the Cask Design Task in preparing a bid package and reviewing the bids received. Interactions will also occur with the testing activity to assure readiness for receipt and acceptance testing of prototype casks.

IX. CASK LEGAL CONSIDERATIONS

Task Activity

In this task, those aspects of the cask procurement program about which significant legal or national policy questions exist will be identified. Examples are questions such as who will be the eventual owners and operators of the cask inventory, and what will be the provision for accident liability protection. The portion of the Program Plan which depicts this activity is reproduced in Figure 11.

Changing cask technical requirements and regulatory restrictions, plus likely delays on key decisions and licensing, make the uncertainties associated with comprehensive cask development so large that few private companies may be willing to risk their own funds on such a program. This is particularly true in the case of a HLW cask. It is expected that the government will fund most of the development activities which comprise the cask procurement program. Indeed, this approach appears to be necessary if the United States is to be guaranteed that prototype shipping casks will be ready for use by the mid-1980's target date.

A number of private companies presently offer radioactive-material shipment services. In the future, if licensed casks are available for purchase and operating regulations and shipping charges are such that industry can operate them profitably, then it is reasonable to expect that the private sector will provide the capability necessary to meet the demand for shipment of waste.

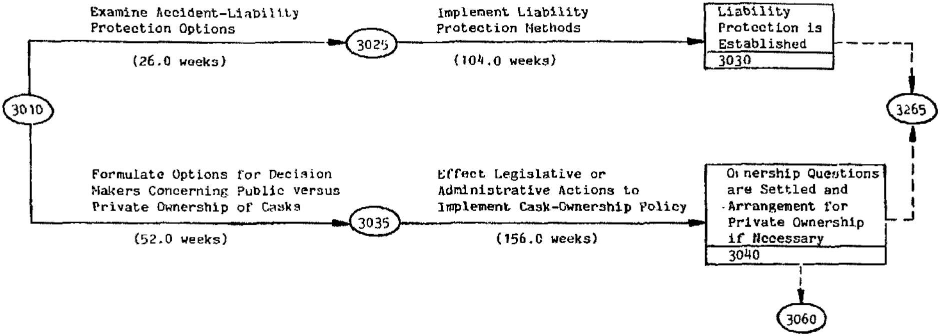

Figure 11. Cask Legal Considerations Task

Although private industry may be willing to undertake the transportation of radioactive waste, there could well be reasons why the government may wish to reserve this activity for itself. One output of this task should be information concerning the relative advantages and disadvantages of government operation, competitive private operation, and regulated-monopoly private operation of the shipping system, respectively.

Another area of great importance to the operation of a waste transportation system concerns the question of insurance protection against liability incurred by shippers during possible transportation accidents. Therefore, the output of this activity will be the formulation of possible liability-protection methods.

Of equal importance is the development of a strategy whereby policy options can be translated into decisions and subsequent actions. For this reason, it will be important to identify the officials who must make the necessary policy decisions. It is quite possible that Congressional legislation may be required to solve some of the problems identified here. In any case, early establishment of lines of communication with all decision makers should enhance the timeliness with which these important decisions are made and implemented.

The matters described above are ones which are obvious at this time. After a more comprehensive examination of the general subjects in this task, other important questions may be identified which should be addressed in follow-on activities.

Technical Expertise

The large number of legal and policy questions associated with this task suggests that a lawyer should have the appropriate training and experience to serve as the principal investigator. He would, of course, require considerable assistance from others knowledgeable about such matters as the operation and logistics of waste transportation systems, the indemnification of accident consequences, and the decision-making process within the government.

Time Schedule

In the overall logic diagram, the paths which represent this task are not part of the critical path.

Despite considerable uncertainty, it is estimated that all phases of the cask-ownership activity will be completed in four years and the concurrent activity related to accident-liability protection will be completed in 2.5 years. However, much of this task will be completed early in the above-mentioned time periods. The impetus for decision and implementation is then transferred to various public officials and agencies.

Critical Program Interactions

There are no critical interactions between this and other tasks in the procurement plan as constructed. However, it would be desirable to settle the question of cask ownership as soon as possible because the eventual owner presumably will be charged with the final implementation of plans formulated by the Maintenance, Decommissioning, and Accident-Recovery Tasks. Any useful information generated by other tasks that could provide input here should be available as needed.

X. CASK MAINTENANCE AND REPAIR TASK

Task Activity

In this task facilities for routine cask maintenance, repair, and decontamination will be established. The portion of the procurement plan that depicts this task is reproduced in Figure 12.

Routine maintenance is required for all operating equipment, and shipping casks are no exception. However, the routine maintenance requirements for such casks should be mimimal. Specific maintenance requirements must be formulated as the cask designs evolve, but such matters as seal integrity, corrosion inhibition, and cleaning and decontamination will be the object of normal maintenance activities.

Minor accidents during cask usage are inevitable. Therefore, provision should be made to repair all resulting minor damage. The damage level below which repairs will be made must be determined and will influence the physical size and capacity of the repair facility. Presumably the repairs envisioned here and the routine maintenance can be accomplished easily at the same facility.

Technical Expertise

Personnel with knowledge of shipping-cask hardware should be responsible for formulation of requirements for shipping-cask maintenance.

Time Schedule

The schedule for this task is flexible, and modest slippage would not have a serious impact on the overall program.

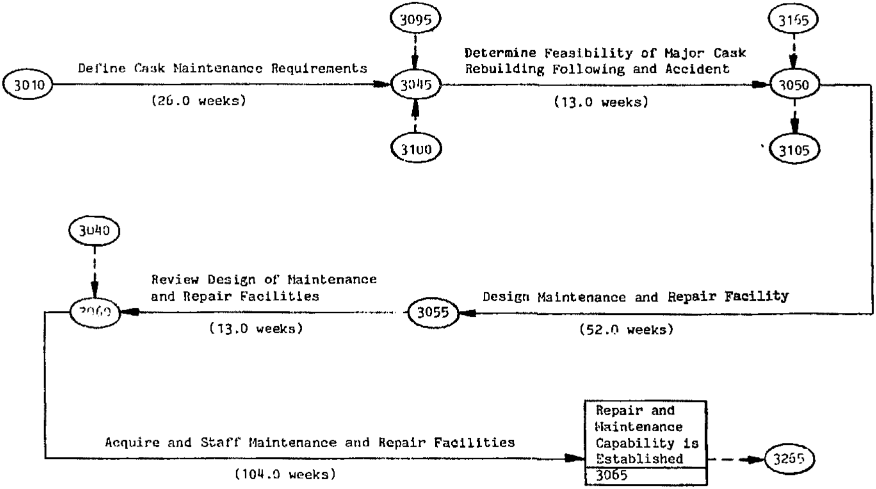

Figure 12. Cask Maintenance and Repair Task

Critical Program Interactions

There are two points where input from other parts of the program are essential. It is necessary to know the cask design details before proceeding with the design of maintenance facilities. Since the owners of the casks undoubtedly will be responsible for their maintenance and repair, the cask owners should also own the maintenance and repair facility. Therefore, it will be highly desirable to have the cask-ownership questions resolved before construction of the maintenance and repair facility begins.

XI. CASK DECOMMISSIONING AND DISPOSAL TASK

Task Activity

In this task the disposal procedure for casks that are no longer serviceable will be determined. Disposal becomes necessary when, for example, casks are severely damaged in accidents, become obsolete in some way, or deteriorate to the point that continued maintenance becomes excessively expensive. A number of different types of casks are to be developed in this program, and the disposal problems associated with each must be addressed. The portion of the program plan that shows this task is reproduced in Figure 13.

The disposal of unusable casks may not be trivial for several reasons. First, neutron emission from the waste, although of modest intensity, over the long term can produce residual activation of the cask itself. Second, a considerably more serious disposal problem will result if, during a severe accident, the cask materials become contaminated with the radioactive materials in the payload which cannot be removed. Third, the large size of many of the casks may mean that tens of tons of cask material, some of it presumably having a low specific level of radioactivity, will have to be disposed of or recycled.

The entire cask-procurement effort could proceed with no consideration given to the ultimate fate of unserviceable casks. However this matter should be investigated so that the thoroughness with which all phases of cask usage have been examined cannot be questioned. Such thoroughness undoubtedly will enhance the

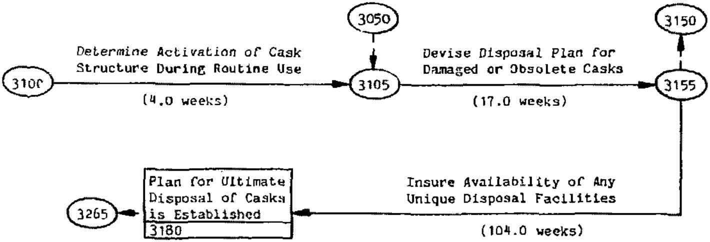

Figure 13. Cask Decommissioning and Disposal Task

credibility of the SARPs and will allay critics who, in the past, have raised questions about provisions for ultimate disposal of obsolete LWR plants and other facilities.

Technical Expertise

This task involves mechanical engineering activities. Therefore, a person with a mechanical-engineering background and experience with radioactive-material shipping containers should be a suitable principal investigator. Since possible radiation hazards complicate the disposal problem, the efforts of a health physicist will certainly be an important contribution to the output of this task.

Time Schedule

It is estimated that completion of a plan for cask disposal should require about five months. The only constraint on the duration of this activity is the need to have information available in a timely fashion for inclusion in the SARPs. Following this phase, the task will be completed when plans have been formulated to insure the availability of any unique facilities needed for cask disposal. Two years have been allocated for this final phase, but this duration is noncritical.

Critical Interactions

There are no critical interactions between this task and other tasks involved extensively with hardware procurement. However, a number of interactions that will facilitate planning are important. For example, information needed to answer questions about the seriousness of residual activation of the cask should be available from Cask Design activities. In addition, any information about cask-design features that would facilitate the ultimate disposal of the casks should be communicated to the designers. An input from Maintenance and Repair is indicated in the Program Plan. The intent of this interaction is to provide an estimate of the number of damaged casks that must be decommissioned before they become obsolete. Finally, as mentioned before, input from this task should be included in the SARPs.

XII. CASK ACCIDENT-RECOVERY TASK

Task Activity

In this task, an accident recovery capability will be assured. Detailed instructions for existing Radiological Emergency Response teams will be disseminated and additional trained personnel with suitable equipment will be assembled as necessary. The need to assure that this capability exists arises because it is undeniable that public confidence regarding radioactive-waste shipments would be improved if it were known that recovery teams would respond promptly, competently, and confidently to any accident that involves shipping casks. The portion of the Program Plan that shows this task is reproduced in Figure 14.

Prompt response to a shipping-cask accident is essential for at least two reasons. First, trained personnel must be on-site as quickly as possible in order to determine the region, if any, from which the public must be excluded temporarily because of a possible radiation hazard. Speed is important here so that the least possible radiation exposure of the public occurs before the danger zone is established. Second, economic losses and inconvenience to the public continue to mount until the wreckage from an accident is cleared away.

Technical Expertise

Input from a number of different technical areas will be required to perform this task. The services of a health physicist should be engaged so that all cleanup plans provide for adequate

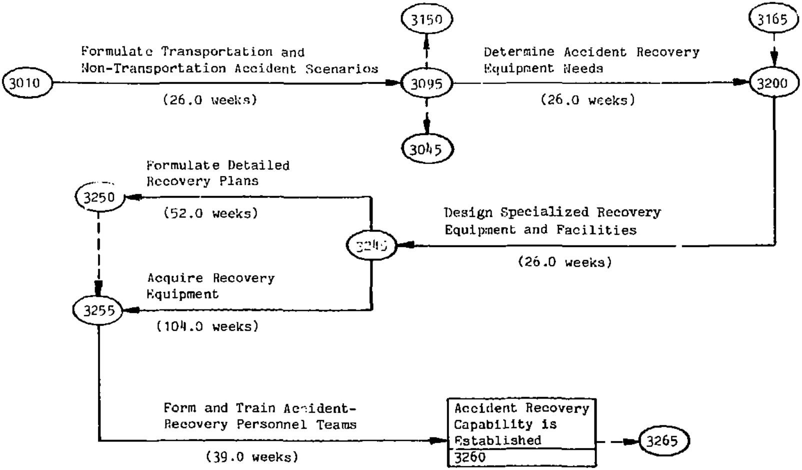

Figure 14. Cask Accident-Recovery Capability Task

monitoring of and protection of personnel from radiation and any other possibly hazardous materials that might be released from a damaged cask.

It is probable that some accident-recovery operations will have to be conducted at remote locations. This will require that a communication system be available to allow recovery teams to call for information, additional equipment, or other assistance during the performance of their job. In addition, and probably just as important, the recovery team must provide, via a communication system, timely information about their progress to appropriate federal, state, and local officials and to the public. The efforts of a specialist in field communication systems are needed to formulate the requirements for such a system.

A person will be needed to formulate plans for dealing with public reactions following a cask accident. For example, if evacuation or spectator control becomes necessary because of a possible radiation hazard, plans must be formulated so this is done in a way which does not create panic. Since coverage of a cask accident by the news media is likely to be extensive, it is essential that complete contingency plans for community relations activities be formulated so that the media receive timely, accurate information about any cask accident and the related clean-up activities.

Time Schedule

The estimated times required to accomplish the activities that comprise this task are shown in Figure 14, but there can be considerable flexibility in this schedule. The important point is that the accident-recovery capability be available when shipping casks are placed in service.

Critical Interactions

There are no critical interactions between this task and other tasks involved extensively with hardware procurement. However, input from this task for the SARPs would be useful. Once final cask designs are available, design and procurement of specialized recovery equipment can proceed without difficulty.

XIII. DISCUSSION AND CONCLUSIONS

The Cask Procurement Plan presented in Figure 1 includes ten tasks associated with the procurement of a waste shipping system to support the presently conceived DOE/OWI LWR spent-fuel recycle/ geologic disposal program. Although the Procurement Plan is subject to revision as the disposal program progresses, there is sufficient detail in the present version to allow conclusions regarding the lead time required to procure various types of shipping casks. The lead time can be obtained by determining the critical path through the logic diagram for the various types of casks required (see page 7, "The Procurement Plan," and Appendix B for further information regarding the critical path).

The Procurement Plan is a combination of four sub-plans based on the procurement options which have been identified for the Program Manager. These options (a-d) were described In Table I as:

a. Use existing LWR spent-fuel shipping casks,

b. Modify existing LWR spent-fuel shipping casks,

c. Design a new shipping cask for LWR spent fuel/design a new shipping cask for HLW, and

d. Design a new shipping cask for CW.

The term "slack" is used to indicate the time an activity or sequence of activities can be delayed beyond its nominal start date and still satisfy its desired completion date. A negative slack indicates that the activity in question should start before the nominal start date by an amount of time equal to the absolute value of the slack. The slacks available to the program manager for each of the four options are shown in Table IV.

Options (a), (b), and (c) are alternative paths for procurement of casks for LWR spent fuel. The only uncertainty associated with this goal is whether or not canistering of spent fuel will be permitted or required. The duration of critical paths through the Program Plan for the above options were summarized in Table III. The latest start dates and maximum slacks shown in this table were obtained by using the minimum fabrication time for the truck and rail casks (see Table II). Conversely, the minimum slacks given in Table IV assume the maximum cask fabrication times. The flexibility indicated by this range of slacks is available to the Program Manager through his selection of a fabricator, but minimization of the fabrication time may involve an economic penalty.

Options (a), (b), and (c) for spent-fuel cask procurement are not mutually exclusive. However, given the negative slacks associated with Option (c) and the diversity of LWR spent-fuel shipping-cask designs available commercially, it is expected that Option (a) will be the preferred approach for accomplishing the procurement objective for spent fuel shipping casks.

Option (c) encompasses two objectives: namely, procurement of both spent-fuel and HLW shipping casks by developing new designs. Casks for these two waste forms will be of similar size and complexity and will require comparable efforts in design, licensing, and fabrication. Hence, the critical paths would be similar and in this report are combined under the same option.

Table IV

Critical Path Parameters for Program Plan Options

Option	Description	Mode of Transportation Selected	Contribution of Design, Licensing and Fabrication to the Critical Path Time (wks)*	Total Critical Path Time (wks)	Approximate Latest Start Date That Permits Prototype Availability on 1/1/86	Slack Available from Nominal Start Date of 4/1/78 (wks) Maximum	Slack Available from Nominal Start Date of 4/1/78 (wks) Minimum
(a)	Use Existing LWR Spent-Fuel Shipping Cask(s)	Truck Rail	52-104 78-182	212-264 230-342	March 1982 Sept 1981	206.6 180.6	154.6 76.6
(b)	Modify Existing LWR Spent-Fuel Shipping Casks(s)	Truck Rail	228-280 263-367	351-403 387-490	July 1979 Nov 1978	67.6 71.4	15.6 32.6
(c)	Design New Cask for Shipping LWR Spent Fuel or Design New Cask for Shipping HLW	Rail	349-375	438-464	**	-19.4	-45.4
(d)	Design New Cask for Shipping CW	Rail	297-323	412-433	May 1978	6.6	-19.4

*Range indicates limits of fabrication times for various suppliers.
**Latest start date already passed.

The only option available to procure casks for shipment of HLW is Option (c). The negative slack associated with this option indicates that, according to the present Procurement Plan, the earliest that a prototype HLW shipping cask can be available, assuming an April 1978 program start date, is May 1986. However, the HLW casks would not be required until after a recycle plant has been in operation for some time and would depend on the amount of on-site storage of HLW canisters available at the facility, the initial throughput of the reprocessor, and the capacity of the cask being procured. Due to these parameters, major uncertainties exist with regard to the required availability date of the HLW cask.

The only procedure identified for providing casks for CW is Option (d). As shown in Table III, the current Procurement Plan indicates a small positive slack for the most optimistic CW cask procurement schedule. As in the HLW cask procurement, however, the required availability date for the CW cask would depend on the start-up date of a recycle plant. By maintaining close contact with personnel involved in DOE policy direction, the Cask Procurement Program Manager should be able to make reasonably accurate decisions regarding the urgency of the various cask procurement schedules.

In summary, investigations have revealed that cask designs suitable for the shipment of LWR spent fuel are readily available. New casks for shipment of long--cooled spent fuel can be obtained in a timely manner by beginning procurement in fiscal year 1978. However, a scheduling problem exists if spent fuel or HLW must be shipped or tests performed with new prototype casks in the first quarter of calendar year 1986. It is likely that attempts to accelerate the schedule for procurement of new shipping casks, as described here, could be partially successful by pursuing certain of the described tasks in parallel rather than sequentially.

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1. See for example:

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E-Z-PERT Project Graphics Reference Manual, Systonetics, Inc.

2. L. B. Shappert, D. S. Joy, and M. M. Heiskell, "Radioactive Waste Transportation System Analysis and Program Plan," Oak Ridge National Laboratory, ORNL-5362, to be published.

3. Title 10, Chapter 1, Code of Federal Regulations Part 71, Packaging of Radioactive Material for Transport and Transportation of Radioactive Material Under Certain Conditions, Amended 37 FR 3985, U.S. Nuclear Regulatory Commission (August 19, 1977).

4. "Siting of Fuel Reprocessing Plants and Related Waste Management Activities," Federal Register 35(222), 17530 (November 14, 1970).

5. C. W. Kee, A. G. Croff, and J. O. Blomeke, Updated Projections of Radioactive Wastes to be Generated by the U.S. Nuclear Power Industry, ORNL TM-5427, Oak Ridge National Laboratory, Oak Ridge, TN (December 1976).

APPENDIX A

GLOSSARY

1. Reactor Spent Fuel

Reactor spent fuel is LWR fuel after its use in a reactor. Its radioactivity level will depend on such parameters as burn-up and cooling time. One or more spent-fuel assemblies constitutes a "large quantity" of radioactive material, as defined in 10 CFR 71 [3], (i.e., it exceeds the Type-B levels defined below) as well as the Fissile Class III category (i.e., shipments which exceed specified quantities of fissile material and which require special criticality controls). Shipping casks for spent fuel require extensive shielding and heat-removal capabilities.

2. High-Level Waste

High-level waste (HLW) has been defined as "those aqueous wastes resulting from the operation of the first-cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels" [4]. In this definition, no statement is made concerning the concentration, composition, or radiation-source density of waste which qualifies it as "high level." In practice, however, and as used in this document, HLW is presumed to contain virtually all (99.5 percent) of the fission products (except ^{3}H, noble gases, I and Br), 99.5 percent of the transplutonic actinides, and a small part (0.5 percent) of the U and Pu contained in the original spent fuel. It is categorized as a "large quantity" of radioactive material for transportation purposes.

In this report HLW is assumed to be fixed in a solid material (borosilicate glass) at a concentration corresponding to 3 ft^3 of concentrated waste per metric tonne of U originally present in the fresh fuel [5]. Since the U loadings of fresh PWR and BWR fuel assemblies are 461.4 and 183.35 kg, respectively, 1 ft^3 of HLW is assumed to contain waste from 0.72 PWR or 1.82 BWR fuel assemblies. Shipping casks for HLW will also require extensive shielding and heat removal capabilities.

3. Intermediate-Level Waste

Intermediate-Level Waste (ILW) is used to describe nonrecycle wastes of fairly high radiation source intensity. Here ILW will be defined as that waste which requires the use of Type-B packages as defined in 10 CFR 71, in order to transport 10 ft^3

or more of the waste material in question. Type-B quantities are defined in the next paragraph. Type-B packages require shielding equivalent of a few inches of lead but no special heat removal capability.

4. Low-Level Waste

Low-Level Waste (LLW) is defined here as that waste which, in quantities up to 10 ft^3, may be transported in the Type-A packages defined in 10 CFR 71. Type-A packages require little or no shielding and no special heat-removal capability. Type-A and Type-B quantities are defined in terms of transport groupings I-VII of radionuclides as follows:

Transport Group	Type A Quantity (Ci) Not to Exceed	Type B Quantity (Ci) Not to Exceed
I	0.001	20
II	0.050	20
III	3	200
IV	20	200
V	20	5000
VI	1000	50000
VII	1000	50000

where transport-group nuclides consist of the following:

Group I:	Heavy radionuclides ($Z > 81$) with half lives less than 10^6 years
Group II:	Light radionuclides ($Z < 82$) with half lives between 10^3 days and 10^6 years
Group III:	Light radionuclides with half lives less than 10^3 days or greater than 10^6 years
Group IV:	Certain short-lived isotopes (half lives range from several days to a few years)
Group V:	Certain gaseous radionuclides in an uncompressed form
Group VI:	^{37}Ar, ^{85}Kr, and ^{133}Xe
Group VII:	^{3}H

5. Clad Waste

Clad Waste (CW) is defined as the waste resulting from the chopping and removing of clad hulls from LWR spent fuel prior to the first-cycle solvent extraction, or equivalent, in a facility for reprocessing irradiated reactor fuels. This waste is assumed to constitute all of the fuel cladding plus 0.05 percent of the fission products, excluding ^{3}H, noble gases, I, and Br; 0.15 percent of the Pu, and 0.0 percent of the other actinides originally in the spent fuel. The CW is assumed to be compressed to 70 percent of theoretical density [5].

Clad Waste from five-year-cooled spent fuel will contain approximately 34 Ci of ^{241}Pu, a Group I nuclide, 2000 Ci of ^{55}Fe, a Group IV nuclide, 51 Ci of ^{134}Cs + ^{106}Ru + ^{106}Rh + ^{144}Ce + ^{144}Pr, *all Group III nuclides, as well as some 1000* Ci of other nuclides per ft^{3}. These activities exceed Type-B limits and will do so even for cooling times much greater than five years. Therefore, for quantities of interest, CW falls under the "large quantity" category of waste defined in 10 CFR 71. Shipping casks for CW will require moderate amounts of shielding, equivalent to a few inches of Pb; however, no special provisions for heat removal will be required.

APPENDIX B

PRELIMINARY COMPUTER ANALYSIS

The Procurement Plan developed here has been subjected to a preliminary computer analysis with the NASA PERT TIME II software system [1]. Here we show two examples for Option (c) of the output that can be produced by this analysis program.

The first printout, reproduced in Table B-I, is a listing of all the activities in the Plan according to their predecessor and successor event numbers. The column headings are fairly descriptive. Probably of most interest in the table are the columns labeled "Expected Start," "Expected Finish," "Latest Allowed Finish," and "Slack" which is given in weeks.

Table B-II shows the computer-generated printout that indicates the length of time required to negotiate various paths through the logic diagram. The critical path is the one having the smallest algebraic value for the slack.

Table B1

```
SANDIA LABORATORIES                               PERT/TIME ACTIVITY REPORT                                          PAGE    1
        RUN   1                           BY PREDECESSOR AND SUCCESSOR EVENT NUMBERS                DATA DATE   5/ 1/78
        NETWORK  CASK PROCUREMENT PLAN                                                                SUBNET  C

    EVENT              PART                   ACTIVITY           TIME        EXPECTED         LATEST    ACTL SCH           RE-   COST/
PRED        SUCC   NUMBER  DESCRIPTION       DESCRIPTION        EST/ACT    START    FINISH    ALLOWED     DATE     SLACK  SOURCE ACCT

 C-3005     3-  0  CASK PROC MGT  START                            .0   4/ 3/78   4/ 3/78   1/ 6/77   4/ 3/78  -62.4     C
 3-  0      3-  0  CASK PROC MGT  MGR OF CASK PROG SELECTED        .0   4/ 3/78   4/ 3/78   1/ 6/77            -62.4     C
 3-  0      3-  5  CASK PROC MGT  DEVELOP CASK PROC PLAN          4.0   4/ 3/78   5/ 1/78   2/ 3/77            -62.4     C
 3-  5      3-  5  CASK PROC MGT  CASK PROC PLAN ACCEPTED          .0   5/ 1/78   5/ 1/78   2/ 3/77            -62.4     C
 3-  5      3- 10  CASK PROC MGT  START CASK PROC ACTIVITIES     13.0   5/ 1/78   8/ 2/78   5/ 5/77            -62.4     C
 3- 10      3- 15  CASK PROC MGT  MODIFY CASK PROC PLAN         434.0   8/ 2/78   3/30/87   1/ 2/86            -62.4     C
 3- 10      3- 20  CASK PROC MGT  MONITOR CASK PROC EFFORT      434.0   8/ 2/78   3/30/87   1/ 2/86            -62.4     C
 3- 10      3- 25  LEGAL ISSUES   ACCIDENT/LIABILITY OPTIONS     26.0   8/ 2/78   2/12/79  11/30/83             241.5     C
 3- 10      3- 35  LEGAL ISSUES   OPT PUBLIC/PRIV OWNERSHIP      52.0   8/ 2/78   8/15/79  10/21/80              59.6     C
 3- 10      3- 45  MAINTNC/REPAIR DEFINE CASK MAINTENCE RQMTS    26.0   8/ 2/78   2/13/79   3/ 4/79              27.6     C
 3- 10      3- 70  INVENTORY DEF  PREP REPOSITIONS,COST,ETC      26.0   8/ 2/78   2/12/79  11/ 8/77            -62.4     C
 3- 10      3- 84  DESIGN         ASSEM/EVAL DATA                  .0   8/ 2/78   8/ 2/78   2/15/78            -23.4     C
 3- 10      3- 85  DESIGN         PROVIDE DATA F/CASK INV DEF    26.0   8/ 2/78   2/12/79   2/16/78            -43.4     C
 3- 10      3- 95  DESIGN         DSN NEW/MOD CASKS              26.0   8/ 2/78   2/12/79   2/16/78            -43.4     C
 3- 10      3- 35  ACCDNT-RECOVER DSN ACCIDENT SCENARIOS         26.0   8/ 2/78   2/12/79   3/ 4/79              23.3     C
 3- 15      3- 20  CASK PROC MGT  RESTRAINT                        .0   3/30/87   3/30/87   1/ 2/86            -62.4     C
 3- 20      3-220  CASK PROC MGT  RESTRAINT                        .0   3/30/87   3/30/87   1/ 2/86            -62.4     C
 3- 25      3- 30  LEGAL ISSUES   IMPLEMENT LIABILITY METHODS   104.0   2/12/79   3/ 3/81   1/ 2/86             241.5     C
 3- 30      3- 30  LEGAL ISSUES   LIAB PROTECTION ESTABLISHED      .0   3/ 3/81   3/ 3/81   1/ 2/86             241.5     C
 3- 30      3-255  LEGAL ISSUES   RESTRAINT                        .0   3/ 3/81   3/ 3/81   1/ 2/86             241.5     C
 3- 35      3- 40  LEGAL ISSUES   PROVIDE CASK-OWNERSHIP PLAN   156.0   8/15/79   8/23/82  11/30/83              59.6     C
 3- 40      3- 45  LEGAL ISSUES   PRIVATE OWNERSHIP ARRANGED       .0   8/23/82   8/23/82  11/30/83              59.6     C
 3- 40      3- 50  LEGAL ISSUES   RESTRAINT                        .0   8/23/82   8/23/82  11/30/83              59.6     C
 3- 40      3-255  LEGAL ISSUES   RESTRAINT                        .0   8/23/82   8/23/82   1/ 2/86             141.5     C
 3- 45      3- 55  MAINTNC/REPAIR STUDY CASK REBUILDING          11.0  11/29/80   3/ 3/81  12/ 5/78            -62.4     C
 3- 50      3- 55  MAINTNC/REPAIR DSN MAINT/REPAIR FACILITIES    52.0   3/ 3/81   3/22/82   2/23/83              72.6     C
 3- 50      3-135  MAINTNC/REPAIR RESTRAINT                        .0   3/ 3/81   3/ 3/81  12/ 5/78            -62.4     C
 3- 55      3- 60  MAINTNC/REPAIR REV DSN OF M/R FACILITIES      13.0   3/22/82   6/22/82  11/30/83              72.6     C
 3- 60      3- 65  MAINTNC/REPAIR ACQUIRE/STAFF M/R FACILITY    164.0   8/23/82  10/13/84   1/ 2/86              59.6     C
 3- 65      3- 65  MAINTNC/REPAIR M/R CAPABILITY ESTAB             .0  10/13/84  10/13/84   1/ 2/86              59.6     C
 3- 65      3-255  MAINTNC/REPAIR RESTRAINT                        .0  10/13/84  10/13/84   1/ 2/86              59.6     C
 3- 70      3- 75  INVENTORY DEF  PERFORM ECONOMIC ANAL          13.0   2/12/79   5/14/79   2/16/78            -62.4     C
 3- 75      3- 75  INVENTORY DEF  TENTATIVE CASK INV ESTAB         .0   5/14/79   5/14/79   2/16/78            -62.4     C
 3- 75      3- 80  INVENTORY DEF  REFINE CASK INV RQMNTS         52.0   5/14/79   5/21/80   2/24/83             137.6     C
 3- 75      3- 90  INVENTORY DEF  RESTRAINT                        .0   5/14/79   5/14/79   2/15/78            -62.4     C
 3- 80      3-210  INVENTORY DEF  RESTRAINT                        .0   5/21/80   5/21/80   2/24/83             137.6     C
 3- 84      3- 90  DESIGN         RESTRAINT                        .0   8/ 2/78   8/ 2/78   2/16/78            -23.4     C
 3- 95      3- 90  DESIGN         RESTRAINT                        .0   2/12/79   2/12/79   2/16/78            -43.4     C
 3- 90      3-170  DESIGN         COMPLETE DESIGN WORK           78.0   5/14/79  11/22/80   3/ 4/79            -62.4     C
 3- 90      3-177  LICENSING      DETERMINE LIST FOR SAR DATA    13.0   5/14/79   8/13/79   5/13/78            -62.4     C
 3- 35      3-150  ACCDNT-RECOVER RESTRAINT                        .0   2/12/79   2/12/79   4/13/80              58.5     C
 3- 35      3- 85  ACCDNT-RECOVER RESTRAINT                        .0   2/12/79   2/12/79   3/ 4/79              28.6     C
 3- 35      3-200  ACCDNT-RECOVER DETERMINE EQUIP NEEDS          26.0   2/12/79   8/15/79   5/16/82             150.2     C
 3-100      3- 45  DECON/DISPOSAL RESTRAINT                        .0  11/28/80  11/28/80   3/ 4/79            -62.4     C
 3-100      3-135  DECON/DISPOSAL STUDY ACTIVATION OF CASK        4.0  11/28/80   1/ 5/81  12/ 5/78            -53.4     C
 3-100      3-110  FABRICATION    INSURE AVAIL OF MATLS           4.0  11/28/80   1/ 5/81  11/ 6/78            -57.4     C
 3-100      3-120  DESIGN         DSN REVIEW FOR CASKS           13.0  11/28/80   3/ 3/81  12/ 5/78            -62.4     C
 3-100      3-160  DESIGN         INSURE INTERFACE COMP           9.0  11/28/80   2/ 2/81  12/ 5/78            -57.4     C
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Table B1 (Cont'd)

SANDIA LABORATORIES
RUN 1
NETWORK CASK PROCUREMENT PLAN

PERT/TIME ACTIVITY REPORT
BY PREDECESSOR AND SUCCESSOR EVENT NUMBER

DATA DATE 6/ 1/79
[illegible] C

PAGE 2

EVENT PREC	SUCC	PART NUMBER DESCRIPTION	ACTIVITY DESCRIPTION	TIME ESTIMATE	EXPECTED START	FINISH	LATEST ALLOWED	EARLY SCH DATE	SLACK	RE- SOURCE	RESP AGEN
3-105	3-155	DECON/DISPOSAL	DEVISE DISPOSAL PLAN	17.0	3/ 9/81	7/ 6/81	4/10/80		-62.4	C	
3-110	3-135	FABRICATION	INSURE AVAIL-FAB CAPABILITY	4.0	1/ 5/81	2/ 2/81	12/ 5/79		-57.4	C	
3-115	3-150	FABRICATION	RESTRAINT	.0	2/ 2/81	2/ 2/81	12/ 5/79		-57.4	C	
3-115	3-120	FABRICATION	DETERMINE QUALIFIED BIDDERS	8.0	2/ 2/81	3/30/81	8/14/82		73.5	C	
3-120	3-160	DESIGN	RESTRAINT	.0	3/ 9/81	3/ 9/81	12/ 5/79		-62.4	C	
3-130	3-140	TESTING	DEV TEST PLANS/SCHEDULES	26.0	9/15/78	[illegible]	11/23/78		-62.4	C	
3-130	3-150	LICENSING	PREPARE SAR	78.0	9/15/78	3/ 3/81	4/10/80		-45.4	C	
3-140	3-145	TESTING	PERF TESTS(MOCKUPS/MODELS)	57.0	2/20/80	3/ 3/81	12/ 5/79		-62.4	C	
3-145	3-245	TESTING	DEV TEST VERIF COMPLETED	.0	3/ 9/81	3/ 9/81	12/ 5/79		-57.4	C	
3-145	3-155	TESTING	RESTRAINT	.0	3/ 9/81	3/ 9/81	4/10/80		-45.4	C	
3-145	3-150	TESTING	RESTRAINT	.0	3/ 9/81	3/ 9/81	12/ 5/79		-62.4	C	
3-150	3-170	LICENSING	REVIEW SAR	9.0	3/ 9/81	5/11/81	6/ 6/80		-62.4	C	
3-153	3-150	DECON/DISPOSAL	RESTRAINT	.0	7/ 8/81	7/ 8/81	4/13/80		-62.4	C	
3-155	3-190	DECON/DISPOSAL	PROC UNIQUE DISPOSAL FAC	104.0	7/ 8/81	8/ 3/83	1/ 7/86		120.6	C	
3-160	3-165	DESIGN	RESTRAINT	.0	3/ 9/81	3/ 9/81	12/ 5/79		-62.4	C	
3-165	3-170	DESIGN	RESTRAINT	.0	3/ 9/81	3/ 9/81	12/ 5/79		-62.4	C	
3-165	3-165	DESIGN	CASK DESIGNS ADOPTED	.0	3/ 9/81	3/ 9/81	12/ 5/79		-62.4	C	
3-165	3-170	DESIGN	RESTRAINT	.0	3/ 9/81	3/ 9/81	7/14/82		76.6	C	
3-165	3-260	DESIGN	RESTRAINT	.0	3/ 9/81	3/ 9/81	9/15/82		72.1	C	
3-170	3-175	FABRICATION	REQ OF PROTOTYPE CASKS	8.0	3/30/81	5/26/81	11/ 9/82		73.4	C	
3-175	3-195	FABRICATION	REVIEW QUOTES	9.0	5/26/81	7/22/81	1/13/83		73.6	C	
3-180	3-190	DECON/DISPOSAL	CASK DISPOSAL PLAN ESTAB	.0	8/ 3/83	8/ 3/83	1/ 7/86		120.6	C	
3-190	3-255	DECON/DISPOSAL	RESTRAINT	.0	8/ 3/83	8/ 3/83	1/ 7/86		120.6	C	
3-195	[illegible]	FABRICATION	FABRICATORS ARE SELECTED	.0	7/22/81	7/22/81	1/13/83		73.6	C	
3-195	3-135	FABRICATION	RESTRAINT	.0	7/22/81	7/22/81	1/13/83		73.6	C	
3-130	3-130	LICENSING	SER COMPLETED	.0	9/ 7/81	9/ 7/81	5/ 5/80		-62.4	C	
3-135	3-195	LICENSING	REVIEW/TIME UPDATED SAR	139.0	9/ 7/81	4/ 3/84	1/13/83		-62.4	C	
3-135	3-135	LICENSING	NRC LICENSE IS GRANTED	.0	4/ 3/84	4/ 3/84	1/13/83		-62.4	C	
3-175	3-275	LICENSING	RESTRAINT	.0	4/ 3/84	4/ 3/84	1/13/83		-62.4	C	
3-200	3-245	ACCDNT-RECOVER	DEV SPECIAL EQUIP/FACILITY	25.0	3/ 3/81	9/17/81	2/24/83		72.6	C	
3-205	3-210	FABRICATION	PLACE INITIAL FAB ORDERS	6.0	4/ 3/84	5/15/84	2/24/83		-62.4	C	
3-210	3-215	FABRICATION	PLACE FOLLOW-ON ORDERS	6.0	5/21/84	7/ 3/84	7/ 3/84		.0	C	
3-210	3-220	FABRICATION	SUP AWARD FAB ACTIVITIES	130.0	5/21/84	12/13/86	7/24/85		-62.4	C	
3-215	3-215	FABRICATION	PROD SCHEDULE IS SATISFIED	.0	7/ 3/84	7/ 3/84	7/ 3/84		.0	C	
3-220	3-220	FABRICATION	INITIAL CASKS DELIVERED	.0	12/13/86	12/13/86	7/24/85		-62.4	C	
3-220	3-225	FABRICATION	RESTRAINT	.0	12/13/86	12/13/86	7/24/85		-62.4	C	
3-225	3-230	TESTING	PERF ACCEPT TEST(PROTOTYPE)	13.0	12/13/86	3/30/87	1/ 2/86		-62.4	C	
3-225	3-235	TESTING	CORRECT DEFICIENCIES	11.0	12/13/86	3/30/87	1/ 2/86		-62.4	C	
3-230	3-235	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-235	3-240	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-240	3-240	TESTING	PROTOTYPE CASKS ACCEPTED	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-240	3-265	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-245	3-250	ACCDNT-RECOVER	DEV DTL RECOVERY PLANS	57.0	3/10/81	5/13/82	3/21/85		124.6	C	
3-245	3-255	ACCDNT-RECOVER	ACQUIRE RECOVERY EQUIP	164.0	3/10/81	10/ 6/83	3/21/85		72.6	C	
3-250	3-255	ACCDNT-RECOVER	RESTRAINT	.0	9/23/82	9/23/82	3/21/85		124.6	C	
3-255	3-260	ACCDNT-RECOVER	OBTAIN/TRAIN PERSONNEL	39.0	10/ 6/83	7/18/84	1/ 2/86		72.6	C	
3-260	3-260	ACCDNT-RECOVER	CAPABILITY IS IN PLACE	.0	7/18/84	7/18/84	1/ 2/86		72.6	C	
3-260	3-265	ACCDNT-RECOVER	RESTRAINT	.0	7/18/84	7/18/84	1/ 2/86		72.6	C	

Table B1 (Cont'd)

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SANDIA LABORATORIES                      PERT/TIME ACTIVITY REPORT                                         PAGE    5
          RUN   1                  BY PREDECESSOR AND SUCCESSOR EVENT NUMBER              DATA DATE   3/ 1/76
          NETWORK   CASK PROCUREMENT PLAN                                                   SUBNET  C

    EVENT                PART                    ACTIVITY            TIME         EXPECTED         LATEST    PACT/ SCH            RE-   ORG/
PREC        SUCC   NUMBER  DESCRIPTION          DESCRIPTION         EST/ACT.    START    FINISH    ALLOWED     DATE      SLACK  SOURCE AGEN

 3-265      3-270  CASK PROC MGT  RESTRAINT                            .0    3/30/87   3/30/87   3/ 2/86               -62.4     C
 3-270      3-270  CASK PROC MGT  LICENSED PROTO CASKS AVAIL           .0    3/30/87   3/30/87   3/ 2/86               -62.4     C
 3-270      3-275  CASK PROC MGT  DISBAND PROC MGT ACTIVITY          13.0    3/30/87   6/30/87   4/ 3/86               -62.4     C
 3-275      3-275  CASK PROC MGT  CASK PROCUREMENT COMP                .0    6/30/87   6/30/87   4/ 3/86               -62.4     C
 3-275      3-2332 CASK PROC MGT  SCH END                              .0    6/30/87   6/30/87   4/ 3/86   4/ 3/86     -62.4     C
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Table B2

SANDIA LABORATORIES
RUN 3
NWTS?K CASK PROCUREMENT PLAN

PERT/TIME ACTIVITY REPORT
BY PATHS OF CRITICALITY

PAGE 1

DATA DATE 5/ 1/77
SUBNET C

EVENT PRED	SUCC	PART NUMBER DESCRIPTION	ACTIVITY DESCRIPTION	TIME EST/ACT.	EXPECTED START	EXPECTED FINISH	LATEST ALLOWED	ACTIV SCH DATE	SLACK	RE- SOURCE	OPER AGEN
3-1P05	3- 9	CASK PROC MGT	START	.0	4/ 3/78	4/ 3/78	1/ 6/77	4/ 3/78	-62.4	C	
3- 9	3- 8	CASK PROC MGT	MGR OF CASK PROC SELECTED	.0	4/ 3/78	4/ 3/78	1/ 6/77		-62.4	C	
3- 8	3- 5	CASK PROC MGT	REV/MOD CASK PROC PLAN	4.0	4/ 3/78	5/ 1/78	2/ 3/77		-62.4	C	
3- 5	3- 6	CASK PROC MGT	CASK PROC PLAN ADOPTED	.0	5/ 1/78	5/ 1/78	2/ 3/77		-62.4	C	
3- 6	3- 10	CASK PROC MGT	START CASK PROC ACTIVITIES	13.0	5/ 1/78	8/ 2/78	5/ 5/77		-62.4	C	
3- 10	3- 20	INVENTORY DEF	PREP REPORT(CSN+COST+ETC)	[illegible]	8/ 2/78	2/12/79	11/ 9/77		-62.4	C	
3- 20	3- 25	INVENTORY DEF	PERFORM ECONOMIC ANAL	13.0	2/12/79	5/14/79	2/16/78		-62.4	C	
3- 25	3- 75	INVENTORY DEF	TENTATIVE CASK INV ESTAB	.0	5/14/79	5/14/79	2/16/78		-62.4	C	
3- 75	3- 90	INVENTORY DEF	RESTRAINT	.0	5/14/79	5/14/79	2/15/78		-62.4	C	
3- 90	3-130	LICENSING	DETERMINE TEST FOR SAR DATA	13.0	5/14/79	8/15/79	5/18/78		-62.4	C	
3-130	3-140	TESTING	DEV TEST PLANS/SCHEDULES	26.0	8/15/79	2/25/80	11/21/78		-62.4	C	
3- 90	3-150	DESIGN	COMPLETE DESIGN WORK	79.0	5/14/79	11/29/80	9/ 4/79		-62.4	C	
3-150	3- 45	DECON/DISPOSAL	RESTRAINT	.0	11/29/80	11/29/80	9/ 4/79		-62.4	C	
3- 45	3- 50	MAINTENC/REPAIR	STUDY CASK REBUILDING	13.0	11/29/80	3/ 3/81	12/ 5/79		-62.4	C	
3- 50	3-115	MAINTENC/REPAIR	RESTRAINT	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-140	3-120	DESIGN	DOE REVIEW FOR CASKS	13.0	11/29/80	3/ 3/81	12/ 5/79		-62.4	C	
3-120	3-165	DESIGN	RESTRAINT	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-140	3-145	TESTING	PERF TESTS(MKUPS/MODELS)	57.0	2/25/80	3/ 3/81	12/ 5/79		-62.4	C	
3-145	3-145	TESTING	DSN TEST VERIF COMPLETED	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-145	3-150	TESTING	RESTRAINT	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-150	3-165	DESIGN	RESTRAINT	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-165	3- 55	DESIGN	RESTRAINT	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-165	3-105	DESIGN	CASK DESIGNS ADOPTED	.0	3/ 3/81	3/ 3/81	12/ 5/79		-62.4	C	
3-105	3-155	DECON/DISPOSAL	DEVISE DISPOSAL PLAN	17.0	3/ 3/81	7/ 3/81	4/10/80		-62.4	C	
3-155	3-150	DECON/DISPOSAL	RESTRAINT	.0	7/ 3/81	7/ 3/81	4/10/80		-62.4	C	
3-150	3-175	LICENSING	REVIEW SAR	9.0	7/ 3/81	9/ 2/81	6/ 6/80		-62.4	C	
3-175	3-131	LICENSING	SAR COMPLETED	.0	9/ 2/81	9/ 2/81	6/ 6/80		-62.4	C	
3-130	3-135	LICENSING	PREP/SUBMIT UPDATED SAR	130.0	9/ 2/81	4/ 3/84	1/13/83		-62.4	C	
3-135	3-135	LICENSING	NRC LICENSE IS GRANTED	.0	4/ 3/84	4/ 3/84	1/13/83		-62.4	C	
3-135	3-205	LICENSING	RESTRAINT	.0	4/ 3/84	4/ 3/84	1/13/83		-62.4	C	
3-205	3-210	FABRICATION	PLACE INITIAL FAB ORDERS	6.0	4/ 3/84	5/21/84	2/24/83		-62.4	C	
3-210	3-220	FABRICATION	SUPERVISE FAB ACTIVITIES	130.0	5/21/84	12/13/86	7/24/85		-62.4	C	
3-220	3-220	FABRICATION	PROTO CASKS DELIVERED	.0	12/13/86	12/13/86	7/24/85		-62.4	C	
3-220	3-225	FABRICATION	RESTRAINT	.0	12/13/86	12/13/86	7/24/85		-62.4	C	
3- 15	3- 15	CASK PROC MGT	MODIFY CASK PROC PLAN	434.0	8/ 2/78	3/30/87	1/ 2/86		-62.4	C	
3- 10	3- 30	CASK PROC MGT	MONITOR CASK PROC EFFORT	434.0	8/ 2/78	3/30/87	1/ 2/86		-62.4	C	
3- 15	3- [illegible]	CASK PROC MGT	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3- 30	3-2[illegible]	CASK PROC MGT	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-225	3-230	TESTING	PERF ACCEPT TEST(PROTOTYPE)	15.0	12/13/86	3/30/87	1/ 2/86		-62.4	C	
3-225	3-235	TESTING	CORRECT DEFICIENCIES	15.0	12/13/86	3/30/87	1/ 2/86		-62.4	C	
3-230	3-235	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-235	3-240	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-240	3-240	TESTING	PROTOTYPE CASKS ACCEPTED	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-240	3-265	TESTING	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-265	3-270	CASK PROC MGT	RESTRAINT	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-270	3-270	CASK PROC MGT	LICENSED PROTO CASKS AVAIL	.0	3/30/87	3/30/87	1/ 2/86		-62.4	C	
3-270	3-275	CASK PROC MGT	DISBAND PROC MGT ACTIVITY	13.0	3/30/87	6/30/87	4/ 3/86		-62.4	C	
3-275	3-335	CASK PROC MGT	CASK PROCUREMENT COMP	.0	6/30/87	6/30/87	4/ 3/86		-62.4	C	

Table B2 (Cont'd)

SANDIA LABORATORIES
RUN 3
NETWORK CASK PROCUREMENT PLAN

PERT/TIME ACTIVITY REPORT
BY PATHS OF CRITICALITY

PAGE 2

DATA DATE 5/ 1/78
SUBNET 0

EVENT PRED	SUCC	RESP NUMBER DESCRIPTION	ACTIVITY DESCRIPTION	TIME ESTIMATE	EXPECTED START	EXPECTED FINISH	LATEST ALLOWED	ACTIV SCH DATE	SLACK	SCH SOURCE	RESP AGEN
3-275	3-2000	CASK PROC MGT	SCH END	.0	6/30/87	6/30/87	4/ 3/86	4/ 3/86	-62.4	C	
3-100	3-110	FABRICATION	INSURE AVAIL OF MATLS	4.0	11/28/80	1/ 5/81	11/ 6/79		-57.4	C	
3-120	3-373	DESIGN	INSURE INTERFACE COMP	8.0	11/24/80	2/ 2/81	12/ 5/79		-57.4	C	
3-130	3-115	FABRICATION	INSURE AVAIL-FAB CAPABILITY	4.0	1/ 5/81	2/ 2/81	12/ 5/79		-57.4	C	
3-115	3-150	FABRICATION	RESTRAINT	.0	2/ 2/81	2/ 2/81	12/ 5/79		-57.4	C	
3-100	3-105	DECOM/DISPOSAL	STUDY ACTIVATION OF CASK	4.0	11/28/80	1/ 5/81	12/ 5/79		-53.4	C	
3- 20	3- 85	DESIGN	PROVIDE DATA F/CASK INV DEF	26.0	8/ 2/78	2/12/79	2/16/78		-49.4	C	
3- 30	3- 30	DESIGN	DSN NEW/MOD CASKS	26.0	8/ 2/78	2/12/79	2/16/78		-49.4	C	
3- 85	3- 30	DESIGN	RESTRAINT	.0	2/12/79	2/12/79	2/16/78		-45.4	C	
3-150	3-150	LICENSING	PREPARE SAR	78.0	9/15/79	3/ 5/81	4/10/80		-45.4	C	
3-145	3-150	TESTING	RESTRAINT	.0	3/ 3/81	3/ 3/81	4/10/80		-45.4	C	
3- 10	3- 84	DESIGN	ASSIM/EVAL DATA	.0	8/ 2/78	8/ 2/78	2/16/78		-23.4	C	
3- 84	3- 35	DESIGN	RESTRAINT	.0	8/ 2/78	8/ 2/78	2/16/78		-23.4	C	
3-210	3-2150	FABRICATION	PLACE FOLLOW-ON ORDERS	6.0	5/21/84	7/ 3/84	7/ 3/84		.0	C	
3-215	3-215	FABRICATION	PROC SCHEDULE IS SATISFIED	.0	7/ 3/84	7/ 3/84	7/ 3/84		.0	C	
3- 10	3- 45	MAINTNC/REPAIR	DEFINE CASK MAINTENANCE RQMTS	26.0	8/ 2/78	2/12/79	8/ 4/79		26.6	C	
3- 10	3- 35	ACCDNT-RECOVER	DSN ACCIDENT SCENARIOS	26.0	8/ 2/78	2/12/79	8/ 4/79		26.6	C	
3- 35	3- 45	ACCDNT-RECOVER	RESTRAINT	.0	2/12/79	2/12/79	8/ 4/79		26.6	C	
3- 35	3-150	ACCDNT-RECOVER	RESTRAINT	.0	2/12/79	2/12/79	4/10/80		58.6	C	
3- 10	3- 35	LEGAL MATTERS	DET PUBLIC/PRIV OWNERSHIP	52.0	8/ 2/78	3/23/79	11/21/80		59.6	C	
3- 35	3- 40	LEGAL MATTERS	PRIVATE CASK-OWNERSHIP PLAN	156.0	3/13/79	3/23/81	11/30/83		59.6	C	
3- 40	3- 40	LEGAL MATTERS	PRIVATE OWNERSHIP ARRANGED	.0	3/23/82	3/23/82	11/30/83		59.6	C	
3- 40	3- 53	LEGAL MATTERS	RESTRAINT	.0	3/23/82	3/23/82	11/30/83		51.6	D	
3- 60	3- 65	MAINTNC/REPAIR	ACQUIRE/STAFF M/R FACILITY	104.0	3/23/82	10/17/84	1/ 2/85		53.6	C	
3- 65	3- 55	MAINTNC/REPAIR	M/R CAPABILITY IS FOUND	.0	10/18/84	10/18/84	1/ 2/85		53.6	C	
3- 65	3-255	MAINTNC/REPAIR	RESTRAINT	.0	10/18/84	10/18/84	1/ 2/86		53.6	C	
3-165	3-200	DESIGN	RESTRAINT	.0	3/ 3/81	3/ 3/81	3/15/82		72.0	C	
3-250	3-245	ACCDNT-RECOVER	DSN SPECIAL EQUIP/FACILITY	25.0	3/ 3/81	8/31/81	2/24/83		72.6	C	
3- 50	3- 55	MAINTNC/REPAIR	DSN MAINT/REPAIR FACILITIES	52.0	3/ 3/81	3/22/82	8/23/83		72.6	C	
3- 55	3- 60	MAINTNC/REPAIR	REV DSN OF M/R FACILITIES	13.0	3/22/82	6/22/82	11/30/83		72.0	C	
3-245	3-255	ACCDNT-RECOVER	ACQUIRE RECOVERY EQUIP	104.0	8/31/81	10/ 5/83	3/21/85		72.0	C	
3-255	3-250	ACCDNT-RECOVER	FORM/TRAIN PERSONNEL	39.0	10/ 6/83	7/13/84	1/ 2/85		72.6	C	
3-260	3-260	ACCDNT-RECOVER	CAPABILITY IS IN PLACE	.0	7/13/84	7/13/84	1/ 2/86		72.6	C	
3-240	3-265	ACCDNT-RECOVER	RESTRAINT	.0	7/13/84	7/13/84	1/ 2/86		72.6	C	
3-115	3-170	FABRICATION	DETERMINE QUALIFIED BIDDERS	8.0	2/ 2/81	3/30/81	3/24/82		73.6	C	
3-170	3-175	FABRICATION	RFQ OF PROTOTYPE CASKS	8.0	3/30/81	5/26/81	11/ 3/82		73.6	C	
3-175	3-185	FABRICATION	REVIEW BIDS	9.0	5/26/81	7/22/81	1/13/83		73.6	C	

Table B2 (Cont'd)

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SANDIA LABORATORIES                              PERT/TIME ACTIVITY REPORT                                                  PAGE     3
           RUN    3                              BY PATHS OF CRITICALITY                              DATA DATE   5/ 1/78
           NETWORK  CASK PROCUREMENT PLAN                                                                SUBNET  C

    EVENT              PART                      ACTIVITY             TIME        EXPECTED          LATEST    *ACT/ SCH               SP-    ORG/
PREC        SUCC   NUMBER  DESCRIPTION          DESCRIPTION         EST/ACT.    START     FINISH    ALLOWED     DATE      SLACK  SOURCE AGEN

 3-185      3-195  FABRICATION     FABRICATORS ARE SELECTED            .0    7/22/81   7/22/81   1/13/83                73.6     0
 3-195      3-235  FABRICATION     RESTRAINT                           .0    7/22/81   7/22/81   1/13/83                73.6     0

 3-165      3-170  DESIGN          RESTRAINT                           .0    3/ 3/81   3/ 3/81   3/14/82                76.6     0

 3-155      3-180  DECON/DISPOSAL PROC UNIQUE DISPOSAL FAC           104.0    9/ 3/81   9/ 3/83   1/ 2/86               120.6     0
 3-180      3-190  DECON/DISPOSAL CASK DISPOSAL PLAN ESTAB             .0    9/ 3/83   9/ 3/83   1/ 2/86               120.6     0
 3-190      3-255  DECON/DISPOSAL RESTRAINT                            .0    9/ 3/83   9/ 3/83   1/ 2/86               120.6     0

 3-245      3-250  ACCDNT-RECOVER DSN DTL RECOVERY PLANS             52.0    3/10/81   3/23/82   3/21/85               124.6     0
 3-250      3-255  ACCDNT-RECOVER RESTRAINT                            .0    3/23/82   3/23/82   3/21/85               124.6     0

 3- 75      3- 80  INVENTORY DEF   DEFINE CASK INV REQMNTS      [illegible]   5/14/79   5/27/80   2/24/83               137.6     0
 3- 80      3-210  INVENTORY DEF   RESTRAINT                           .0    5/27/80   5/27/80   2/24/83               137.6     0

 3- 95      3-230  ACCDNT-RECOVER DETERMINE EQUIP NEEDS              26.0    2/12/79   8/15/79   8/16/82               150.6     0

 3- 40      3-255  LEGAL ISSUES    RESTRAINT                           .0    3/23/82   3/23/82   1/ 2/86               163.6     0

 3- 10      3- 25  LEGAL ISSUES    ACCIDENT/LIABILITY OPTIONS        26.0    3/ 2/78   2/12/79  11/30/83               241.6     0
 3- 25      3- 30  LEGAL ISSUES    IMPLEMENT LIABILITY METHODS      104.0    2/12/79   3/ 3/81   1/ 2/86               241.6     0
 3- 30      3- 30  LEGAL ISSUES    LIAB PROTECTION ESTABLISHED         .0    3/ 3/81   3/ 3/81   1/ 2/86               241.6     0
 3- 30      3-255  LEGAL ISSUES    RESTRAINT                           .0    3/ 3/81   3/ 3/81   1/ 2/86               241.6     0
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