ORNL/Sub/86-SA094/2
ORNL/Sub/86-SA224/2
HR/JAI-289

ornl

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Use of Transportable Storage Casks in the Nuclear Waste Management System

Appendices

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

DISCLAIMER

ORNL/Sub/86-SA094/2
ORNL/Sub/86-SA224/2
HR/JAI-289
Dist. Categories UC-71, -85

USE OF TRANSPORTABLE STORAGE CASKS IN THE NUCLEAR WASTE MANAGEMENT SYSTEM

Appendices

December 1987

Program Sponsored by the Office of Civilian Radioactive Waste Management Systems Integration Program

ORNL/Sub--86-SA094/2

DE88 007846

Prepared by

H&R Technical Associates, Inc.
545 Oak Ridge Turnpike
Oak Ridge, Tennessee 37831

E. R. Johnson Associates, Inc.
10461 White Granite Drive, Suite 204
Oakton, Virginia 22124

Under Subcontract Numbers 41X-SA094V and 30X-SA224V

for

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

LIST OF APPENDICES

APPENDIX A

ESTIMATED CAPITAL COSTS FOR METAL AND CONCRETE STORAGE CASKS

APPENDIX A

ESTIMATED CAPITAL COSTS FOR METAL AND CONCRETE STORAGE CASKS

TABLE OF CONTENTS

APPENDIX A

ESTIMATED CAPITAL COSTS FOR METAL AND CONCRETE STORAGE CASKS

The purpose of this Appendix is to develop an estimate of the capital cost of metal and concrete storage casks so that the capital costs associated with the use of a TSC for at-reactor storage can be compared with those of using a SOC and a concrete cask.

1.0 METAL CASKS (STORAGE ONLY)

This section discusses the capital costs associated with metal casks that are designed and licensed for at-reactor storage of spent fuel. It was assumed that at the time of their design and licensing, no attempt would be made to certify them for use as a transport casks even though they may be able to be used for a one-time shipment or placed in a protective package and shipped at the end of the storage period.

Discussions were held with two separate designers of metal storage casks to obtain the current estimated costs for such casks. One firm estimated that a metal cask designed for storage-only of 24 PWR or 52 BWR assemblies would cost about $1.05-million (1987 dollars). A second cask designer estimated the cost for a 21 PWR assembly cask at $1.0-million (1987 dollars); this cask could accommodate as many as 57 BWR assemblies. Included in these costs was the cost of performing the initial design of the cask and the project management activities associated with the cask design and fabrication effort (licensing, quality assurance, etc.). These costs are summarized in Table A-1.

TABLE A-1

ESTIMATED COST OF DESIGN AND LICENSING OF SOCs

($000, 1987)

Description	First Two Casks	Each Additional Cask
Design and Engineering	$ 534	-
Project Management & Licensing	600	$ 32
Total	$1,134	$ 32

For the purposes of this study, it was assumed that a storage cask having a capacity for storing 21 PWR assemblies or 46 BWR assemblies would cost $1.0-million (1987 dollars). This was believed to represent a conservative composite of the cost estimates obtained from cask design firms. Moreover, it was assumed that this cost assumed that the design and initial production costs were to be written off over the first 8 casks produced. This would put the cost of a cask, before design and initial production costs were added, at about $830-thousand. Assuming that the cost of procurement management, fabrication follow and the like would amount to 10 percent of the cost of fabrication, the actual cost of the fabrication would then amount to about $755-thousand. This compared favorably with an independent estimate of the cost of cask manufacture developed during the course of the study.

The prospective reduction of fabrication costs as more casks are produced was considered. The nodular iron cask costs described by Sorenson in Reference (1) and the Transnuclear cost data shown in Reference (2) were subjected to several curve fitting analyses. As a result, the following algorithm was developed which shows the relationship of cask fabrication cost to the number of casks that have been produced:

$$C_n = C_i n^{-.046}$$

where: C_n = cost of the nth cask produced

C_i = cost of the initial cask produced

By using the foregoing relationship, and writing off the design and development costs over the first 10 casks produced, the cost of SOCs were calculated for various stages in the "learning curve", as shown in Table A-2.

TABLE A-2

ESTIMATED COSTS FOR SOCs

(1987 Dollars)

	Average Cost of SOC ($000)				SOC Capacity (MTU)		Cost/Unit Capacity ($/kgU)	
	Design & Licensing	Fabric-ation	Admin & Procure-ment	Total	Intact Fuel[a]	Con-solidated Fuel[b]	Intact Fuel	Con-solidated Fuel
First 10 Units[c]	139	747	75	961	9.26	15.37	103.8	62.5
50th Unit	-	668	67	735	9.26	15.37	79.4	47.8
100th Unit	-	647	65	712	9.26	15.37	76.9	46.3
500th Unit	-	601	60	661	9.26	15.37	71.4	43.0

[a] Weighted average based on a cask capacity of 21 PWR or 46 BWR assemblies, a 2/1 weight ratio of PWR to BWR fuel, and 461 kgU/PWR assembly and 183 kgU/BWR assembly

[b] Assumes fuel rods are consolidated and structural parts are compacted so together there is a net compaction ratio of 1.66

[c] Assumes fabrication cost for first cask produced is $800-thousand.

2.0 TRANSPORTABLE STORAGE CASKS

This section discusses the capital costs associated with metal casks that are designed and licensed for at-reactor storage of spent fuel and are certified for use as transport casks at the time they are manufactured.

Discussions were held with three separate designers of casks. One firm estimated that an additional $300-thousand would be required to make its SOC certifiable for transport, because a more rugged design would be required for the baskets involved. A second designer believed that the basket used in connection with its cask was sufficiently rugged for use in transport service, and that no additional cost would be required to make its SOC certifiable for transport. A third designer believed that a TSC would cost about $100-thousand more than a SOC. Therefore, for the purposes of this study it was assumed that the fabrication cost (net of design, licensing, administration and procurement costs) for the first TSC produced would be $100-thousand higher than a corresponding SOC (as described in Section 1.0 of this Appendix A), or $900-thousand, to cover the added cost of manufacturing a cask of somewhat more rugged design than a SOC. It was assumed that the same algorithm that was developed for fabrication of SOCs in Section 1.0 of this Appendix A would be applicable for the fabrication of TSCs. However, in this case, in addition to the cost fabrication, it was assumed that 10 percent would have to be added for administration and procurement activities increasing the costs therefor to $990-thousand. Moreover, it was also assumed that design and certification of the TSC would have to be added for the foregoing cost.

Both EG&G and one cask designer estimated the cost of engineering and certification of a TSC at about $3.0-million (1986 dollars); this would amount to about $3.2-million in 1987 dollars. In a study performed for DOE in 1983-1985, Transnuclear, Inc. (TNI) estimated the cost of design and certification of a transport cask at about $3.5-million in 1985 dollars (Reference (1)). As a result of a review of the latter costs, it was concluded that they would also be applicable to the design and certification of a TSC. The personnel-related costs associated with the foregoing TNI estimate were escalated by 6.6 percent, and the cost of machinery and equipment included in the estimate was escalated by 5 percent, to convert the costs to 1987 dollars. These cost estimates for the design and certification of TSCs, are summarized in the following Table A-3.

TABLE A-3

ESTIMATED COST OF DESIGN & CERTIFICATION OF TSCs

($000, 1987)

Description	First Two Casks	Each Additional Cask
Design & Engineering	$ 858	$ -
Testing & Certification	1,192	-
Procurement Activities Associated With Prototype	103	-
Fabrication Follow Associated with Prototype	91	-
Project Management & Licensing	1,450	32
Total	$3,694	$ 32

Applying the algorithm that was developed in Section 1.0 of this Appendix A to the cost of fabrication of a TSC, 10 percent of the cost of fabrication for procurement management and fabrication follow, and writing off the design and certification costs over the first 10 casks produced, the costs of TSCs were calculated for various stages of the "learning curve", as shown in Table A-4.

TABLE A-4

ESTIMATED COSTS FOR TSCs

(1987 Dollars)

	Cost of TSC ($000)				TSC Capacity (MTU)		Cost/Unit Capacity ($/kgU)	
	Design & Licensing	Fabric-ation	Admin & Procure-ment	Total	Intact Fuel[a]	Con-solidated Fuel[b]	Intact Fuel	Con-solidated Fuel
First 10 Units[c]	$395	$840	$84	$1,319	9.26	15.37	$142.4	$85.8
50th Unit	-	752	75	827	9.26	15.37	89.3	53.8
100th Unit	-	728	73	801	9.26	15.37	86.5	52.1
500th Unit	-	676	68	744	9.26	15.37	80.3	48.4

[a] Weighted average based on a cask capacity of 21 PWR or 46 BWR assemblies, a 2/1 weight ratio of PWR to BWR fuel, and 461 kgU/PWR assembly and 183/BWR assembly

[b] Assumes fuel rods are consolidated and structural parts are compacted so together there is a net compaction ratio of 1.66

[c] Assumes fabrication cost for first cask produced is $900-thousand.

3.0 CONCRETE STORAGE CASKS

This section discusses the capital costs associated with concrete storage casks, designed and licensed for at-reactor storage. While it was not the basic purpose of this study to perform a comparative assessment of the use of metal storage casks and concrete storage modules, it was necessary to make an assessment of any increased costs a utility might incur in using TSCs over other dry storage alternatives that could be used at reactor sites in order to properly determine the extent to which the use of a TSC was viable. The viability of use of TSCs relies on the cost (and other) advantages to the combined utility/DOE spent fuel management system at least offsetting the disadvantages involved.

Discussions were held with Nuclear Packaging Inc. (NUPAC) and NUTECH, Inc. regarding estimated costs of storage of spent fuel in concrete storage modules.

As a result of these discussions it was assumed that the concrete storage cask would have a capacity for storing 9 PWR assemblies or 25 BWR assemblies, for an average capacity of 4.291 MTU/cask. The cost of the first cask built was estimated at $150-thousand and the design and development cost of the cask and its loading and unloading equipment was estimated to be $1.75-million.

A learning curve similar to that described in Section 1.0 of this Appendix A for metal storage casks was applied to the cost of manufacture of concrete casks, even though such may not be as dramatic inasmuch as concrete casks will probably be produced near the location they are used. This means there are likely to be many more locations producing concrete casks than metal casks, with limited numbers being produced at any given location. However, the same learning curve effect was used for concrete casks as for metal casks since it was assumed that the designer would procure the concrete cask fabrication services and would pass along his fabrication knowledge to the fabricator.

The cost of concrete storage casks were calculated for various stages in the learning curve as shown in Table A-5.

TABLE A-5

ESTIMATED COSTS FOR CONCRETE STORAGE CASKS

(1987 Dollars)

	Cost of Concrete Cask ($000)				Concrete Cask Capacity (MTU)		Cost/Unit Capacity ($/kgU)	
	Design & Licensing	Fabric-ation	Admin & Procure-ment	Total	Intact Fuel[a]	Con-solidated Fuel[b]	Intact Fuel	Con-solidated Fuel
Average for								
First 22 Units[c]	$ 80	$136	14	230	4.29	7.12	$ 53.6	$32.3
108th Unit	-	121	12	133	4.29	7.12	31.0	18.7
216th Unit	-	117	12	129	4.29	7.12	30.1	18.1
1079th Unit	-	108	11	119	4.29	7.12	27.7	16.7

[a] Weighted average based on a cask capacity of 9 PWR and 25 BWR assemblies, a 2/1 weight ratio of PWR to BWR fuel, and 461 kgU/PWR assembly and 183 kgU/BWR assembly

[b] Assumes fuel rods are consolidated and structural parts are compacted so together there is a net compaction ratio of 1.66

[c] Assumes fabrication cost for first cask produced is $150-thousand.

In addition to the concrete casks, it is necessary for a utility to have a means of transferring the spent fuel from the reactor pool to the cask loading area, and for loading the casks. This requires a transfer cask, a plug cask, a loading collar, and a platform on which the operations are conducted. This type of equipment is currently in use at Three Mile Island for loading of a transport cask with canisters of fuel material that has been recovered from the reactor. In this case the pool water is too heavily contaminated to load the transport cask in the pool. In the case of concrete casks it has been assumed that these will have to be loaded outside the pool. The cost of the equipment was estimated at about $1.0-million (1987 dollars). It was assumed that $750-thousand of this equipment could be leased from a service company, but that $250-thousand would represent a needed capital investment by the utility.

The cost of leasing the loading equipment was estimated to be $1.45/kgU for intact fuel assemblies and $1.26/kgU for consolidated fuel. This is based on the following assumptions:

(1) Annual revenue requirements of the lessor for use of the equipment would be $226.4-thousand, assuming:

  (a) a 15 percent discounted cash flow return on investment after taxes
  (b) a 10-year depreciation period
  (c) a 45 percent Federal tax rate
  (d) a 6 percent state tax rate
  (e) property taxes and insurance at $1/$100 valuation

(2) The equipment would be used at 6 different reactor sites during the year for intact fuel assemblies or 7 different sites during the year for consolidated fuel; 28 MTU of spent fuel would be loaded at each site

(3) It would cost $3,000 to move the equipment between sites

(4) Set up and takedown time would amount to 7 days each, shipping time would amount to 7 days, 6.7 days would be required for loading an annual discharge of intact fuel assemblies, 4.5 days would be required for loading an annual discharge of consolidated fuel, and a 50% utilization efficiency would be realized for the use of the casks.

In addition to the costs shown in Appendix B for operations at the reactor, there is a total capital cost of $395-thousand required in connection with the use of the concrete cask at a reactor site, $145-thousand of which is for canning equipment and $250-thousand which is for loading equipment.

It should be pointed out that there has been little demonstration work performed to date on the viability of the use of concrete storage modules for at-reactor storage of spent fuel. While there is no apparent reason why such storage would not prove feasible from an operating standpoint, the costs associated with such storage are less certain than those involved in the use of metal storage casks.

4.0 REFERENCES FOR APPENDIX A

(1) K. B. Sorenson, Cask Materials Cost Comparison Report, Sandia National Laboratories, October 17, 1986

(2) E. R. Johnson Associates, Inc., Assessment of the Use of a Multi-Purpose and Centralized Facility for the Disassembly and Packaging of Spent Nuclear Fuel to Support the Various Segments of the DOE Waste Management System, JAI-254, DOE Contract No. DE-AC01-84RW00037

APPENDIX B

ESTIMATED COST OF HANDLING OPERATIONS AT THE REACTOR SITE INVOLVING SPENT FUEL DRY STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS

APPENDIX B

ESTIMATED COST OF HANDLING OPERATIONS AT THE REACTOR SITE INVOLVING SPENT FUEL DRY STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS

TABLE OF CONTENTS

APPENDIX B

ESTIMATED COST OF HANDLING OPERATIONS AT THE REACTOR SITE INVOLVING SPENT FUEL DRY STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS

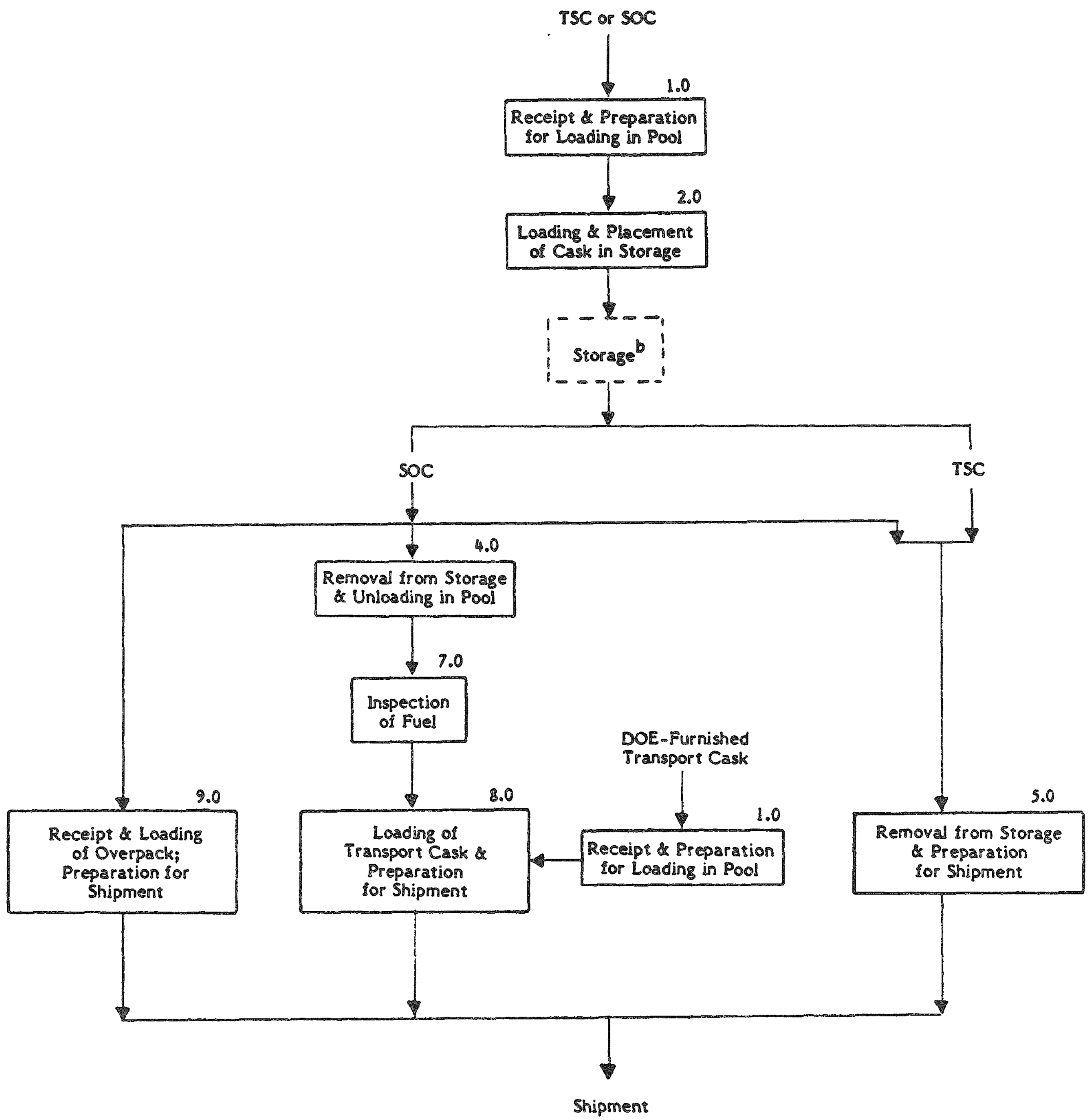
There are a number of costs that would be associated with the handling of TSCs, SOCs, concrete storage casks, DOE-furnished transport casks, and overpacks for SOCs (assuming that SOCs would be shipped in overpacks), at the reactor site. In this Appendix estimates of the costs associated with the at-reactor handling of TSCs, SOCs and concrete storage casks and their contents have been developed, along with estimates of the costs involved for receipt, loading and shipping of DOE-furnished transport casks, and overpacks for SOCs.

The various operations involved with the handling of TSCs, SOCs, and concrete storage casks at the reactor site are summarized in the flowsheets shown in Figure B-1 and B-2. Figure B-1 shows the operations associated with the use of TSCs as well as SOCs; three different options have been shown for the use of SOCs including:

- unloading of SOCs and loading of the contents thereof into DOE-supplied shipping casks
- direct shipment of SOCs to DOE (use in a single transport)
- direct shipment of SOCs to DOE after placing the SOC in a NRC-approved overpack

Figure B-2 shows the operations associated with the use of concrete storage casks.

The cost for the various handling operations described in Figures B-1 and B-2 were estimated in 1987 dollars. In developing these cost estimates for operations involving metal casks (TSCs, SOCs and DOE-furnished transport casks), the study made use of previous work performed by Pacific Northwest Laboratories (PNL) which included a detailed time and motion analysis of the activities involved in the receipt, loading, decontamination, testing and shipment of transport casks (Reference (1)), many of which are applicable to the use of TSCs and SOCs. In developing cost estimates for the

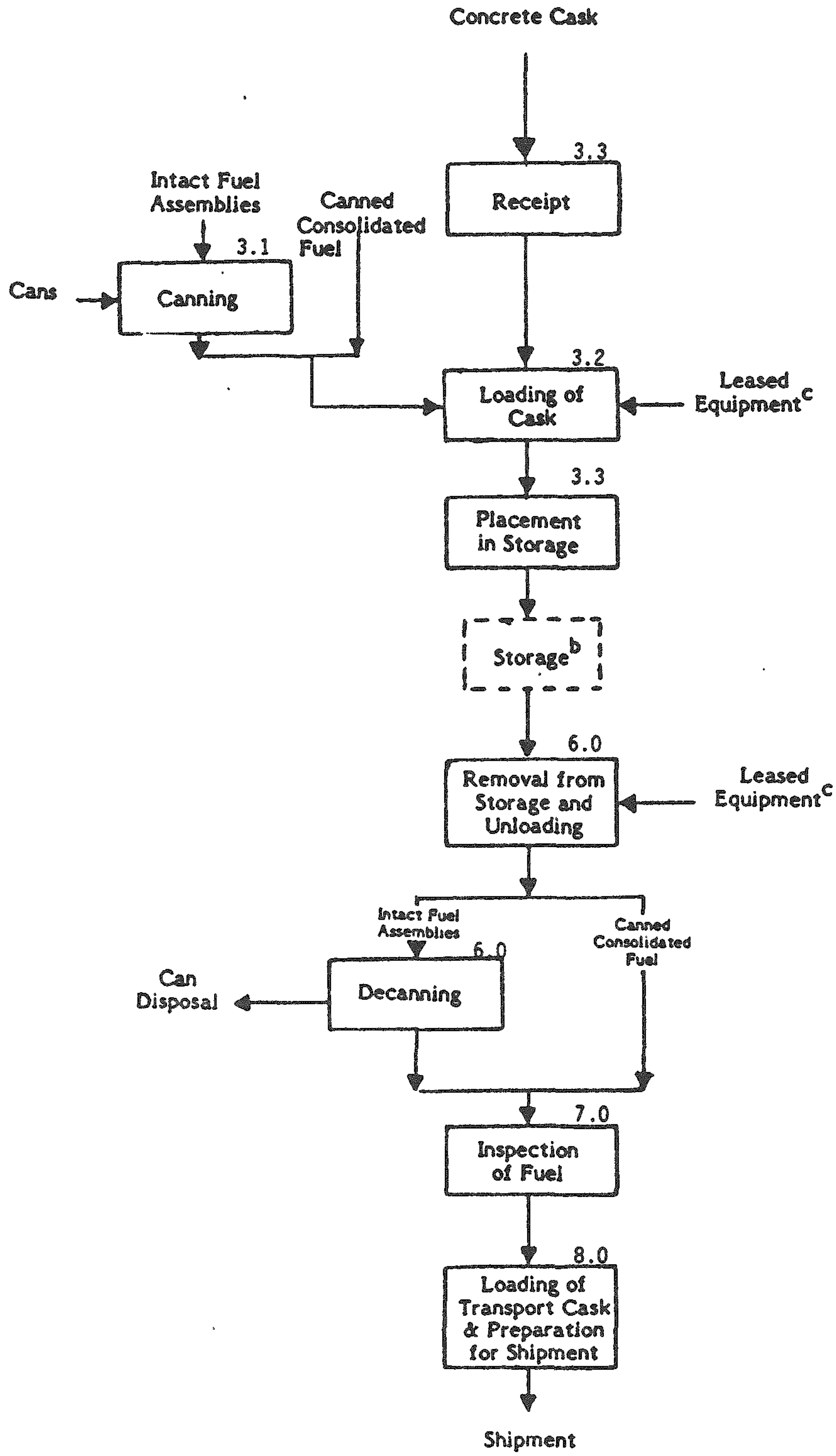


a Numbers on upper right hand corner of box are Section numbers in Appendix B in which costs are developed.

b Costs associated with storage were not included in this estimate.

FIGURE B-1

SUMMARY OF OPERATIONS ASSOCIATED WITH THE HANDLING OF METAL STORAGE CASKS AT REACTOR SITES[a]



a Numbers on upper right hand corner of box are Section numbers in Appendix B in which costs are developed.

b Costs associated with storage were not included in this estimate.

c Part of the equipment necessary for loading of casks was leased and the cost thereof was included in these estimates.

FIGURE B-2

SUMMARY OF OPERATIONS ASSOCIATED WITH THE HANDLING OF CONCRETE STORAGE CASKS AT REACTOR SITES[a] canning of spent fuel, inspection, and loading/unloading of a concrete storage cask, the study made use of previous work performed by E. R. Johnson Associates, Inc. (JAI) for PNL as well as the experience which has been gained recently at Three Mile Island in the dry loading of canisters of irradiated fuel pieces into a shipping cask. In developing cost estimates for the loading of an overpack containing a SOC onto the transport vehicle, the study made use of the 1986 FIS Fee Study (Reference (2)) for time requirements for riggers as well as crane rental costs.

In addition to the foregoing, the following assumptions formed the basis for the cost estimates developed:

(1) Operating costs were based on an assumed rate of $63/hour for plant operators, which covered the cost of wages, supervision, overhead and operating supplies.

(2) The capacity of TSCs, SOCs and DOE-furnished transport casks was assumed to be 21 PWR assemblies or 46 BWR assemblies, or the same number of cans of consolidated spent fuel.

(3) The capacity of concrete storage casks was assumed to be 9 PWR assemblies or 25 BWR assemblies, or the same number of cans of consolidated spent fuel.

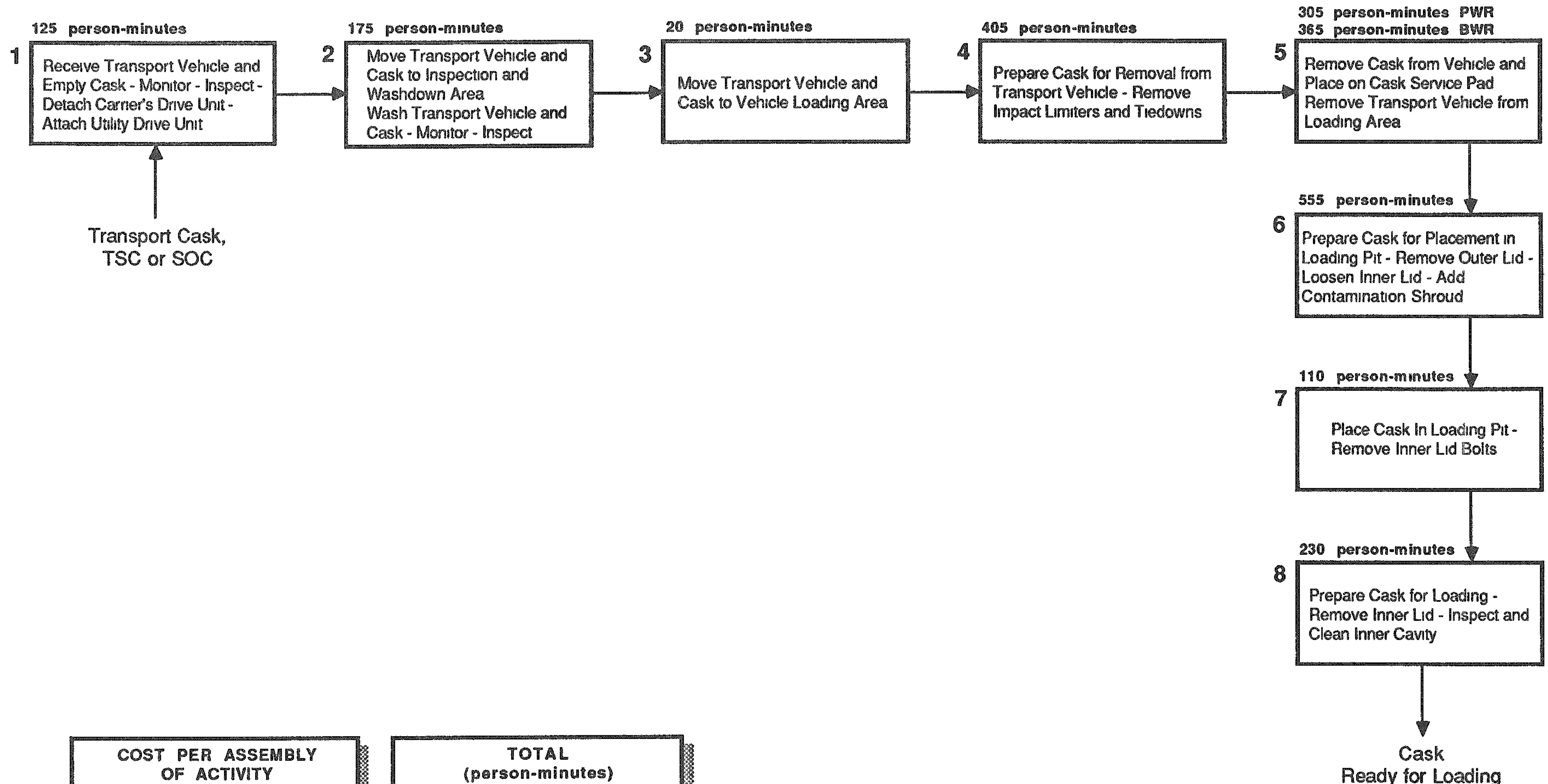
(4) Where consolidated spent fuel was involved, it was assumed that consolidation of 10 fuel assemblies would result in 5 cans of fuel rods and 1 can of compacted structural parts, with each can having a slightly larger cross section than the fuel assembly from which the consolidated fuel originated (about 9-inches x 9-inches for PWR fuel and 6-inches x 6-inches for BWR fuel).

(5) The reactor has a capability for handling a 120-ton loaded cask. (If a reactor does not have such a capability, a costly dry transfer system would be required.)

The following sections describe the details of the cost estimates that were made.

1.0 ESTIMATED COST OF RECEIPT OF DOE-FURNISHED TRANSPORT CASKS OR METAL STORAGE CASK AND PREPARATION FOR LOADING

The various steps involved in the receipt of a transport cask, TSC or SOC, placing it in the reactor pool, and preparing it for the loading of spent fuel assemblies or cans, is shown in Figure B-3, along with the



COST PER ASSEMBLY OF ACTIVITY
PWR - $96.3/Assembly or can
BWR - $45.3/Assembly or can

TOTAL (person-minutes)
PWR - 1925 person-minutes
BWR - 1985 person-minutes

Figure B-3

Operations To Receive And Prepare Transport Casks Or Metal Storage Casks For Loading Spent Fuel At The Reactor Site corresponding operating labor time requirements. At $63/person-hour the cost amounts to $2,021 for a cask for PWR fuel ($96.3/assembly or can), and $2,084 for a cask for BWR fuel ($45.3/assembly or can). This represents an average of $0.22/kgU contained in fuel assemblies, based on an assumed mix of two thirds of the weight of uranium handled being in the form of PWR fuel assemblies and containing 461 kgU, and one third of the weight of uranium handled being in the form of BWR assemblies and containing 183 kgU. For consolidated fuel the average cost is $0.13/kgU.

2.0 ESTIMATED COST OF LOADING A TSC OR SOC AND PLACEMENT IN STORAGE

The various steps involved in removing the spent fuel from the storage pool, loading it into TSCs or SOCs, removal of the cask from the pool, and transferring it to the storage area at the reactor site, are shown in Figure B-4, along with the corresponding operating labor time requirements. The costs involved amount to $3,392 for a cask loaded with PWR fuel ($161.5/assembly or can), and $5,423 for a cask loaded with BWR fuel ($117.9/assembly or can). This represents an average of $0.45/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.27/kgU for consolidated fuel.

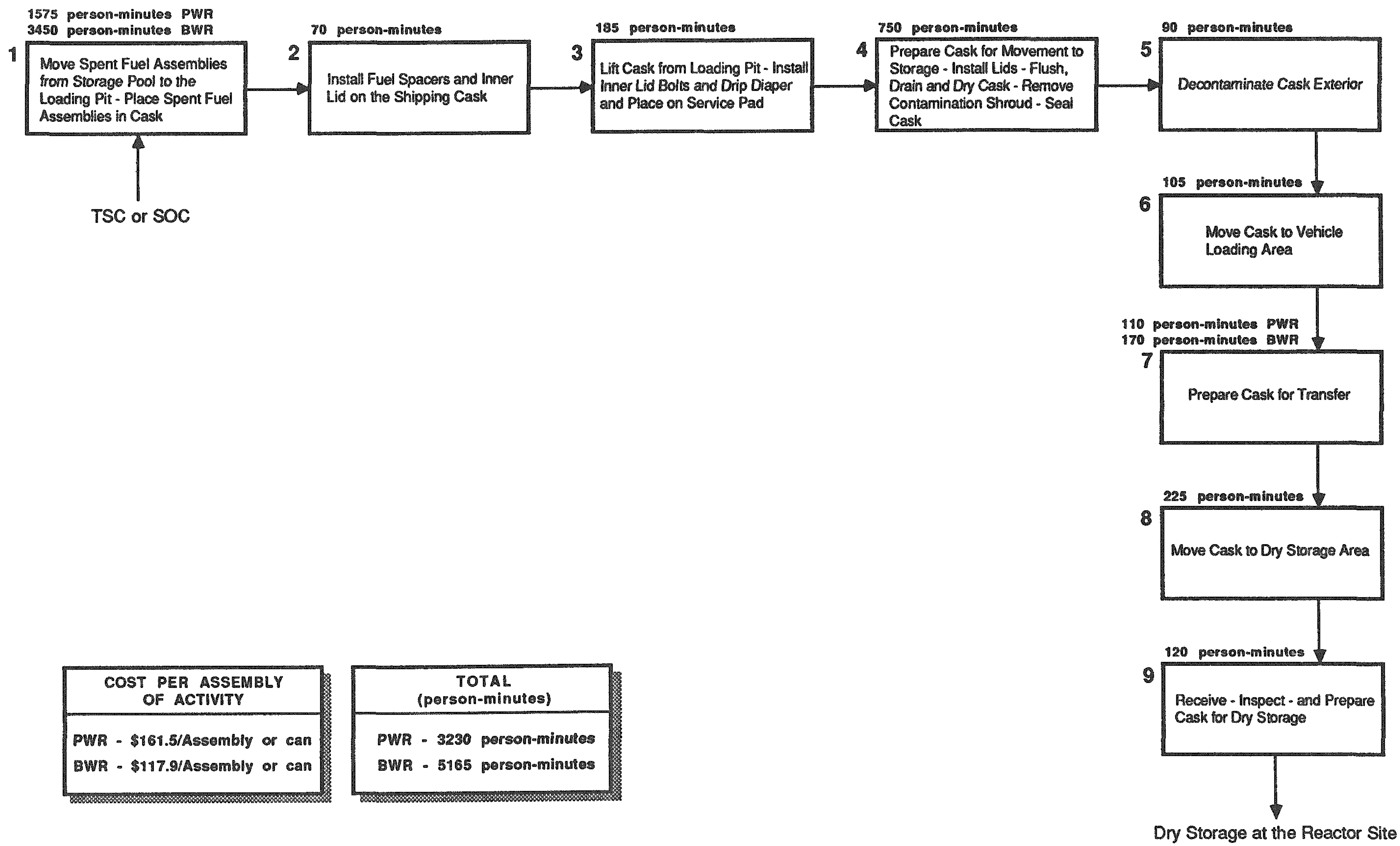


Figure B-4

Operations To Transfer Spent Fuel From The Fuel Pool To A TSC Or SOC And Move The Cask To The Dry Storage Area

3.0 ESTIMATED COST OF LOADING A CONCRETE CASK AND PLACEMENT IN STORAGE

In developing the estimated costs for loading a concrete cask and placing it in storage, the following assumptions were made:

(1) the concrete cask would be loaded vertically

(2) the cask could not be loaded in the reactor pool but would rather have to be loaded outside the pool using a transfer cask

(3) the cask would be brought from a nearby fabrication location, loaded close to the reactor building and heavy-hauled to its storage pad

(4) the spent fuel would have to be canned prior to placing it in the cask.

The following sections describe the estimated cost for cask loading and placement in storage.

3.1 ESTIMATED COST OF CANNING

The estimated capital costs associated with a canning station for spent fuel assemblies or for consolidated fuel are set forth in Table B-1.

TABLE B-1

ESTIMATED CAPITAL COST FOR CANNING STATION EQUIPMENT

($000, 1987)

Description	Cost
Canister Rack	$ 7.3
Jib Hoist	10.3
Tools	13.3
Purge System	25.8
Inert Gas Backfill System	4.5
	61.2
Modifications to Pool	22.1
Equipment Installation	29.2
	112.5
Engineering	13.6
	126.1
Contingency (15%)	18.9
Total	$ 145.0

These costs were derived from estimates developed in Reference (3) and escalated to 1987 using the Machinery and Equipment index. These captial costs would be incurred by a utility separately from the operating costs otherwise estimated in this Appendix B, Section 3.0.

The estimated cost of canisters for canning of spent fuel assemblies and consolidated fuel are set forth in Table B-2.

TABLE B-2

ESTIMATED COST OF CANISTERS

(1987 Dollars)

Description		Cost
Materials		$ 778
SS Sheet & Plate	459	
Flange Nuts & Bolts	83	
Purge Lines & Fittings	156	
Gasket & Miscellaneous	80	
Fabrication		2,074
Can & Base Plate	1,555	
Top Plate	363	
Flange	156	
Quality Assurance		518
		$ 3,370
Contingency (15%)		506
Total		$ 3,876

These costs were also derived from estimates developed in Reference (3) and escalated to 1987. These costs represent an average of $9.03/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B). No incremental cost of canisters is required for consolidated fuel inasmuch as it would have already been canned as part of the consolidation process.

The labor requirements for canning were estimated in Reference (3) to be 3.4 person hours per canister. Thus, the costs involved amount to $223/canister, including an allowance for incremental utility costs. This cost represents an average of $0.52/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B).

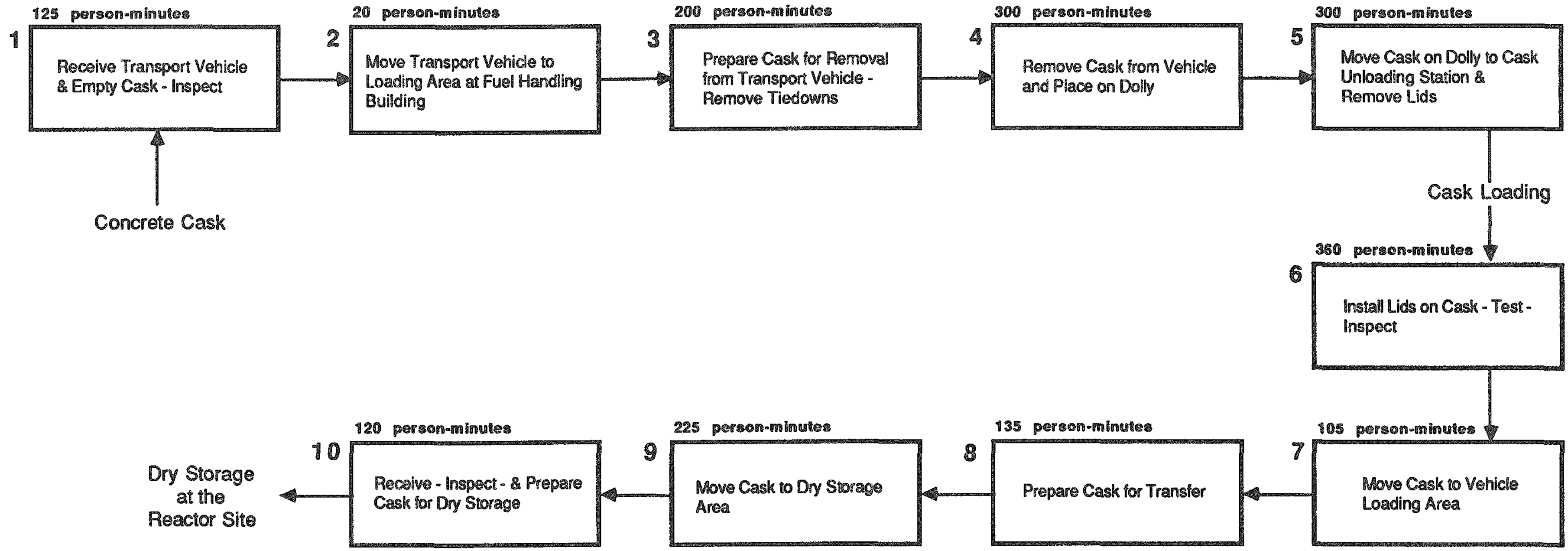
3.2 ESTIMATED COST OF LOADING CONCRETE CASKS

Members of the project team involved in this study visited the Three Mile Island (TMI) nuclear power plant to observe the transfer of canisters of recovered fuel rubble from Unit No. 2 from the spent fuel storage pool to a transport cask located outside of the pool, inasmuch as this involved the same type of operations visualized for loading the concrete casks. During the course of the visit it was learned that TMI had been successful in performing a single transfer operation in 2 hours using a crew of 10 operators. While this is considered to be better than average performance by TMI, for the purposes of this study it was considered to be achievable in routine operations involving intact spent assemblies or consolidated fuel which did not involve transfer of highly contaminated items such as that involved at TMI.

Thus, the labor requirements for the transfer of a can containing 1 PWR assembly, 2 BWR assemblies, or consolidated fuel from a reactor storage pool to a concrete storage cask was estimated to be 20 person hours; the costs involved amount to $1,300/canister, including an allowance for incremental utility costs. These costs represent an average of $3.03/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0), and an average of 1.70/kgU for consolidated fuel.

3.3 ESTIMATED COST OF RECEIPT OF CONCRETE CASK, CLOSURE AFTER LOADING, AND PLACEMENT IN STORAGE

The various steps involved in receiving the concrete cask at the reactor site, closure and inspection after loading, and transfering it to the storage area, are shown in Figure B-5 along with the corresponding operating labor time requirements. The costs involved amount to $1,985/cask. This cost represents an average of $0.46/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.29/kgU for consolidated fuel.



COST PER ASSEMBLY OF ACTIVITY
PWR - $210/Assembly or can
BWR - $75.6/Assembly or can

TOTAL (person-minutes)
1890 person-minutes

Figure B-5

Operations To Receive Concrete Cask, Close After Loading, And Move The Cask To The Dry Storage Area

4.0 ESTIMATED COST OF REMOVAL OF A SOC FROM STORAGE AND UNLOADING IN REACTOR POOL

The various steps involved in removal of a SOC from the dry storage area at the reactor site, placing it in the unloading pool, and unloading the contents thereof, are set forth in Figure B-6, along with the corresponding operating labor time requirements. The costs involved amount to $2,388 for a cask loaded with PWR fuel ($113.8/assembly or can), and $3,239 for a cask loaded with BWR fuel ($70.4/assembly or can). This represents an average of $0.29/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.18/kgU for consolidated fuel.

5.0 ESTIMATED COST OF REMOVAL OF A TSC FROM STORAGE AND PREPARATION FOR SHIPMENT

The various steps involved in removal of a TSC from the dry storage area at the reactor site, and preparing it for shipment to DOE, are set forth in Figure B-7 along with the corresponding operating labor time requirements. The costs involved amount to $1,150. This represents an average of $0.12/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.08/kgU for consolidated fuel.

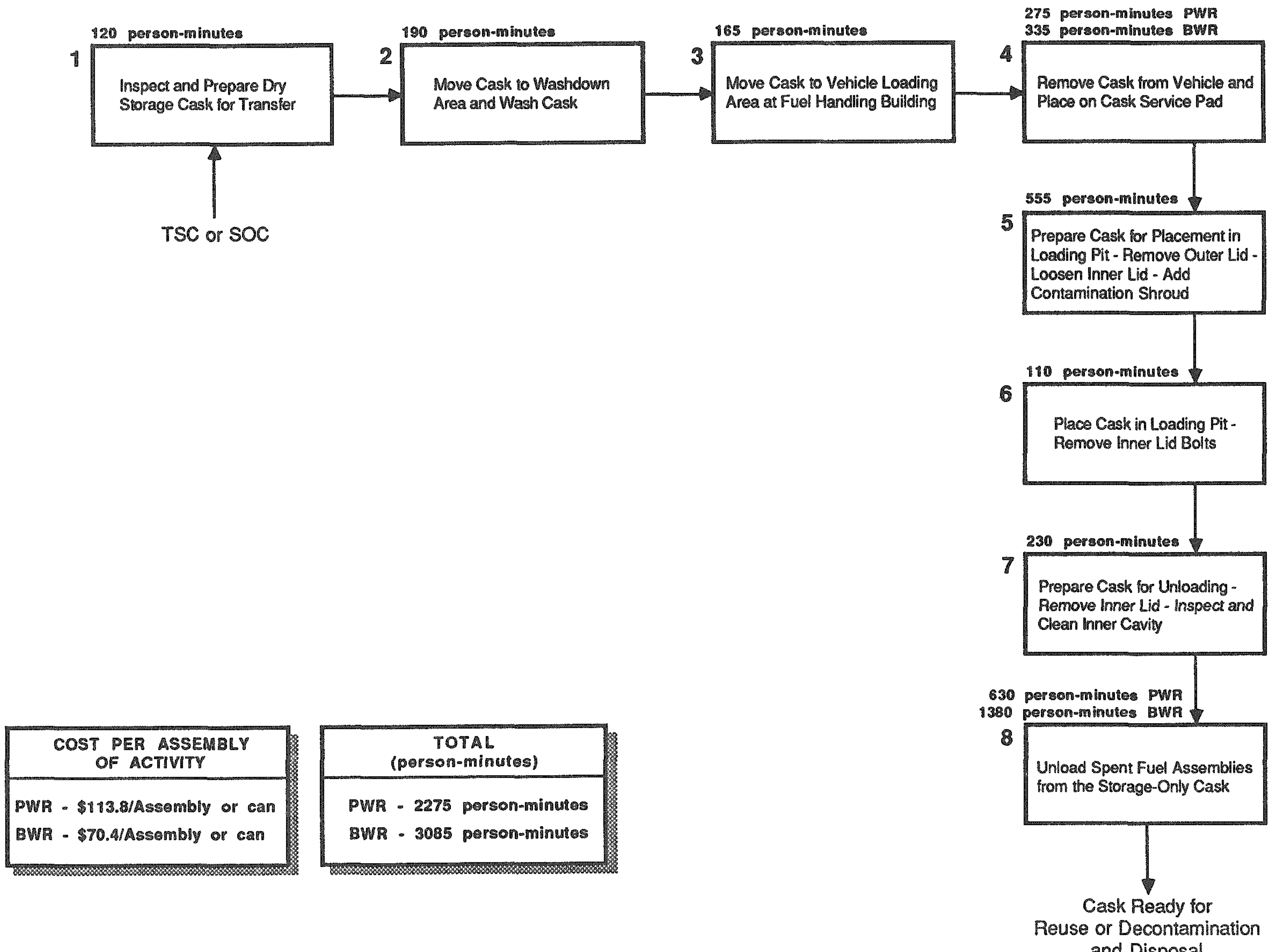


Figure B-6

Operations To Move A TSC Or SOC From The Dry Storage Area To The Fuel Pool and Unload Spent Fuel Into The Pool

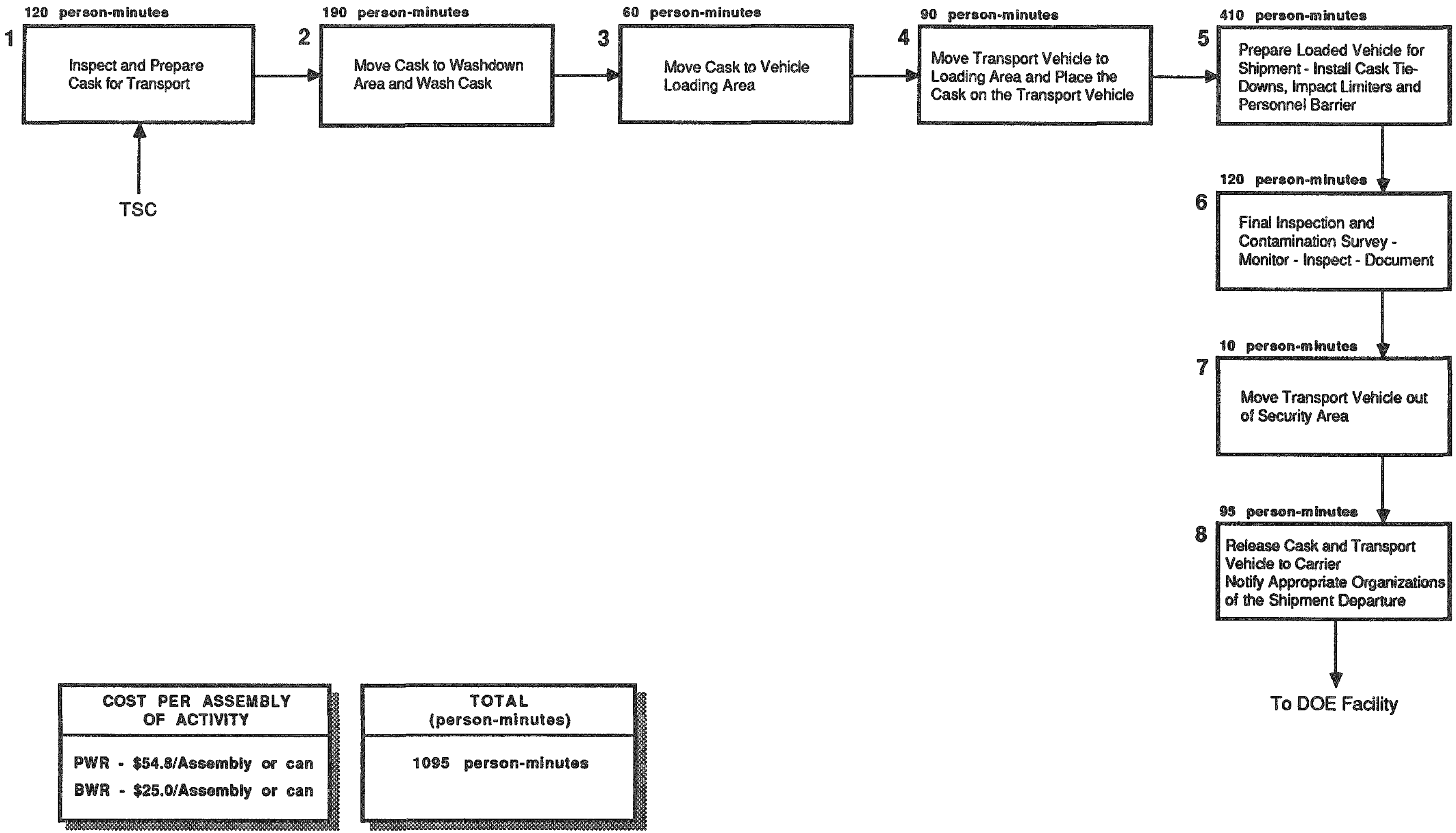


Figure B-7

Operations To Remove TSC From Storage And Prepare For Shipping From The Reactor Site

6.0 ESTIMATED COST OF REMOVAL OF A CONCRETE CASK FROM STORAGE AND UNLOADING

The various steps involved in removal of a concrete cask from the dry storage area at a reactor site are shown in Figure B-8. The costs involved amount to $929/cask. This represents an average of $0.22/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.13/kgU for consolidated fuel.

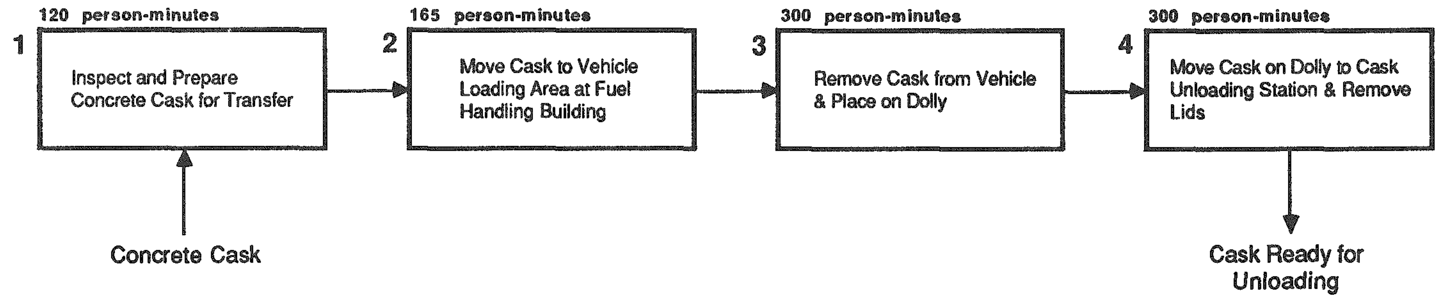
The cost of unloading cans from the concrete casks and the removal of the fuel from the cans was assumed to be the same as for loading the casks (see Section 3.2 of this Appendix B) and canning the fuel (see Section 3.1 of this Appendix B), respectively. Of course, in this instance there would be no cost for canisters nor any capital costs for equipment since it would have been purchased earlier in connection with the canning operation. The leased equipment described in Section 3.0 of Appendix A ($750-thousand for a portion of the transfer equipment) would be required again, and the cost thereof incurred during unloading of the concrete casks. This amounted to $1.45/kgU for intact fuel assemblies and $1.26/kgU for consolidated fuel.

However, it was assumed that the cans used for intact fuel would have to be disposed of after use. The cost of disposal of cans was estimated as follows:

(1) It was estimated that a canister had about 0.5 cu.ft. volume of metal and that it could be compacted so that when packaged the net packing efficiency would be 50 percent.

(2) It was assumed that each canister would be capable of holding 1 PWR assembly or 2 BWR assemblies.

(3) It was estimated that the cost of crushing and packaging a can would amount to $250 and that the cost of shipping to a disposal site would amount to $200.



COST PER ASSEMBLY OF ACTIVITY
PWR - $103/Assembly or can
BWR - $37/Assembly or can

TOTAL (person-minutes)
885 person-minutes

Figure B-8

Operations To Move A Concrete Cask From The Dry Storage Area To The Fuel Handling Building

(4) It was estimated that the cost of disposal of a can at a low level waste burial site would be $40, based on Chem-Nuclear Systems, Inc. schedule of charges for 1987 (Reference (4)). This is based on an average of 1 cubic foot/can and the following rates:

Standard Waste	$31.50/cu.ft.
Extended Care Fund	2.80
South Carolina Low Level Radioactive Waste Disposal Tax	4.00
Southeast Regional Compact Fee	0.84
Barnwell County Business License Tax (2.4%)	0.94
Total	$40.08/cu.ft.

The above amounts to a total cost of $490/canister. This represents an average of $1.15/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B).

7.0 ESTIMATED COST OF INSPECTION

It was assumed that in the event it was necessary to remove spent fuel from a TSC, SOC or concrete cask after a long storage period, it would also be necessary to reinspect the fuel prior to shipment to DOE in a DOE-furnished transport cask.

In a recent EPRI study Reference (5), it was estimated that it would require 9.63 person-hours/PWR assembly and 6.74 person-hours/BWR assembly to perform a thorough visual inspection of the corresponding assembly.

It was assumed in this study that only about half of this time requirement would apply to cans of consolidated fuel (for visual examination and pressure testing). Moreover, it was assumed that no capital equipment additions would be required for reinspection inasmuch as the necessary equipment would have already been purchased for the initial inspection. Thus, the costs involved amount to $607/PWR assembly and $425/BWR assembly, and $304/can of consolidated PWR fuel and $213/can of consolidated BWR fuel. This represents an average of $1.66/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.50/kgU for consolidated fuel.

8.0 ESTIMATED COST OF LOADING A TRANSPORT CASK AND PREPARING IT FOR SHIPMENT TO A DOE SITE

The various steps involved in loading spent fuel into a transport cask (or a TSC if such is used as part of the DOE cask fleet), removing it from the cask loading pool, and preparing it for shipment to a DOE site, are shown in Figure B-9, along with the corresponding operating labor time requirements. The costs involved amount to $3,717 for a cask loaded with PWR fuel ($177/assembly or can), and $5,748 for a cask loaded with BWR fuel ($125/assembly or can). This represents an average of $0.48/kgU contained in intact fuel assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.29/kgU for consolidated fuel.

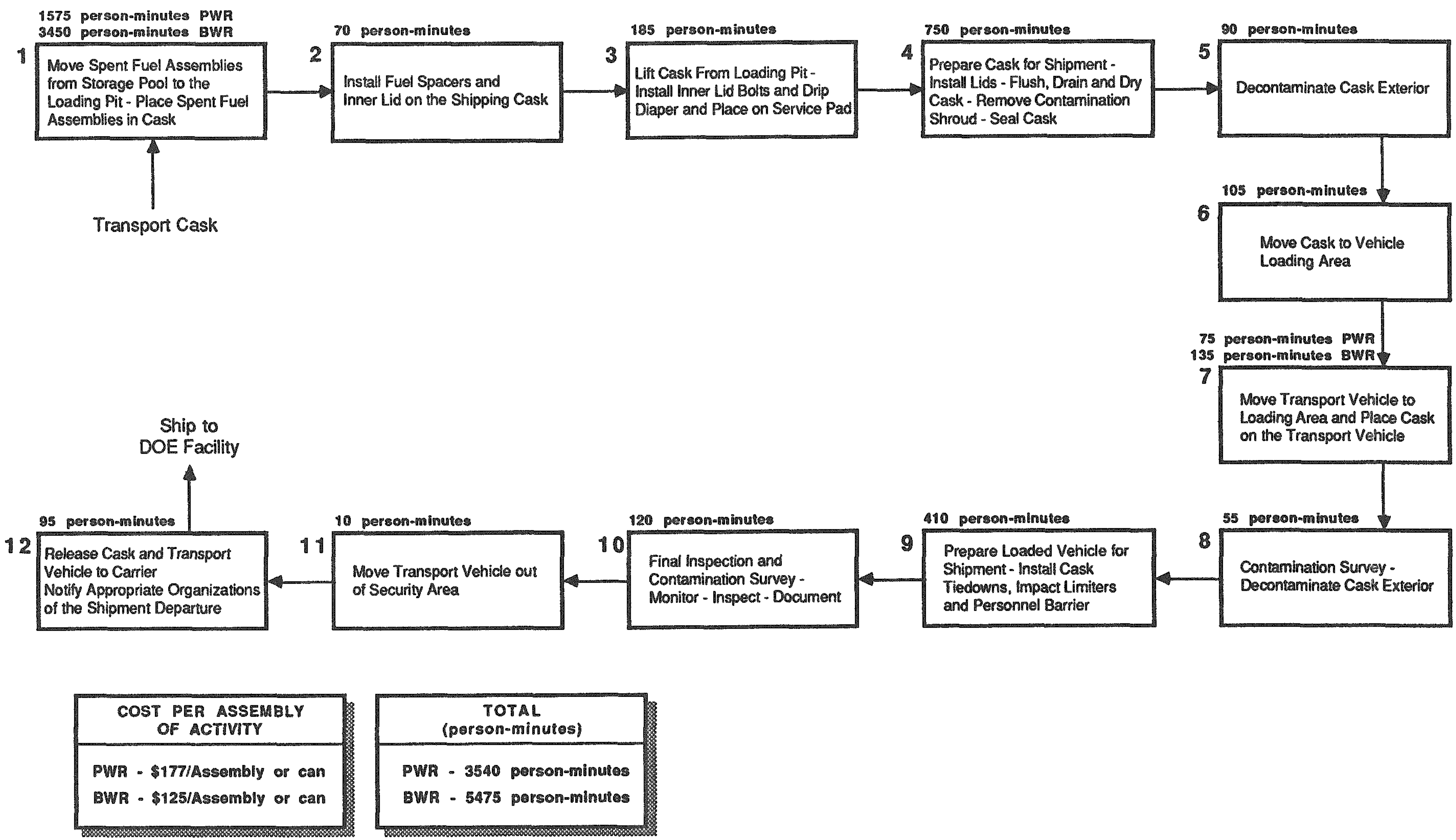


Figure B-9

Operations To Load Spent Fuel In Tranport Casks And Prepare The Casks For Leaving The Reactor Site

9.0 ESTIMATED COST FOR RECEIPT AND LOADING OF SOC OVERPACK, AND PREPARATION FOR SHIPMENT

The various steps involved in the receipt of an overpack, loading of a SOC into the overpack, and preparing it for shipment to a DOE site, is shown in Figure B-10, along with the corresponding operating labor time requirements. At $63/person-hour the cost amounts to $3,843/cask, or $183/assembly or can for PWR fuel and $83.5/assembly or can for BWR fuel. In addition crane rental costs for each such loading are estimated to amount to $3,282 ($1,641/day, 2 days minimum rental), or $156.3/assembly or can of PWR fuel and $71.3/assembly or can for BWR fuel. This represents an average total cost of $0.77/kgU contained in intact assemblies (assuming the same mix and weights set forth in Section 1.0 of this Appendix B), and an average of $0.46/kgU for consolidated fuel.

10.0 SUMMARY OF ESTIMATED AT-REACTOR COSTS

A summary of the unit operating costs developed in Sections 1.0 through 9.0 of this Appendix B is set forth in Tables B-3 and B-4 for intact fuel assemblies and consolidated fuel, respectively.

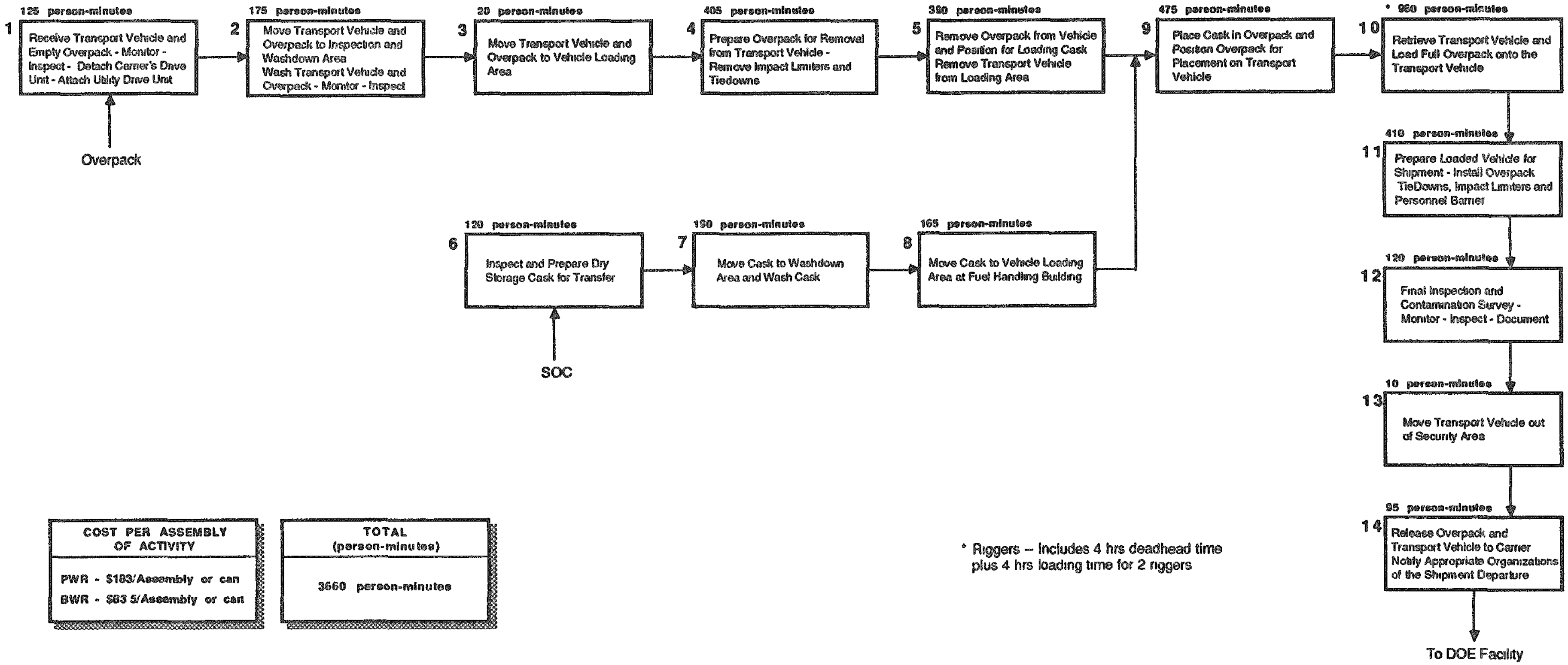


Figure B-10

Operations To Remove A SOC From Storage, Receive An Overpack And Prepare For Shipping From The Reactor Site

TABLE B-3

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Intact Fuel Assemblies)

	Section Reference[b]	Average Cost ($/kgU, 1987)[a] TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.22	$0.22	$0.22	$ -[c]
(b) Cans	-	-	-	-	9.03
(c) Canning	3.1	-	-	-	0.52
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.45	0.45	0.45	3.49
(e) Equipment Rental	App A, 3.0	-	-	-	1.45
Subtotal		0.67	0.67	0.67	14.49
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.29	3.25
(b) Decanning	6.0	-	-	-	0.52
(c) Can Disposal	6.0	-	-	-	1.15
(d) Fuel Inspection	7.0	-	-	1.66	1.66
(e) Receiving of Transport Cask	1.0	-	-	0.22	0.22
(f) Loading of Transport Cask	8.0	-	-	0.48	0.48
(g) Equipment Rental	6.0	-	-	-	1.45
(h) Preparation of TSC or SOC for Shipment	5.0	0.12	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.77	-	-
Subtotal		0.12	0.77	2.65	8.73
Total		$0.79	$1.44	$3.32	$23.22

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 461 kgU/assembly, and a cask capacity of 21 assemblies; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 183 kgU/assembly, and a cask capacity of 46 assemblies.

[b] References are to Sections in Appendix B unless otherwise indicated

[c] Included in the costs shown in (1)(d)

TABLE B-4

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Consolidated Fuel)

	Section Reference[b]	Average Cost ($/kgU, 1987)[a]: TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.13	$0.13	$0.13	$ -[c]
(b) Cans	-	-	-	-	-[d]
(c) Canning	3.1	-	-	-	-[d]
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.27	0.27	0.27	1.99
(e) Equipment Rental	App A, 3.0	-	-	-	1.26
Subtotal		0.40	0.40	0.40	3.25
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.18	1.83
(b) Decanning	6.0	-	-	-	-
(c) Can Disposal	6.0	-	-	-	-
(d) Fuel Inspection	7.0	-	-	0.50	0.50
(e) Receiving of Transport Cask	1.0	-	-	0.13	0.13
(f) Loading of Transport Cask	8.0	-	-	0.29	0.29
(g) Equipment Rental	6.0	-	-	-	1.26
(h) Preparation of TSC or SOC for Shipment	5.0	0.08	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.46	-	-
Subtotal		0.08	0.46	1.10	4.01
Total		$0.48	$0.86	$1.50	$ 7.26

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 770 kgU/can, and a cask capacity of 21 cans; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 306 kgU/can, and a cask capacity of 46 cans.

[b] References are to Sections in Appendix B unless otherwise indicated

[c] Included in the costs shown in (1)(d)

[d] Consolidated fuel assumed to be canned already

11.0 REFERENCES FOR APPENDIX B

(1) K. J. Schneider et al, Radiation Dose Analysis of a Postulated Reference Transportation System for Commercial Spent Fuel (Draft), Pacific Northwest Laboratories, September 1986.

(2) U. S. Department of Energy, 1986 Federal Interim Storage Fee Study Update: A Technical and Economic Analysis, PNL-6031, September 1986

(3) E. R. Johnson Associates, Inc., Impacts of Certain Spent Fuel Storage Acceptance Criteria, JAI-196, PNL Subcontract No. B-B2473-A-G, October 1982

(4) Chem-Nuclear Systems Inc., Barnwell Low-Level Radioactive Waste Management Facility Rate Schedule, effective January 1, 1987

(5) E. R. Johnson Associates, Inc., Waste Acceptance Criteria Study, (Preliminary Draft), JAI-267, August 26, 1986

APPENDIX C

ESTIMATES OF LIFE CYCLE AND UNIT COSTS FOR USE OF DRY SPENT FUEL STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS AT REACTOR SITES

APPENDIX C

ESTIMATES OF LIFE CYCLE AND UNIT COSTS FOR USE OF DRY SPENT FUEL STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS AT REACTOR SITES

TABLE OF CONTENTS

APPENDIX C

ESTIMATES OF LIFE CYCLE AND UNIT COSTS FOR USE OF DRY SPENT FUEL STORAGE MODULES, TRANSPORT CASKS, AND SOC OVERPACKS AT REACTOR SITES

The purpose of this Appendix is to develop estimates of the life cycle costs for the utility spent fuel management system that result from the use of TSCs, SOCs and concrete storage casks, as well as the unit costs involved. These costs include the capital costs of the storage modules involved, the capital cost of special equipment required, and the operating costs associated with the handling of the different storage modules, DOE-furnished transport casks, and SOC overpacks. Specifically excluded from these estimates, however, are the capital cost of storage facilities (storage pad, fencing, security system, monitoring equipment, and the like), and the cost of operation thereof during the storage period. For this purposes of this study such costs were assumed to be the same for the different types of storage modules, even though the cost of storage of concrete casks can be expected to be slightly higher than for TSCs or SOCs. Thus the life cycle and unit costs presented herein do not represent the total costs associated with at-reactor storage by the individual storage modes considered, but rather provide a means of estimating the <u>differences</u> in the costs of the storage methods considered.

1.0 ESTIMATED REQUIREMENTS FOR DRY STORAGE AT REACTOR SITES

An estimate was first made of the prospective requirements for additional storage at reactor sites and the amount that would be provided by dry storage. This involved the determination of the amounts of storage that would be required by utilities in the future in excess of their maximum pool capacity. In this connection the data developed in Reference (1) was used -- which involved no new orders and extended fuel burnup. The projected acceptance rate of spent fuel by DOE was subtracted from the annual amounts of storage that would otherwise be needed by the utilities. Three different DOE acceptance rates were considered; these included the 1998 date and spent fuel receiving rates set forth in the June 1985 Mission Plan (Reference 2) for the Authorized System, and those involving delays of 5 years and 10 years. The requirements for dry cask storage were developed from the estimates of additional at-reactor storage requirements by evaluating the fraction of such needs that are likely to be met using other technologies. Based on an evaluation of current utility plans, it was estimated that 50 percent of the projected needs for storage would be met by the utilities through consolidation or transshipment, with remaining 50 percent being met by dry storage. Tables C-1 and C-2 show the prospective requirements for dry storage capacity at reactor sites, and the numbers of metal or concrete casks that would be required if either were used alone to meet 50 percent of the projected needs. Table C-1 shows the numbers of storage modules required if all fuel were in the form of intact fuel assemblies, while Table C-2 shows the numbers of modules required if all fuel were in the form of consolidated fuel rods and compacted structural parts.

TABLE C-1

PROSPECTIVE DRY STORAGE MODULE REQUIREMENTS FOR AT-REACTOR STORAGE -- INTACT FUEL ASSEMBLIES

	No New Orders/[a] Ext. Burnup Cum. Storage Req'd. (MTU)	Cumulative Rate DOE Acceptance (MTU)			Cumulative Additional AR Storage Required (MTU)[c]			No. 9.26 MTU Capacity Metal Casks Required To Meet 50% of Storage Requirements[d]			No. 4.291 MTU Capacity Concrete Casks Required To Meet 50% of Storage Requirements[d]		
		On-Time[b]	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay
1985	3				3	3	3	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
1986	30				30	30	30	2 (1)	2 (1)	2 (1)	4 (3)	4 (3)	4 (3)
1987	54				54	54	54	3 (1)	3 (1)	3 (1)	7 (3)	7 (3)	7 (3)
1988	160				160	160	160	9 (6)	9 (6)	9 (6)	19 (12)	19 (12)	19 (12)
1989	323				323	323	323	18 (9)	18 (9)	18 (9)	38 (19)	38 (19)	38 (19)
1990	449				449	449	449	25 (7)	25 (7)	25 (7)	53 (15)	53 (15)	53 (15)
1991	687				687	687	687	38 (13)	38 (13)	38 (13)	80 (27)	80 (27)	80 (27)
1992	973				973	973	973	53 (15)	53 (15)	53 (15)	114 (34)	114 (34)	114 (34)
1993	1,231				1,231	1,231	1,231	67 (14)	67 (14)	67 (14)	144 (30)	144 (30)	144 (30)
1994	1,659				1,659	1,659	1,659	90 (23)	90 (23)	90 (23)	194 (50)	194 (50)	194 (50)
1995	2,024				2,024	2,024	2,024	110 (20)	110 (20)	110 (20)	236 (42)	236 (42)	236 (42)
1996	2,478				2,478	2,478	2,478	134 (24)	134 (24)	134 (24)	289 (53)	289 (53)	289 (53)
1997	2,994				2,994	2,994	2,994	162 (28)	162 (28)	162 (28)	349 (60)	349 (60)	349 (60)
1998	3,563	400			3,163	3,563	3,563	171 (9)	193 (31)	193 (31)	369 (20)	416 (67)	416 (67)
1999	4,235	800			3,435	4,235	4,235	186 (15)	229 (36)	229 (36)	401 (32)	494 (78)	494 (78)
2000	5,025	1,200			3,825	5,025	5,025	207 (21)	272 (43)	272 (43)	446 (45)	586 (92)	586 (92)
2001	5,869	2,100			3,769	5,869	5,869	204 (-3)	317 (45)	317 (45)	440 (-6)	684 (98)	684 (98)
2002	6,796	3,900			2,896	6,796	6,796	157 (-47)	367 (50)	367 (50)	338 (-102)	792 (108)	792 (108)
2003	7,811	6,900	400		911	7,411	7,811	50 (-107)	402 (35)	422 (55)	107 (-231)	864 (72)	911 (119)
2004	8,717	9,900	800			7,917	8,717	(-50)	428 (26)	471 (49)	(-107)	923 (59)	1,016 (105)
2005	9,736		1,200			8,536	9,736		461 (33)	526 (55)		995 (72)	1,135 (119)
2006	10,823		2,100			8,723	10,823		471 (10)	585 (59)		1,017 (22)	1,262 (127)
2007	11,906		3,900			8,006	11,906		433 (-38)	643 (58)		933 (-84)	1,388 (126)
2008	13,214		6,900	400		6,314	12,814		341 (-92)	692 (49)		736 (-197)	1,494 (106)
2009	14,464		9,900	800		4,564	13,664		247 (-94)	738 (46)		532 (-204)	1,593 (99)
2010	15,999		12,900	1,200		3,099	14,799		168 (-79)	799 (61)		362 (-170)	1,725 (132)
2011	17,649		15,900	2,100		1,749	15,549		95 (-73)	840 (41)		204 (-158)	1,812 (87)
2012	19,038		18,900	3,900		138	15,138		8 (-87)	818 (-22)		16 (-188)	1,764 (-48)
2013	20,229		21,900	6,900			13,329		(-8)	720 (-98)		(-16)	1,554 (-210)
2014	21,313			9,900			11,413			617 (-103)			1,330 (-224)
2015	21,818			12,900			8,918			482 (-135)			1,040 (-290)
2016	22,824			15,900			6,924			374 (-108)			807 (-233)
2017	23,783			18,900			4,883			264 (-110)			569 (-238)
2018	24,383			21,900			2,483			134 (-130)			290 (-279)
2019	25,148			24,900			248			14 (-120)			29 (-261)
2020	25,784			27,900						(-14)			(-29)

[a] Reference (1); requirements in excess of existing capacity

[b] From Reference (2)

[c] Underlined values represent the maximum amount of additional at-reactor (AR) storage required for the individual scenarios involved

[d] Numbers shown represent cumulative numbers of storage modules assumed to be in at-reactor storage service. Numbers in parenthesis represent the number of storage modules introduced to, or removed from (negative numbers), at-reactor storage during each year.

TABLE C-2

PROSPECTIVE DRY STORAGE MODULE REQUIREMENTS FOR AT-REACTOR STORAGE -- CONSOLIDATED FUEL

	No New Orders/[a] Ext. Burnup Cum. Storage Req'd. (MTU)	Cumulative Rate DOE Acceptance (MTU)			Cumulative Additional AR Storage Required (MTU)[c]			No. 15.37 MTU Capacity Metal Cask Required To Meet 50% of Storage Requirements[d]			No. 7.12 MTU Capacity Concrete Casks Required To Meet 50% of Storage Requirements[d]		
		On-Time[b]	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay	On-Time	5-Yr. Delay	10-Yr. Delay
1985	3				3	3	3	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
1986	30				30	30	30	1 (0)	1 (0)	1 (0)	3 (2)	3 (2)	3 (2)
1987	54				54	54	54	2 (1)	2 (1)	2 (1)	4 (1)	4 (1)	4 (1)
1988	160				160	160	160	6 (4)	6 (4)	6 (4)	12 (8)	12 (8)	12 (8)
1989	323				323	323	323	11 (5)	11 (5)	11 (5)	23 (11)	23 (11)	23 (11)
1990	449				449	449	449	15 (4)	15 (4)	15 (4)	32 (9)	32 (9)	32 (9)
1991	687				687	687	687	22 (7)	22 (7)	22 (7)	49 (17)	49 (17)	49 (17)
1992	973				973	973	973	32 (10)	32 (10)	32 (10)	69 (20)	69 (20)	69 (20)
1993	1,231				1,231	1,231	1,231	40 (8)	40 (8)	40 (8)	87 (18)	87 (18)	87 (18)
1994	1,659				1,659	1,659	1,659	54 (14)	54 (14)	54 (14)	117 (30)	117 (30)	117 (30)
1995	2,024				2,024	2,024	2,024	66 (12)	66 (12)	66 (12)	143 (26)	143 (26)	143 (26)
1996	2,478				2,478	2,478	2,478	81 (15)	81 (15)	81 (15)	174 (31)	174 (31)	174 (31)
1997	2,994				2,994	2,994	2,994	98 (17)	98 (17)	98 (17)	211 (37)	211 (37)	211 (37)
1998	3,563	400			3,163	3,563	3,563	103 (5)	116 (18)	116 (18)	223 (12)	251 (40)	251 (40)
1999	4,235	800			3,435	4,235	4,235	112 (9)	138 (22)	138 (22)	242 (19)	298 (47)	298 (47)
2000	5,025	1,200			3,825	5,025	5,025	124 (12)	164 (26)	104 (26)	269 (27)	353 (55)	353 (55)
2001	5,869	2,100			3,769	5,869	5,869	123 (-1)	191 (27)	191 (27)	265 (-4)	413 (60)	413 (60)
2002	6,796	3,900			2,896	6,796	6,796	94 (-29)	222 (31)	222 (31)	204 (-61)	478 (65)	478 (65)
2003	7,811	6,900	400		911	7,411	7,811	30 (-64)	241 (19)	254 (32)	64 (-140)	521 (43)	549 (71)
2004	8,717	9,900	800			7,917	8,717	(-30)	258 (17)	284 (30)	(-64)	556 (35)	613 (64)
2005	9,736		1,200			8,536	9,736		278 (20)	317 (33)		600 (44)	684 (71)
2006	10,823		2,100			8,723	10,823		284 (6)	353 (36)		613 (13)	760 (76)
2007	11,906		3,900			8,006	11,906		261 (-23)	388 (35)		563 (-50)	836 (76)
2008	13,214		6,900	400		6,314	12,814		206 (-35)	417 (29)		444 (-119)	900 (64)
2009	14,464		9,900	800		4,564	13,664		149 (-57)	445 (28)		321 (-123)	960 (60)
2010	15,999		12,900	1,200		3,099	14,799		101 (-48)	482 (37)		218 (-103)	1040 (80)
2011	17,649		15,900	2,100		1,749	15,549		57 (-44)	506 (24)		123 (-95)	1092 (52)
2012	19,038		18,900	3,900		138	15,138		5 (-52)	493 (-13)		10 (-113)	1063 (-29)
2013	20,229		21,900	6,900			13,329		(-5)	434 (-59)		(-10)	936 (-127)
2014	21,313			9,900			11,413			372 (-62)			802 (-134)
2015	21,818			12,900			8,918			291 (-81)			627 (-175)
2016	22,824			15,900			6,924			226 (-65)			487 (-140)
2017	23,783			18,900			4,883			159 (-67)			343 (-144)
2018	24,383			21,900			2,483			81 (-78)			175 (-168)
2019	25,148			24,900			248			9 (-72)			18 (-157)
2020	25,784			27,900						(-9)			(-18)

[a] Reference (1); requirements in excess of existing capacity

[b] From Reference (2)

[c] Underlined values represent the maximum amount of additional at-reactor (AR) storage required for the individual scenarios involved

[d] Numbers shown represent cumulative numbers of storage modules assumed to be in at-reactor storage service. Numbers in parenthesis represent the number of storage modules introduced to, or removed from (negative numbers), at-reactor storage during each year.

2.0 ESTIMATES OF LIFE CYCLE AND UNIT COSTS

Using the required numbers of storage modules and schedule developed in Section 1.0 of this Appendix C, and the costs of using TSCs, SOCs and concrete storage casks for at-reactor storage as developed in Appendix A and Appendix B, life cycle costs were developed for the following cases:

Case No.	Type of Cask Used For AR Storage	Type Of Fuel	Method of Shipment to DOE Facilities
1	TSC	Intact assemblies	In TSC
2	TSC	Consolidated fuel	In TSC
3	SOC	Intact assemblies	In DOE-furnished transport cask
4	SOC	Consolidated fuel	In DOE-furnished transport cask
5	SOC	Intact assemblies	In SOC; one-time use of SOC for shipment
6	SOC	Consolidated fuel	In SOC; one-time use of SOC for shipment
7	SOC	Intact assemblies	In SOC in overpack
8	SOC	Consolidated fuel	In SOC in overpack
9	Concrete Cask	Intact assemblies	In DOE-furnished transport cask
10	Concrete Cask	Consolidated fuel	In DOE-furnished transport cask

For each of the foregoing cases, life cycle costs were developed for three scenarios of deployment of a repository; on-time (1998), 5-year delay (2003), and 10-year delay (2008). These were designated as subcases A, B and C, respectively, for each of the cases described above.

The life cycle costs and resulting unit costs for each of the foregoing cases are shown in Tables C-3 through C-32. Summaries of these costs are shown in Tables C-33 and C-34 for intact fuel assemblies and consolidated fuel, respectively. The figures set forth in the tables were developed as follows:

(1) The cumulative amounts of additional fuel to be stored at reactors (AR), in excess of their existing storage capacity, were the same as those shown in Tables C-1 and C-2. The annual amounts of fuel stored at the reactor represent new additions to storage, and for any given year were determined by subtracting the cumulative amount stored in the preceding year

from the cumulative amount stored in the given year. Only 50% of these amounts were assumed to be stored in TSCs, SOCs or concrete casks.

(2) The number of metal casks or concrete casks shown in the tables represent the number of casks introduced to at-reactor (AR) storage in each year. (The number of casks removed from storage are shown in parentheses.) These were determined by dividing the number of MTU introduced to storage annually by the capacity of the corresponding cask -- for metal casks the capacities were assumed to be 9.26 MTU/cask for intact fuel assemblies and 15.37 MTU/cask for consolidated fuel; for concrete casks the capacities were assumed to be 4.291 MTU/cask for intact fuel assemblies and 7.12 MTU/cask for consolidated fuel. The capacities for consolidated fuel included the compacted structural parts resulting from consolidation.

The foregoing capacities were based on the following assumptions:

(a) Two-thirds of the weight of fuel (MTU) would be in the form of PWR fuel, and one-third would be in the form of BWR fuel.

(b) Metal casks would have a capacity for storing 21 intact PWR assemblies or cans of consolidated PWR fuel, or 46 BWR assemblies or cans of consolidated BWR fuel.

(c) Concrete casks would have a capacity for storing 9 intact PWR assemblies or cans of consolidated PWR fuel, or 25 intact BWR assemblies or cans of consolidated BWR fuel.

(d) A PWR fuel assembly would contain 461 kgU and a BWR fuel assembly would contain 183 kgU.

(e) A can of consolidated PWR fuel would contain 765 kgU and a can of consolidated BWR fuel would contain 304 kgU. This represents an average consolidation ratio of 1.66, including compacted structural parts.

(3) The costs of the casks for each year were determined by multiplying the number of casks required by the corresponding unit cost of the cask. The unit cost of the casks for any given year was the average unit cost of casks for that year, taking into account the total number of casks produced to that point. Thus by referring to the cumulative numbers of casks required to the mid-point of any year in Tables C-1 or C-2, applying the algorithm described in Appendix A to obtain fabrication costs, and adding the cost of design and licensing (as applicable) and administration and procurement (10% of fabrication cost), the average cost of casks for the year was obtained. For example, in the case of a SOC in Table C-9, the

mid-point in the number of casks required for intact fuel in 1994 was 78. Using the algorithm from Appendix A, the fabrication cost of the 78th cask produced is calculated to be $655-thousand. The total cost of the cask is 10 percent higher, or $721-thousand, when administration and procurement costs are added. This unit cost for the cask is applied against the total of 23 casks needed that year, giving a total cask cost of $16,583-thousand.

The unit costs for TSCs used to develop the cask costs in the tables did not include any cost for design and licensing, while the unit costs for SOCs and concrete casks did include such costs. The reason for this was that it was assumed that DOE would use TSCs for its rail shipping fleet and that the cost for design and licensing would be incurred by DOE in connection with the procurement of the fleet.

(4) The cost of loading of a storage module and placement thereof in storage was determined by multiplying the sum of the applicable unit costs from Tables B-3 or B-4 by the mathematical product of the number of casks introduced to storage and their respective storage capacities.

(5) The cost of removal of a storage module from storage and preparation for shipment was determined by multiplying the sum of the applicable unit costs from Tables B-3 or B-4 by the mathematical product of the number of casks removed from storage and their respective storage capacities.

(6) In cases involving the use of concrete storage casks, the capital costs of canning and cask loading equipment were included in a separate column in Tables C-27 through C-32. The capital cost of a canning station was estimated in Appendix B (Section 3.1) to be $145-thousand, and the capital cost of loading equipment was estimated in Appendix A (Section 3.0) to be $250-thousand. (The cost of rental equipment was included in the operating costs covered in (4) and (5), above.) It was assumed that this equipment would be added to the utility spent fuel management system as follows:

(a) For cases where the repository commences operation in 1998 -- one set of equipment would be added to the system each year through 1996.

(b) For cases where the repository commences operation in 2003 -- one set of equipment would be added to the system each year through 1996, and two sets of equipment would be added to the system each year during the period 1997-2001 (inclusive).

(c) For cases where the repository commences operation in 2008 -- one set of equipment would be added to the system each year through 1996, two sets of equipment would be added to the system each year during the period 1997-2001 (inclusive), and three sets of equipment would be added to the system each year during the period 2002-2006 (inclusive).

In cases involving the storage of intact fuel assemblies, each set of equipment costs \$395-thousand; in cases involving the storage of consolidated fuel, the equipment set costs were only \$250-thousand inasmuch as they did not include the \$145-thousand cost of canning equipment -- since it was assumed that the fuel would have already been canned as part of the consolidation process.

(7) The total costs were discounted by two different net discount rates to 1987 (3 percent/year and 5 percent/year) to get the total discounted costs (and the total discounted cost for each element thereof) associated with the use of the different casks, in each of the different scenarios involved in terms of 1987 dollars. The reason two different discount rates were used was to illustrate the impact of the discount rate on the unit cost. However, the unit costs resulting from the use of the 3 percent/year discount rate were used for analysis purposes elsewhere in this report.

(8) The unit costs were determined by dividing the total discounted costs by the total discounted amount (MTU) of spent fuel introduced to storage, as follows:

Discounted Costs = Discounted (Unit Costs x Units of Storage)

Discounted Costs = Unit Costs x Discounted Units of Storage

$$\text{Unit Cost} = \frac{\text{Discounted Costs}}{\text{Discounted Units of Storage}}$$

TABLE C-3
CASE 1A -- COST OF TSCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	942	6		948	948	948	12	12
1988	106	160	6	5,472	37		5,509	5,349	5,247	51	50
1989	163	323	9	7,918	56		7,974	7,516	7,233	77	74
1990	126	449	7	6,024	43		6,067	5,553	5,241	58	54
1991	238	687	13	10,983	81		11,064	9,830	9,102	106	98
1992	286	973	15	12,454	93		12,547	10,823	9,831	123	112
1993	258	1,231	14	11,482	87		11,569	9,689	8,633	108	96
1994	428	1,659	23	18,656	143		18,799	15,285	13,360	174	152
1995	365	2,024	20	16,020	124		16,144	12,744	10,927	144	124
1996	454	2,478	24	19,035	149		19,184	14,703	12,366	174	146
1997	516	2,994	28	22,050	174		22,224	16,537	13,643	192	158
1998	169	3,163	9	7,037	56		7,093	5,124	4,147	61	49
1999	272	3,435	15	11,694	93		11,787	8,267	6,563	95	76
2000	390	3,825	21	16,325	130		16,455	11,205	8,727	133	103
2001			(3)			3	3	2	2		
2002			(47)			52	52	34	25		
2003			(107)			119	119	74	54		
2004			(50)			56	56	34	24		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			205	166,092	1,272	230	167,594	133,716	116,074	1,508	1,306
TOTAL DISC @3%				132,562	1,011	143		133,716			
UNIT COST/KG				$87.9	$.7	$.1		$88.7			
TOTAL DISC @5%				115,093	875	106			116,074		
UNIT COST/KG				$88.1	$.7	$.1			$88.9		

TABLE C-4
CASE 1B -- COST OF TSCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	942	6		948	948	948	12	12
1988	106	160	6	5,472	37		5,509	5,349	5,247	51	50
1989	163	323	9	7,918	56		7,974	7,516	7,233	77	74
1990	126	449	7	6,024	43		6,067	5,553	5,241	58	54
1991	238	687	13	10,983	81		11,064	9,830	9,102	106	98
1992	286	973	15	12,454	93		12,547	10,823	9,831	123	112
1993	258	1,231	14	11,482	87		11,569	9,689	8,633	108	96
1994	428	1,659	23	18,656	143		18,799	15,285	13,360	174	152
1995	365	2,024	20	16,020	124		16,144	12,744	10,927	144	124
1996	454	2,478	24	19,035	149		19,184	14,703	12,366	174	146
1997	516	2,994	28	22,050	174		22,224	16,537	13,643	192	158
1998	569	3,563	31	24,168	192		24,360	17,598	14,243	206	166
1999	672	4,235	36	27,864	223		28,087	19,700	15,640	236	187
2000	790	5,025	43	33,040	267		33,307	22,680	17,663	269	209
2001	844	5,869	45	34,323	279		34,602	22,876	17,476	279	213
2002	927	6,796	50	37,856	310		38,166	24,497	18,359	298	223
2003	615	7,411	33	24,836	205		25,041	15,605	11,471	192	141
2004	506	7,917	26	19,510	161		19,671	11,901	8,583	153	110
2005	619	8,536	33	24,651	205		24,856	14,600	10,328	182	129
2006	187	8,723	10	7,459	62		7,521	4,289	2,976	53	37
2007			(38)			42	42	23	16		
2008			(92)			102	102	55	37		
2009			(94)			104	104	55	36		
2010			(79)			88	88	44	29		
2011			(73)			81	81	40	25		
2012			(87)			97	97	46	29		
2013			(8)			9	9	4	3		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			467	364,743	2,897	523	368,164	262,991	213,444	3,086	2,493
TOTAL DISC @3%				260,665	2,059	268		262,991			
UNIT COST/KG				$84.5	$.7	$.1		$85.2			
TOTAL DISC @5%				211,607	1,664	173			213,444		
UNIT COST/KG				$84.9	$.7	$.1			$85.6		

TABLE C-5

CASE 1C -- COST OF TSCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	942	6		948	948	948	12	12
1988	106	160	6	5,472	37		5,509	5,349	5,247	51	50
1989	163	323	9	7,918	56		7,974	7,516	7,233	77	74
1990	126	449	7	6,024	43		6,067	5,553	5,241	58	54
1991	238	687	13	10,983	81		11,064	9,830	9,102	106	98
1992	286	973	15	12,454	93		12,547	10,823	9,831	123	112
1993	258	1,231	14	11,482	87		11,569	9,689	8,633	108	96
1994	428	1,659	23	18,656	143		18,799	15,285	13,360	174	152
1995	365	2,024	20	16,020	124		16,144	12,744	10,927	144	124
1996	454	2,478	24	19,035	149		19,184	14,703	12,366	174	146
1997	516	2,994	28	22,050	174		22,224	16,537	13,643	192	158
1998	569	3,563	31	24,168	192		24,360	17,598	14,243	206	166
1999	672	4,235	36	27,864	223		28,087	19,700	15,640	236	187
2000	790	5,025	43	33,040	267		33,307	22,680	17,663	269	209
2001	844	5,869	45	34,323	279		34,602	22,876	17,476	279	213
2002	927	6,796	50	37,856	310		38,166	24,497	18,359	298	223
2003	1,015	7,811	55	41,394	341		41,735	26,008	19,119	316	232
2004	906	8,717	49	36,603	304		36,907	22,329	16,102	274	198
2005	1,019	9,736	55	40,899	341		41,240	24,224	17,136	299	212
2006	1,087	10,823	59	43,675	366		44,041	25,116	17,429	310	215
2007	1,083	11,906	58	42,739	360		43,099	23,863	16,244	300	204
2008	908	12,814	49	35,942	304		36,246	19,484	13,010	244	163
2009	850	13,664	46	33,638	285		33,923	17,704	11,597	222	145
2010	1,135	14,799	61	44,469	378		44,847	22,724	14,601	288	185
2011	750	15,549	41	29,843	254		30,097	14,806	9,332	184	116
2012			(22)			24	24	12	7		
2013			(98)			109	109	50	31		
2014			(103)			114	114	52	31		
2015			(135)			150	150	66	38		
2016			(108)			120	120	51	29		
2017			(110)			122	122	50	28		
2018			(130)			144	144	58	32		
2019			(120)			133	133	52	28		
2020			(14)			16	16	6	3		
TOTAL			838	637,489	5,199	933	643,622	412,983	314,710	4,943	3,747
TOTAL DISC @3%				409,275	3,312	396		412,983			
UNIT COST/KG				$82.8	$.7	$.1		$83.5			
TOTAL DISC @5%				311,972	2,510	227			314,710		
UNIT COST/KG				$83.3	$.7	$.1			$84.0		

TABLE C-6

CASE 2A -- COST OF TSCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	959	6		965	965	965	12	12
1988	106	160	4	3,716	25		3,741	3,632	3,562	51	50
1989	163	323	5	4,500	31		4,531	4,271	4,110	77	74
1990	126	449	4	3,520	25		3,545	3,244	3,062	58	54
1991	238	687	7	6,064	43		6,107	5,426	5,024	106	98
1992	286	973	10	8,505	61		8,566	7,390	6,712	123	112
1993	258	1,231	8	6,714	49		6,763	5,664	5,047	108	96
1994	428	1,659	14	11,607	86		11,693	9,508	8,310	174	152
1995	365	2,024	12	9,842	74		9,916	7,828	6,711	144	124
1996	454	2,478	15	12,201	92		12,293	9,422	7,924	174	146
1997	516	2,994	17	13,694	105		13,799	10,267	8,471	192	158
1998	169	3,163	5	4,005	31		4,036	2,916	2,360	61	49
1999	272	3,435	9	7,189	55		7,244	5,081	4,034	95	76
2000	390	3,825	12	9,531	74		9,605	6,540	5,094	133	103
2001			(1)			1	1	1	1		
2002			(29)			36	36	23	17		
2003			(64)			79	79	49	36		
2004			(30)			37	37	22	16		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			123	102,047	756	152	102,956	82,247	71,456	1,508	1,306
TOTAL DISC @3%				81,550	602	95		82,247			
UNIT COST/KG				$54.1	$.4	$.1		$54.5			
TOTAL DISC @5%				70,865	522	70			71,456		
UNIT COST/KG				$54.3	$.4	$.1			$54.7		

TABLE C-7

CASE 2B - COST OF TSCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASES	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	959	6		965	965	965	12	12
1988	106	160	4	3,716	25		3,741	3,632	3,562	51	50
1989	163	323	5	4,500	31		4,531	4,271	4,110	77	74
1990	126	449	4	3,520	25		3,545	3,244	3,062	58	54
1991	238	687	7	6,064	43		6,107	5,426	5,024	106	98
1992	286	973	10	8,505	61		8,566	7,390	6,712	123	112
1993	258	1,231	8	6,714	49		6,763	5,664	5,047	108	96
1994	428	1,659	14	11,607	86		11,693	9,508	8,310	174	152
1995	365	2,024	12	9,842	74		9,916	7,828	6,711	144	124
1996	454	2,478	15	12,201	92		12,293	9,422	7,924	174	146
1997	516	2,994	17	13,694	105		13,799	10,267	8,471	192	158
1998	569	3,563	18	14,378	111		14,489	10,467	8,471	206	166
1999	672	4,235	22	17,424	135		17,559	12,316	9,778	236	187
2000	790	5,025	26	20,446	160		20,606	14,032	10,928	269	209
2001	844	5,869	27	21,050	166		21,216	14,026	10,716	279	213
2002	927	6,796	31	24,029	191		24,220	15,546	11,650	298	223
2003	615	7,411	20	15,412	123		15,535	9,681	7,117	192	141
2004	506	7,917	17	13,062	105		13,167	7,966	5,745	153	110
2005	619	8,536	20	15,323	123		15,446	9,073	6,418	182	129
2006	187	8,723	6	4,583	37		4,620	2,635	1,828	53	37
2007			(23)			28	28	16	11		
2008			(55)			68	68	36	24		
2009			(57)			70	70	37	24		
2010			(48)			59	59	30	19		
2011			(44)			54	54	27	17		
2012			(52)			64	64	31	19		
2013			(5)			6	6	3	2		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			284	227,029	1,746	349	229,124	163,534	132,664	3,086	2,493
TOTAL DISC @3%				162,116	1,239	178		163,534			
UNIT COST/KG				$52.5	$.4	$.1		$53.0			
TOTAL DISC @5%				131,547	1,002	115			132,664		
UNIT COST/KG				$52.8	$.4	$.0			$53.2		

TABLE C-8

CASE 2C -- COST OF TSCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN TSC
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASES	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	959	6		965	965	965	12	12
1988	106	160	4	3,716	25		3,741	3,632	3,562	51	50
1989	163	323	5	4,500	31		4,531	4,271	4,110	77	74
1990	126	449	4	3,520	25		3,545	3,244	3,062	58	54
1991	238	687	7	6,064	43		6,107	5,426	5,024	106	98
1992	286	973	10	8,505	61		8,566	7,390	6,712	123	112
1993	258	1,231	8	6,714	49		6,763	5,664	5,047	108	96
1994	428	1,659	14	11,607	86		11,693	9,508	8,310	174	152
1995	365	2,024	12	9,842	74		9,916	7,828	6,711	144	124
1996	454	2,478	15	12,201	92		12,293	9,422	7,924	174	146
1997	516	2,994	17	13,694	105		13,799	10,267	8,471	192	158
1998	569	3,563	18	14,378	111		14,489	10,467	8,471	206	166
1999	672	4,235	22	17,424	135		17,559	12,316	9,778	236	187
2000	790	5,025	26	20,446	160		20,606	14,032	10,928	269	209
2001	844	5,869	27	21,050	166		21,216	14,026	10,716	279	213
2002	927	6,796	31	24,029	191		24,220	15,546	11,650	298	223
2003	1,015	7,811	32	24,624	197		24,821	15,467	11,371	316	232
2004	906	8,717	30	22,950	184		23,134	13,997	10,093	274	198
2005	1,019	9,736	33	25,134	203		25,337	14,883	10,528	299	212
2006	1,087	10,823	35	26,499	215		26,714	15,235	10,572	310	215
2007	1,083	11,906	35	26,381	215		26,596	14,726	10,024	300	204
2008	908	12,814	29	21,794	178		21,972	11,811	7,887	244	163
2009	850	13,664	28	20,979	172		21,151	11,039	7,231	222	145
2010	1,135	14,799	37	27,597	227		27,824	14,098	9,059	288	185
2011	750	15,549	24	17,847	148		17,995	8,852	5,580	184	116
2012			(13)			16	16	8	5		
2013			(59)			73	73	34	20		
2014			(62)			76	76	34	20		
2015			(81)			100	100	44	25		
2016			(65)			80	80	34	19		
2017			(67)			82	82	34	19		
2018			(78)			96	96	38	21		
2019			(72)			89	89	34	19		
2020			(9)			11	11	4	2		
TOTAL			504	392,454	3,099	622	396,175	254,373	193,936	4,943	3,747
TOTAL DISC @3%				252,134	1,975	264		254,373			
UNIT COST/KG				$51.0	$.4	$.1		$51.5			
TOTAL DISC @5%				192,287	1,498	151			193,936		
UNIT COST/KG				$51.3	$.4	$.0			$51.8		

TABLE C-9

CASE 3A -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	169	3,163	9	6,255	56		6,311	4,559	3,690	61	49
1999	272	3,435	15	10,395	93		10,488	7,356	5,840	95	76
2000	390	3,825	21	14,511	130		14,641	9,970	7,765	133	103
2001			(3)			74	74	49	37		
2002			(47)			1,153	1,153	740	555		
2003			(107)			2,626	2,626	1,636	1,203		
2004			(50)			1,227	1,227	742	535		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			205	140,628	1,272	5,080	154,979	122,976	106,459	1,508	1,306
TOTAL DISC @3%				118,798	1,011	3,168		122,976			
UNIT COST/KG				$78.8	$.7	$2.1		$81.5			
TOTAL DISC @5%				103,254	875	2,330			106,459		
UNIT COST/KG				$79.1	$.7	$1.8			$81.5		

TABLE C-10
CASE 3B -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 9/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	615	7,411	33	22,077	205		22,282	13,885	10,208	192	141
2004	506	7,917	26	17,342	161		17,503	10,590	7,637	153	110
2005	619	8,536	33	21,912	205		22,117	12,991	9,190	182	129
2006	187	8,723	10	6,630	62		6,692	3,816	2,648	53	37
2007			(38)			932	932	516	351		
2008			(92)			2,258	2,258	1,214	810		
2009			(94)			2,307	2,307	1,204	789		
2010			(79)			1,939	1,939	982	631		
2011			(73)			1,791	1,791	881	555		
2012			(87)			2,135	2,135	1,020	630		
2013			(8)			196	196	91	55		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			467	325,208	2,897	11,558	339,663	240,635	194,532	3,086	2,493
TOTAL DISC @3%				232,669	2,059	5,908		240,635			
UNIT COST/KG				$75.4	$.7	$1.9		$78.0			
TOTAL DISC @5%				189,045	1,664	3,823			194,532		
UNIT COST/KG				$75.8	$.7	$1.5			$78.0		

TABLE C-11

CASE 3C -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES -- 11/ 4/1987

REPOSITORY COMMENCES OPERATION IN 2008

SHIPMENT IN DOE TRANSPORT CASK

(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	1,015	7,811	55	36,795	341		37,136	23,142	17,013	316	232
2004	906	8,717	49	32,536	304		32,840	19,869	14,328	274	198
2005	1,019	9,736	55	36,355	341		36,696	21,555	15,248	299	212
2006	1,087	10,823	59	38,822	366		39,188	22,348	15,508	310	215
2007	1,083	11,906	58	37,990	360		38,350	21,233	14,454	300	204
2008	908	12,814	49	31,948	304		32,252	17,337	11,577	244	163
2009	850	13,664	46	29,900	285		30,185	15,754	10,319	222	145
2010	1,135	14,799	61	39,528	378		39,906	20,220	12,992	288	185
2011	750	15,549	41	26,527	254		26,781	13,175	8,304	184	116
2012			(22)			549	540	258	159		
2013			(98)			2,405	2,405	1,115	676		
2014			(103)			2,528	2,528	1,138	677		
2015			(135)			3,313	3,313	1,448	845		
2016			(108)			2,650	2,650	1,125	644		
2017			(110)			2,699	2,699	1,112	625		
2018			(130)			3,190	3,190	1,276	703		
2019			(120)			2,945	2,945	1,144	618		
2020			(14)			344	344	130	69		
TOTAL			838	567,648	5,199	20,613	593,460	376,822	285,785	4,943	3,747
TOTAL DISC @3%				364,766	3,312	8,744		376,822			
UNIT COST/KG				$73.8	$.7	$1.8		$76.2			
TOTAL DISC @5%				278,258	2,510	5,016			285,785		
UNIT COST/KG				$74.3	$.7	$1.3			$76.3		

TABLE C-12
CASE 4A -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. CF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	169	3,163	5	3,560	31		3,591	2,594	2,099	61	49
1999	272	3,435	9	6,390	55		6,445	4,521	3,589	95	76
2000	390	3,825	12	8,472	74		8,546	5,819	4,532	133	103
2001			(1)			17	17	11	9		
2002			(29)			490	490	315	236		
2003			(64)			1,082	1,082	674	496		
2004			(30)			507	507	307	221		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			123	92,111	756	2,096	94,964	75,741	65,779	1,508	1,306
TOTAL DISC @3%				73,832	602	1,307		75,741			
UNIT COST/KG				$49.0	$.4	$.9		$50.2			
TOTAL DISC @5%				64,296	522	961			65,779		
UNIT COST/KG				$49.2	$.4	$.7			$50.4		

TABLE C-13

CASE 4B -- COST OF SOCs FOR AT REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	.24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	615	7,411	20	13,700	123		13,823	8,614	6,332	192	141
2004	506	7,917	17	11,611	105		11,716	7,088	5,111	153	110
2005	619	8,536	20	13,620	123		13,743	8,073	5,710	182	129
2006	187	8,723	6	4,074	37		4,111	2,344	1,627	53	37
2007			(23)			389	389	215	147		
2008			(55)			930	930	500	334		
2009			(57)			964	964	503	329		
2010			(48)			812	812	411	264		
2011			(44)			744	744	366	231		
2012			(52)			879	879	420	260		
2013			(5)			85	85	39	24		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			284	203,206	1,746	4,802	209,754	149,140	120,826	3,086	2,493
TOTAL DISC @3%				145,446	1,239	2,454		149,140			
UNIT COST/KG				$47.1	$.4	$.8		$48.3			
TOTAL DISC @5%				118,236	1,002	1,588			120,826		
UNIT COST/KG				$47.4	$.4	$.6			$48.5		

TABLE C-14

CASE 4C -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING OF TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	1,015	7,811	32	21,888	197		22,085	13,762	10,117	316	232
2004	906	8,717	30	20,400	184		20,584	12,454	8,981	274	198
2005	1,019	9,736	33	22,341	203		22,544	13,242	9,367	299	212
2006	1,087	10,823	35	23,555	215		23,770	13,556	9,407	310	215
2007	1,083	11,906	35	23,450	215		23,665	13,103	8,919	300	204
2008	908	12,814	29	19,372	178		19,550	10,509	7,017	244	163
2009	850	13,664	28	18,648	172		18,820	9,822	6,434	222	145
2010	1,135	14,799	37	24,531	227		24,758	12,545	8,061	288	185
2011	750	15,549	24	15,864	148		16,012	7,877	4,965	184	116
2012			(13)			220	220	105	65		
2013			(59)			998	998	463	281		
2014			(62)			1,048	1,048	472	281		
2015			(81)			1,369	1,369	599	349		
2016			(65)			1,099	1,099	466	267		
2017			(67)			1,133	1,133	467	262		
2018			(78)			1,319	1,319	527	291		
2019			(72)			1,217	1,217	473	255		
2020			(9)			152	152	57	30		
TOTAL			504	350,250	3,099	8,555	361,904	231,065	175,806	4,943	3,747
TOTAL DISC @3%				225,461	1,975	3,629		231,065			
UNIT COST/KG				$45.6	$.4	$.7		$46.7			
TOTAL DISC @5%				172,227	1,498	2,081			175,806		
UNIT COST/KG				$46.0	$.4	$.6			$46.9		

TABLE C-15

CASE 5A -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
(50% of AR Storage Requirements Provided by Casks)

10/29/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	169	3,163	9	6,255	56		6,311	4,559	3,690	61	49
1999	272	3,435	15	10,395	93		10,488	7,356	5,840	95	76
2000	390	3,825	21	14,511	130		14,641	9,970	7,765	133	103
2001			(3)			3	3	2	2		
2002			(47)			52	52	34	25		
2003			(107)			119	119	74	54		
2004			(50)			56	56	34	24		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			205	148,628	1,272	230	150,130	119,952	104,235	1,508	1,306
TOTAL DISC @3%				118,798	1,011	143		119,952			
UNIT COST/KG				$78.8	$.7	$.1		$79.5			
TOTAL DISC @5%				103,254	875	106			104,235		
UNIT COST/KG				$79.1	$.7	$.1			$79.8		

TABLE C-16

CASE 5B -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2003
ONE-TIME USE OF SOC FOR SHIPMENT
(50% of AR Storage Requirements Provided by Casks)

11/ 3/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	615	7,411	33	22,077	205		22,282	13,885	10,208	192	141
2004	506	7,917	26	17,342	161		17,503	10,590	7,637	153	110
2005	619	8,536	33	21,912	205		22,117	12,991	9,190	182	129
2006	187	8,723	10	6,630	62		6,692	3,816	2,648	53	37
2007			(38)			42	42	23	16		
2008			(92)			102	102	55	37		
2009			(94)			104	104	55	36		
2010			(79)			88	88	44	29		
2011			(73)			81	81	40	25		
2012			(87)			97	97	46	29		
2013			(8)			9	9	4	3		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			467	325,208	2,897	523	328,629	234,995	190,882	3,086	2,493
TOTAL DISC @3%				232,669	2,059	268		234,995			
UNIT COST/KG				$75.4	$.7	$.1		$76.2			
TOTAL DISC @5%				189,045	1,664	173			190,882		
UNIT COST/KG				$75.8	$.7	$.1			$76.6		

TABLE C-17

CASE 5C -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES -- 10/29/1987
REPOSITORY COMMENCES OPERATION IN 2008
ONE-TIME USE OF SOC FOR SHIPMENT
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	1,015	7,811	55	36,795	341		37,136	23,142	17,013	316	232
2004	906	8,717	49	32,536	304		32,840	19,869	14,328	274	198
2005	1,019	9,736	55	36,355	341		36,696	21,555	15,248	299	212
2006	1,087	10,823	59	38,822	366		39,188	22,348	15,508	310	215
2007	1,083	11,906	58	37,990	360		38,350	21,233	14,454	300	204
2008	908	12,814	49	31,948	304		32,252	17,337	11,577	244	163
2009	850	13,664	46	29,900	285		30,185	15,754	10,319	222	145
2010	1,135	14,799	61	39,528	378		39,906	20,220	12,992	288	185
2011	750	15,549	41	26,527	254		26,781	13,175	8,304	184	116
2012			(22)			24	24	12	7		
2013			(98)			109	109	50	31		
2014			(103)			114	114	52	31		
2015			(135)			150	150	66	38		
2016			(108)			120	120	51	29		
2017			(110)			122	122	50	28		
2018			(130)			144	144	58	32		
2019			(120)			133	133	52	28		
2020			(14)			16	16	6	3		
TOTAL			838	567,648	5,199	933	573,781	368,474	280,996	4,943	3,747
TOTAL DISC @3%				364,766	3,312	396		368,474			
UNIT COST/KG				$73.8	$.7	$.1		$74.5			
TOTAL DISC @5%				278,258	2,510	227			280,996		
UNIT COST/KG				$74.3	$.7	$.1			$75.0		

TABLE C-18
CASE 6A -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
(50% of AR Storage Requirements Provided by Casks)

11/ 3/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	169	3,163	5	3,560	31		3,591	2,594	2,099	61	49
1999	272	3,435	9	6,390	55		6,445	4,521	3,589	95	76
2000	390	3,825	12	8,472	74		8,546	5,819	4,532	133	103
2001			(1)			1	1	1	1		
2002			(29)			36	36	23	17		
2003			(64)			79	79	49	36		
2004			(30)			37	37	22	16		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			123	92,111	756	152	93,020	74,529	64,888	1,508	1,306
TOTAL DISC @3%				73,832	602	95		74,529			
UNIT COST/KG				$49.0	$.4	$.1		$49.4			
TOTAL DISC @5%				64,296	522	70			64,888		
UNIT COST/KG				$49.2	$.4	$.1			$49.7		

TABLE C-19

CASE 6B -- COST OF SOCs FOR AT REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2003
ONE-TIME USE OF SOC FOR SHIPMENT
(56% of AR Storage Requirements Provided by Casks)

11/ 3/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	615	7,411	20	13,700	123		13,823	8,614	6,332	192	141
2004	506	7,917	17	11,611	105		11,716	7,088	5,111	153	110
2005	619	8,536	20	13,620	123		13,743	8,073	5,710	182	129
2006	187	8,723	6	4,074	37		4,111	2,344	1,627	53	37
2007			(23)			28	28	16	11		
2008			(55)			68	68	36	24		
2009			(57)			70	70	37	24		
2010			(48)			59	59	30	19		
2011			(44)			54	54	27	17		
2012			(52)			64	64	31	19		
2013			(5)			6	6	3	2		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			284	203,206	1,746	349	205,301	146,864	119,354	3,086	2,493
TOTAL DISC @3%				145,446	1,239	178		146,864			
UNIT COST/KG				$47.1	$.4	$.1		$47.6			
TOTAL DISC @5%				118,236	1,002	115			119,354		
UNIT COST/KG				$47.4	$.4	$.0			$47.9		

TABLE C-20

CASE 6C -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2008
ONE-TIME USE OF SOC FOR SHIPMENT
(50% of AR Storage Requirements Provided by Casks)

11/ 3/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	1,015	7,811	32	21,888	197		22,085	13,762	10,117	316	232
2004	906	8,717	30	20,400	184		20,584	12,454	8,981	274	198
2005	1,019	9,736	33	22,341	203		22,544	13,242	9,367	299	212
2006	1,087	10,823	35	23,555	215		23,770	13,556	9,407	310	215
2007	1,083	11,906	35	23,450	215		23,665	13,103	8,919	300	204
2008	908	12,814	29	19,372	178		19,550	10,509	7,017	244	163
2009	850	13,664	28	18,648	172		18,820	9,822	6,434	222	145
2010	1,135	14,799	37	24,531	227		24,758	12,545	8,061	288	185
2011	750	15,549	24	15,864	148		16,012	7,877	4,965	184	116
2012			(13)			16	16	8	5		
2013			(59)			73	73	34	20		
2014			(62)			76	76	34	20		
2015			(81)			100	100	44	25		
2016			(65)			80	80	34	19		
2017			(67)			82	82	34	19		
2018			(78)			96	96	38	21		
2019			(72)			89	89	34	19		
2020			(9)			11	11	4	2		
TOTAL			504	350,250	3,099	622	353,971	227,700	173,876	4,943	3,747
TOTAL DISC @3%				225,461	1,975	264		227,700			
UNIT COST/KG				$45.6	$.4	$.1		$46.1			
TOTAL DISC @5%				172,227	1,498	151			173,876		
UNIT COST/KG				$46.0	$.4	$.0			$46.4		

TABLE C-21

CASE 7A -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	169	3,163	9	6,255	56		6,311	4,559	3,690	61	49
1999	272	3,435	15	10,395	93		10,488	7,356	5,840	95	76
2000	390	3,825	21	14,511	130		14,641	9,970	7,765	133	103
2001			(3)			21	21	14	11		
2002			(47)			335	335	215	161		
2003			(1C7)			763	763	475	350		
2004			(50)			357	357	216	156		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			205	148,628	1,272	1,476	151,376	120,729	104,806	1,508	1,306
TOTAL DISC @3%				118,798	1,011	920		120,729			
UNIT COST/KG				$78.8	$.7	$.6		$80.0			
TOTAL DISC @5%				103,254	875	677			104,806		
UNIT COST/KG				$79.1	$.7	$.5			$80.3		

TABLE C-22
CASE 7B -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN OVERPACKED SOCs
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	615	7,411	33	22,077	205		22,282	13,885	10,208	192	141
2004	506	7,917	26	17,342	161		17,503	10,590	7,637	153	110
2005	619	8,536	33	21,912	205		22,117	12,991	9,190	182	129
2006	187	8,723	10	6,630	62		6,692	3,816	2,648	53	37
2007			(38)			271	271	150	102		
2008			(92)			656	656	353	235		
2009			(94)			670	670	350	229		
2010			(79)			563	563	285	183		
2011			(73)			521	521	256	161		
2012			(87)			620	620	296	183		
2013			(8)			57	57	26	16		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			467	325,208	2,897	3,358	331,464	236,444	191,820	3,086	2,493
TOTAL DISC @3%				232,669	2,059	1,717		236,444			
UNIT COST/KG				$75.4	$.7	$.6		$76.6			
TOTAL DISC @5%				189,045	1,664	1,111			191,820		
UNIT COST/KG				$75.8	$.7	$.4			$76.9		

TABLE C-23

CASE 7C -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES -- 11/ 4/1987
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN OVERPACKED SOC
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	6	5,736	37		5,773	5,605	5,498	51	50
1989	163	323	9	7,038	56		7,094	6,687	6,434	77	74
1990	126	449	7	5,355	43		5,398	4,940	4,663	58	54
1991	238	687	13	9,763	81		9,844	8,746	8,098	106	98
1992	286	973	15	11,070	93		11,163	9,629	8,747	123	112
1993	258	1,231	14	10,206	87		10,293	8,620	7,681	108	96
1994	428	1,659	23	16,583	143		16,726	13,600	11,887	174	152
1995	365	2,024	20	14,240	124		14,364	11,339	9,722	144	124
1996	454	2,478	24	16,920	149		17,069	13,082	11,003	174	146
1997	516	2,994	28	19,600	174		19,774	14,714	12,139	192	158
1998	569	3,563	31	21,483	192		21,675	15,659	12,673	206	166
1999	672	4,235	36	24,768	223		24,991	17,528	13,916	236	187
2000	790	5,025	43	29,369	267		29,636	20,181	15,716	269	209
2001	844	5,869	45	30,510	279		30,789	20,355	15,551	279	213
2002	927	6,796	50	33,650	310		33,960	21,798	16,335	298	223
2003	1,015	7,811	55	36,795	341		37,136	23,142	17,013	316	232
2004	906	8,717	49	32,536	304		32,840	19,869	14,328	274	198
2005	1,019	9,736	55	36,355	341		36,696	21,555	15,248	299	212
2006	1,087	10,823	59	38,822	366		39,188	22,348	15,508	310	215
2007	1,083	11,906	58	37,990	360		38,350	21,233	14,454	300	204
2008	908	12,814	49	31,948	304		32,252	17,337	11,577	244	163
2009	850	13,664	46	29,900	285		30,185	15,754	10,319	222	145
2010	1,135	14,799	61	39,528	378		39,906	20,220	12,992	288	185
2011	750	15,549	41	26,527	254		26,781	13,175	8,304	184	116
2012			(22)			157	157	75	46		
2013			(58)			699	699	324	197		
2014			(103)			734	734	331	197		
2015			(125)			963	963	421	246		
2016			(108)			770	770	327	187		
2017			(110)			784	784	323	181		
2018			(130)			927	927	371	204		
2019			(120)			856	856	332	180		
2020			(14)			100	100	38	20		
TOTAL			838	567,648	5,199	5,989	578,836	370,619	282,226	4,943	3,747
TOTAL DISC @3%				364,766	3,312	2,541		370,619			
UNIT COST/KG				$73.8	$.7	$.5		$75.0			
TOTAL DISC @5%				278,258	2,510	1,457			282,226		
UNIT COST/KG				$74.3	$.7	$.4			$75.3		

TABLE C-24

CASE 8A -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	169	3,163	5	3,560	31		3,591	2,594	2,099	61	49
1999	272	3,435	9	6,390	55		6,445	4,521	3,589	95	76
2000	390	3,825	12	8,472	74		8,546	5,819	4,532	133	103
2001			(1)			7	7	5	4		
2002			(29)			205	205	132	99		
2003			(64)			452	452	282	207		
2004			(30)			212	212	128	93		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			123	92,111	756	877	93,744	74,980	65,220	1,508	1,306
TOTAL DISC @3%				73,832	602	547		74,980			
UNIT COST/KG				$49.0	$.4	$.4		$49.7			
TOTAL DISC @5%				64,296	522	402			65,220		
UNIT COST/KG				$49.2	$.4	$.3			$49.9		

TABLE C-25

CASE 8D -- COST OF SOCs FOR AT REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN OVERPACKED SOC
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	615	7,411	20	13,700	123		13,823	8,614	6,332	192	141
2004	506	7,917	17	11,611	105		11,716	7,088	5,111	153	110
2005	619	8,536	20	13,620	123		13,743	8,073	5,710	182	129
2006	187	8,723	6	4,074	37		4,111	2,344	1,627	53	37
2007			(23)			163	163	90	61		
2008			(55)			389	389	209	140		
2009			(57)			403	403	210	138		
2010			(48)			339	339	172	110		
2011			(44)			311	311	153	96		
2012			(52)			368	368	176	109		
2013			(5)			35	35	16	10		
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			284	203,206	1,746	2,008	206,960	147,712	119,902	3,086	2,493
TOTAL DISC @3%				145,446	1,239	1,026		147,712			
UNIT COST/KG				$47.1	$.4	$.3		$47.9			
TOTAL DISC @5%				118,236	1,002	664			119,902		
UNIT COST/KG				$47.4	$.4	$.3			$48.1		

TABLE C-26
CASE 8C -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN OVERPACKED SOC
(50% of AR Storage Requirements Provided by Casks)

11/ 4/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE, OVERPACKING & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	6		962	962	962	12	12
1988	106	160	4	3,824	25		3,849	3,736	3,665	51	50
1989	163	323	5	4,780	31		4,811	4,535	4,363	77	74
1990	126	449	4	3,128	25		3,153	2,885	2,723	58	54
1991	238	687	7	5,390	43		5,433	4,827	4,470	106	98
1992	286	973	10	7,560	61		7,621	6,574	5,972	123	112
1993	258	1,231	8	5,968	49		6,017	5,039	4,490	108	96
1994	428	1,659	14	10,318	86		10,404	8,459	7,394	174	152
1995	365	2,024	12	8,748	74		8,822	6,964	5,971	144	124
1996	454	2,478	15	10,845	92		10,937	8,382	7,050	174	146
1997	516	2,994	17	12,172	105		12,277	9,135	7,537	192	158
1998	569	3,563	18	12,780	111		12,891	9,312	7,537	206	166
1999	672	4,235	22	15,488	135		15,623	10,958	8,700	236	187
2000	790	5,025	26	18,174	160		18,334	12,484	9,723	269	209
2001	844	5,869	27	18,711	166		18,877	12,480	9,534	279	213
2002	927	6,796	31	21,359	191		21,550	13,832	10,366	298	223
2003	1,015	7,811	32	21,888	197		22,085	13,762	10,117	316	232
2004	906	8,717	30	20,400	184		20,584	12,454	8,981	274	198
2005	1,019	9,736	33	22,341	203		22,544	13,242	9,367	299	212
2006	1,087	10,823	35	23,555	215		23,770	13,556	9,407	310	215
2007	1,083	11,906	35	23,450	215		23,665	13,103	8,919	300	204
2008	908	12,814	29	19,372	178		19,550	10,509	7,017	244	163
2009	850	13,664	28	18,648	172		18,820	9,822	6,434	222	145
2010	1,135	14,799	37	24,531	227		24,758	12,545	8,061	288	185
2011	750	15,549	24	15,864	148		16,012	7,877	4,965	184	116
2012			(13)			92	92	44	27		
2013			(59)			417	417	193	117		
2014			(62)			438	438	197	117		
2015			(81)			573	573	250	146		
2016			(65)			460	460	195	112		
2017			(67)			474	474	195	110		
2018			(78)			551	551	221	122		
2019			(72)			509	509	198	107		
2020			(9)			64	64	24	13		
TOTAL			504	350,250	3,099	3,578	356,926	228,954	174,595	4,943	3,747
TOTAL DISC @3%				225,461	1,975	1,517		228,954			
UNIT COST/KG				$45.6	$.4	$.3		$46.3			
TOTAL DISC @5%				172,227	1,498	870			174,595		
UNIT COST/KG				$46.0	$.4	$.2			$46.6		

TABLE C-27

CASE 9A - COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES -- REPOSITORY COMMENCES OPERATION IN 1998

SHIPMENT IN DOE TRANSPORT CASK

(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF CANNING & LOADING EQUIPMENT ($000)	COST OF CANNING, LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, DECANNING, INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	3	678	395	187		1,260	1,260	1,260	12	12
1988	106	160	12	2,712	395	746		3,853	3,741	3,670	51	50
1989	163	323	19	2,698	395	1,181		4,274	4,029	3,877	77	74
1990	126	449	15	2,085	395	933		3,413	3,123	2,948	58	54
1991	238	687	27	3,672	395	1,679		5,746	5,105	4,727	106	98
1992	286	973	34	4,556	395	2,114		7,065	6,094	5,536	123	112
1993	258	1,231	30	3,960	395	1,865		6,220	5,209	4,642	108	96
1994	428	1,659	50	6,500	395	3,109		10,004	8,134	7,110	174	152
1995	365	2,024	42	5,418	395	2,611		8,424	6,650	5,702	144	124
1996	454	2,478	53	6,784	395	3,295		10,474	8,028	6,752	174	146
1997	516	2,994	60	7,620		3,731		11,351	8,446	6,968	192	158
1998	169	3,163	20	2,500		1,244		3,744	2,704	2,189	61	49
1999	272	3,435	32	4,000		1,990		5,990	4,201	3,335	95	76
2000	390	3,825	45	5,625		2,798		8,423	5,734	4,467	133	103
2001			(6)				225	225	149	113		
2002			(102)				3,820	3,820	2,452	1,838		
2003			(231)				8,651	8,651	5,391	3,963		
2004			(107)				4,007	4,007	2,425	1,748		
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020												
TOTAL			442	58,808	3,950	27,482	16,703	106,944	82,877	70,844	1,508	1,306
TOTAL DISC @3%				47,145	3,471	21,845	10,416		82,877			
UNIT COST/KG				$31.3	$2.3	$14.5	$6.9		$54.9			
TOTAL DISC @5%				41,065	3,203	18,914	7,663			70,844		
UNIT COST/KG				$31.4	$2.5	$14.5	$5.9			$54.2		

TABLE C-28

CASE 9B -- COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF CANNING & LOADING EQUIPMENT ($000)	COST OF CANNING, LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, DECANNING, INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	3	678	395	187		1,260	1,260	1,260	12	12
1988	106	160	12	2,712	395	746		3,853	3,741	3,670	51	50
1989	163	323	19	2,698	395	1,181		4,274	4,029	3,877	77	74
1990	126	449	15	2,085	395	933		3,413	3,123	2,948	58	54
1991	238	687	27	3,672	395	1,679		5,746	5,105	4,727	106	98
1992	286	973	34	4,556	395	2,114		7,065	6,094	5,536	123	112
1993	258	1,231	30	3,960	395	1,865		6,220	5,209	4,642	108	96
1994	428	1,659	50	6,500	395	3,109		10,004	8,134	7,110	174	152
1995	365	2,024	42	5,418	395	2,611		8,424	6,650	5,702	144	124
1996	454	2,478	53	6,784	395	3,295		10,474	8,028	6,752	174	146
1997	516	2,994	60	7,620	790	3,731		12,141	9,034	7,453	192	158
1998	569	3,563	67	8,375	790	4,166		13,331	9,630	7,794	206	166
1999	672	4,235	78	9,672	790	4,850		15,312	10,739	8,526	236	187
2000	790	5,025	92	11,316	790	5,720		17,826	12,139	9,454	269	209
2001	844	5,869	98	11,956	790	6,093		18,839	12,455	9,515	279	213
2002	927	6,796	108	13,176		6,715		19,891	12,767	9,568	298	223
2003	615	7,411	72	8,712		4,477		13,189	8,219	6,042	192	141
2004	506	7,917	59	7,139		3,668		10,807	6,539	4,715	153	110
2005	619	8,536	72	8,640		4,477		13,117	7,705	5,450	182	129
2006	187	8,723	22	2,640		1,368		4,008	2,286	1,586	53	37
2007			(84)				3,146	3,146	1,742	1,186		
2008			(197)				7,378	7,378	3,966	2,648		
2009			(204)				7,640	7,640	3,987	2,612		
2010			(170)				6,367	6,367	3,226	2,073		
2011			(158)				5,917	5,917	2,911	1,835		
2012			(188)				7,041	7,041	3,363	2,079		
2013			(16)				599	599	278	169		
2014												
2015												
2016												
2017												
2018												
2019												
2020												
TOTAL			1013	128,309	7,900	62,985	38,088	237,282	162,359	128,927	3,086	2,493
TOTAL DISC @3%				91,933	6,243	44,710	19,473		162,359			
UNIT COST/KG				$29.8	$2.0	$14.5	$6.3		$52.6			
TOTAL DISC @5%				74,793	5,407	36,125	12,601			128,927		
UNIT COST/KG				$30.0	$2.2	$14.5	$5.1			$51.7		

TABLE C-29

CASE 9C -- COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

11/ 5/1987

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF CANNING & LOADING EQUIPMENT ($000)	COST OF CANNING, LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, DECANNING, INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	3	678	395	187		1,260	1,260	1,260	12	12
1988	106	160	12	2,712	395	746		3,853	3,741	3,670	51	50
1989	163	323	19	2,698	395	1,181		4,274	4,029	3,877	77	74
1990	126	449	15	2,085	395	933		3,413	3,123	2,948	58	54
1991	238	687	27	3,672	395	1,679		5,746	5,105	4,727	106	98
1992	286	973	34	4,556	395	2,114		7,065	6,094	5,536	123	112
1993	258	1,231	30	3,960	395	1,865		6,220	5,209	4,642	108	96
1994	428	1,659	50	6,500	395	3,109		10,004	8,134	7,110	174	152
1995	365	2,024	42	5,418	395	2,611		8,424	6,650	5,702	144	124
1996	454	2,478	53	6,784	395	3,295		10,474	8,028	6,752	174	146
1997	516	2,994	60	7,620	790	3,731		12,141	9,034	7,453	192	158
1998	569	3,563	67	8,375	790	4,166		13,331	9,630	7,794	206	166
1999	672	4,235	78	9,672	790	4,850		15,312	10,739	8,526	236	187
2000	790	5,025	92	11,316	790	5,720		17,826	12,139	9,454	269	209
2001	844	5,869	98	11,956	790	6,093		18,839	12,455	9,515	279	213
2002	927	6,796	108	13,176	1,185	6,715		21,076	13,528	10,138	298	223
2003	1,015	7,811	119	14,399	1,185	7,399		22,983	14,322	10,529	316	232
2004	906	8,717	105	12,600	1,185	6,529		20,314	12,290	8,863	274	198
2005	1,019	9,736	119	14,280	1,185	7,399		22,864	13,430	9,500	299	212
2006	1,087	10,823	127	15,113	1,185	7,896		24,194	13,798	9,575	310	215
2007	1,083	11,906	126	14,994		7,834		22,828	12,639	8,604	300	204
2008	908	12,814	106	12,508		6,591		19,099	10,267	6,855	244	163
2009	850	13,664	99	11,682		6,155		17,837	9,309	6,098	222	145
2010	1,135	14,799	132	15,576		8,207		23,783	12,051	7,743	288	185
2011	750	15,549	87	10,179		5,409		15,588	7,668	4,833	184	116
2012			(48)				1,798	1,798	859	531		
2013			(210)				7,865	7,865	3,647	2,212		
2014			(224)				8,389	8,389	3,777	2,247		
2015			(290)				10,861	10,861	4,747	2,771		
2016			(233)				8,726	8,726	3,703	2,120		
2017			(238)				8,914	8,914	3,672	2,062		
2018			(279)				10,449	10,449	4,179	2,303		
2019			(261)				9,775	9,775	3,796	2,051		
2020			(29)				1,086	1,086	409	217		
TOTAL			1808	222,509	13,825	112,415	67,862	416,612	253,463	188,216	4,943	3,747
TOTAL DISC @3%				143,229	9,831	71,613	28,789		253,463			
UNIT COST/KG				$29.0	$2.0	$14.5	$5.8		$51.3			
TOTAL DISC @5%				109,422	7,999	54,282	16,514			188,216		
UNIT COST/KG				$29.2	$2.1	$14.5	$4.4			$50.2		

TABLE C-30
CASE 10A -- COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	TOTAL AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF LOADING EQUIPMENT ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	226	250	23		499	499	499	12	12
1988	106	160	8	1,808	250	185		2,243	2,178	2,136	51	50
1989	163	323	11	2,486	250	255		2,991	2,819	2,713	77	74
1990	126	449	9	1,278	250	208		1,736	1,589	1,500	58	54
1991	238	687	17	2,380	250	393		3,023	2,686	2,487	106	98
1992	286	973	20	2,720	250	463		3,433	2,961	2,690	123	112
1993	258	1,231	18	2,430	250	417		3,097	2,593	2,311	108	96
1994	428	1,659	30	3,990	250	694		4,934	4,012	3,507	174	152
1995	365	2,024	26	3,432	250	602		4,284	3,382	2,899	144	124
1996	454	2,478	31	4,061	250	717		5,028	3,854	3,241	174	146
1997	516	2,994	37	4,810		856		5,666	4,216	3,479	192	158
1998	169	3,163	12	1,548		278		1,826	1,319	1,067	61	49
1999	272	3,435	19	2,451		440		2,891	2,027	1,610	95	76
2000	390	3,825	27	3,456		625		4,081	2,779	2,164	133	103
2001			(4)				114	114	76	58		
2002			(61)				1,742	1,742	1,118	838		
2003			(140)				3,997	3,997	2,491	1,831		
2004			(64)				1,827	1,827	1,106	797		
2005												
2006												
2007												
2008												
2009												
2010												
2011												
2012												
2013												
2014												
2015												
2016												
2017												
2018												
2019												
2020												
TOTAL			266	37,076	2,500	6,155	7,680	53,412	41,704	35,826	1,508	1,306
TOTAL DISC @3%				29,826	2,197	4,892	4,790		41,704			
UNIT COST/KG				$19.8	$1.5	$3.2	$3.2		$27.6			
TOTAL DISC @5%				26,041	2,027	4,234	3,524			35,826		
UNIT COST/KG				$19.9	$1.6	$3.2	$2.7			$27.4		

TABLE C-31

CASE 10B -- COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2003
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF LOADING EQUIPMENT ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	226	250	23		499	499	499	12	12
1988	106	160	8	1,808	250	185		2,243	2,178	2,136	51	50
1989	163	323	11	2,486	250	255		2,991	2,819	2,713	77	74
1990	126	449	9	1,278	250	208		1,736	1,589	1,500	58	54
1991	238	687	17	2,380	250	393		3,023	2,686	2,487	106	98
1992	286	973	20	2,720	250	463		3,433	2,961	2,690	123	112
1993	258	1,231	18	2,430	250	417		3,097	2,593	2,311	108	96
1994	428	1,659	30	3,990	250	694		4,934	4,012	3,507	174	152
1995	365	2,024	26	3,432	250	602		4,284	3,382	2,899	144	124
1996	454	2,478	31	4,061	250	717		5,028	3,854	3,241	174	146
1997	516	2,994	37	4,810	500	856		6,166	4,588	3,785	192	158
1998	569	3,563	40	5,160	500	926		6,586	4,758	3,850	206	166
1999	672	4,235	47	6,016	500	1,088		7,604	5,333	4,234	236	187
2000	790	5,025	55	6,985	500	1,273		8,758	5,964	4,644	269	209
2001	844	5,869	60	7,500	500	1,388		9,388	6,207	4,742	279	213
2002	927	6,796	65	8,060		1,504		9,564	6,139	4,600	298	223
2003	615	7,411	43	5,332		995		6,327	3,943	2,898	192	141
2004	506	7,917	35	4,305		810		5,115	3,095	2,232	153	110
2005	619	8,536	44	5,412		1,018		6,430	3,777	2,672	182	129
2006	187	8,723	13	1,599		301		1,900	1,083	752	53	37
2007			(50)				1,428	1,428	790	538		
2008			(119)				3,398	3,398	1,826	1,220		
2009			(123)				3,512	3,512	1,833	1,201		
2010			(103)				2,941	2,941	1,490	957		
2011			(95)				2,712	2,712	1,334	841		
2012			(113)				3,226	3,226	1,541	953		
2013			(10)				286	286	132	80		
2014												
2015												
2016												
2017												
2018												
2019												
2020												
TOTAL			610	79,990	5,000	14,115	17,502	116,607	80,406	64,183	3,086	2,493
TOTAL DISC @3%				57,489	3,952	10,018	8,947		80,406			
UNIT COST/KG				$18.6	$1.3	$3.2	$2.9		$26.1			
TOTAL DISC @5%				46,877	3,422	8,094	5,790			64,183		
UNIT COST/KG				$18.8	$1.4	$3.2	$2.3			$25.7		

TABLE C-32
CASE 10C -- COST OF CONCRETE CASKS FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 2008
SHIPMENT IN DOE TRANSPORT CASK
(50% of AR Storage Requirements Provided by Casks)

YEAR	TOTAL AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF CONCRETE CASKS	COST OF CONCRETE CASKS ($000)	COST OF LOADING EQUIPMENT ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF UNLOADING, INSPECTION & LOADING TRANSPORT CASK ($000)	TOTAL ($000)	TOTAL COST DISC. AT 3% TO 1987 ($000)	TOTAL COST DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	226	250	23		499	499	499	12	12
1988	106	160	8	1,808	250	185		2,243	2,178	2,136	51	50
1989	163	323	11	2,486	250	255		2,991	2,819	2,713	77	74
1990	126	449	9	1,278	250	208		1,736	1,589	1,500	58	54
1991	238	687	17	2,380	250	393		3,023	2,686	2,487	106	98
1992	286	973	20	2,720	250	463		3,433	2,961	2,690	123	112
1993	258	1,231	18	2,430	250	417		3,097	2,593	2,311	108	96
1994	428	1,659	30	3,990	250	694		4,934	4,012	3,507	174	152
1995	365	2,024	26	3,432	250	602		4,284	3,382	2,899	144	124
1996	454	2,478	31	4,061	250	717		5,028	3,854	3,241	174	146
1997	516	2,994	37	4,810	500	856		6,166	4,588	3,785	192	158
1998	569	3,563	40	5,160	500	926		6,586	4,758	3,850	206	166
1999	672	4,235	47	6,016	500	1,088		7,604	5,333	4,234	236	187
2000	790	5,025	55	6,985	500	1,273		8,758	5,964	4,644	269	209
2001	844	5,869	60	7,500	500	1,388		9,388	6,207	4,742	279	213
2002	927	6,796	65	8,060	750	1,504		10,314	6,620	4,961	298	223
2003	1,015	7,811	71	8,804	750	1,643		11,197	6,978	5,129	316	232
2004	906	8,717	64	7,872	750	1,481		10,103	6,112	4,408	274	198
2005	1,019	9,736	71	8,662	750	1,643		11,055	6,494	4,594	299	212
2006	1,087	10,823	76	9,272	750	1,759		11,781	6,718	4,662	310	215
2007	1,083	11,906	76	9,196		1,759		10,955	6,065	4,129	300	204
2008	908	12,814	64	7,744		1,481		9,225	4,959	3,311	244	163
2009	850	13,664	60	7,260		1,388		8,648	4,514	2,956	222	145
2010	1,135	14,799	80	9,600		1,851		11,451	5,802	3,728	288	185
2011	750	15,549	52	6,240		1,203		7,443	3,662	2,308	184	116
2012			(29)				828	828	395	245		
2013			(127)				3,626	3,626	1,681	1,020		
2014			(134)				3,826	3,826	1,722	1,025		
2015			(175)				4,996	4,996	2,184	1,275		
2016			(140)				3,997	3,997	1,696	971		
2017			(144)				4,111	4,111	1,694	951		
2018			(168)				4,797	4,797	1,919	1,057		
2019			(157)				4,483	4,483	1,741	941		
2020			(18)				514	514	194	103		
TOTAL			1089	137,992	8,750	25,199	31,178	203,119	124,572	93,012	4,943	3,747
TOTAL DISC @3%				89,073	6,222	16,051	13,226		124,572			
UNIT COST/KG				$18.0	$1.3	$3.2	$2.7		$25.2			
TOTAL DISC @5%				68,199	5,062	12,165	7,586			93,012		
UNIT COST/KG				$18.2	$1.4	$3.2	$2.0			$24.8		

TABLE C-33

COMPARATIVE COSTS OF USE OF CASKS IN AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES

($/kgU, 1987)[a]

	Unit Costs for Indicated Equipment or Activity				
	Casks	Loading Equipment	Loading & Placement In Storage	Removal From Storage & Preparation For Shipment	Total
On-Time Repository					
TSC Shipped Directly to DOE	$87.9	$ -	$ 0.7	$0.1	$88.7
SOC One-Time Direct Shipment to DOE	78.8	-	0.7	0.1	79.6
SOC Shipped to DOE In Overpack	78.8	-	0.7	0.6	80.1
SOC Used for At-Reactor Storage Only	78.8	-	0.7	2.1	81.6
Concrete Cask	31.3	2.3	14.5	6.9	55.0
5-Year Repository Delay					
TSC Shipped Directly to DOE	84.5	-	0.7	0.1	85.3
SOC One-Time Direct Shipment to DOE	75.4	-	0.7	0.1	76.2
SOC Shipped to DOE In Overpack	75.4	-	0.7	0.5	76.6
SOC Used for At-Reactor Storage Only	75.4	-	0.7	1.9	78.0
Concrete Cask	29.8	2.0	14.5	6.3	52.6
10-Year Repository Delay					
TSC Shipped Directly to DOE	82.8	-	0.7	0.1	83.4
SOC One-Time Direct Shipment to DOE	73.8	-	0.7	0.1	74.6
SOC Shipped to DOE In Overpack	73.8	-	0.7	0.5	75.0
SOC Used for At-Reactor Storage Only	73.8	-	0.7	1.8	76.3
Concrete Cask	29.0	2.0	14.5	5.8	51.3

[a]Averaged at a 3%/year discount rate

TABLE C-34

COMPARATIVE COSTS OF USE OF CASKS IN AT-REACTOR STORAGE OF CONSOLIDATED FUEL

($/kgU, 1987)[a]

	Unit Costs for Indicated Equipment or Activity				
	Casks	Loading Equipment	Loading & Placement In Storage	Removal From Storage & Preparation For Shipment	Total
On-Time Repository					
TSC Shipped Directly to DOE	$54.1	$ -	$ 0.4	$0.1	$54.6
SOC One-Time Direct Shipment to DOE	49.0	-	0.4	0.1	49.5
SOC Shipped to DOE In Overpack	49.0	-	0.4	0.4	49.8
SOC Used for At-Reactor Storage Only	49.0	-	0.4	0.9	50.3
Concrete Cask	19.8	1.5	3.2	3.2	27.7
5-Year Repository Delay					
TSC Shipped Directly to DOE	52.5	-	0.4	0.1	53.0
SOC One-Time Direct Shipment to DOE	47.1	-	0.4	0.1	47.6
SOC Shipped to DOE In Overpack	47.1	-	0.4	0.3	47.8
SOC Used for At-Reactor Storage Only	47.1	-	0.4	0.8	48.3
Concrete Cask	18.6	1.3	3.2	2.9	26.0
10-Year Repository Delay					
TSC Shipped Directly to DOE	51.0	-	0.4	0.1	51.5
SOC One-Time Direct Shipment to DOE	45.6	-	0.4	0.1	46.1
SOC Shipped to DOE In Overpack	45.6	-	0.4	0.3	46.3
SOC Used for At-Reactor Storage Only	45.6	-	0.4	0.7	46.7
Concrete Cask	18.0	1.3	3.2	2.7	25.2

[a]Averaged at a 3%/year discount rate

The following basic conclusions can be drawn from the results shown in Tables C-33 and C-34 with respect to the comparative costs of acquiring and handling TSCs, SOCs and concrete casks at the reactor site:

(1) TSCs cost about $7.2/kgU (or 9.1 percent) more than SOCs when used to store intact fuel assemblies, and about $4.6/kgU (or 9.5 percent) more than SOCs when used to store consolidated fuel -- if the SOC has to be unloaded at the end of the storage period and the contained fuel loaded into a DOE-supplied transport cask for shipment to a DOE facility.

(2) If the loaded SOCs can be licensed for a one-time shipment to DOE facilities, TSCs would cost about $9/kgU (or 11.7 percent) more than SOCs when used to store intact fuel assemblies, and about $5.3/kgU (or 11.1 percent) more than SOCs when used to store consolidated fuel.

(3) If the loaded SOCs must be overpacked for a one-time shipment to DOE facilities, TSCs would cost about $8.6/kgU (or 11.1 percent) more than SOCs when used to store intact fuel assemblies, and about $5.1/kgU (or 9.5 percent) more than SOCs when used to store consolidated fuel.

(4) TSCs cost about $33/kgU (or 62 percent) more than concrete casks when used to store intact fuel assemblies, and about $27/kgU (or 104 percent) more when used to store consolidated fuel.

However, it should be remembered that the costs associated with storage of spent fuel in concrete casks have not yet been demonstrated and thus the foregoing conclusions regarding the costs of such storage may be optimistic. In addition, other factors may make the concrete cask less desirable, such as:

(1) Higher land requirements

(2) Larger number of fuel handling operations

(3) Higher prospective worker exposure

(4) The prospective transportability of TSCs and SOCs -- which give a lesser impression of the permanence of storage

There are concrete storage cask designs that reportedly <u>might</u> be capable of being loaded in the reactor pool, thus eliminating the concerns outlined in (2) and (3), above, and which have the potential for further reducing the costs involved. The results of further demonstration work with concrete casks (both the NUHOMS horizontally loaded modules as well as the NUPAC vertically loaded cask) should help to clarify the relative desirability of concrete and metal casks.

It should also be recognized that there are also significant uncertainties about the cost of licensable TSCs as well as the feasibility of shipping SOCs either on a one-time basis or in overpacks. Thus the foregoing comparisons have a wide range of uncertainty associated with them. Nonetheless, the comparisons are indicative of the fact that the use of TSCs or SOCs for at-reactor storage of spent fuel may well result in significantly higher costs to utilities than alternative methods of dry storage -- which would have to be offset by savings in the DOE spent fuel management system resulting from the use of TSCs or SOCs, or other advantages of their use, in order for them to be viable.

3.0 REFERENCES FOR APPENDIX C

(1) C. M. Heeb, R. A. Libby, R.C. Walling and W. L. Purcell, Reactor-Specific Spent Fuel Discharge Projections; 1985 to 2020, PNL-5833, Pacific Northwest Laboratory, September 1986

(2) U. S. Department of Energy, Mission Plan for the Civilian Radioactive Waste Management Program, DOE/RW-0005, June 1985

APPENDIX D

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM REACTOR SITES TO DOE FACILITIES IN STANDARD TRANSPORT CASKS, TSCs, AND SOCs (BOTH WITH AND WITHOUT OVERPACKS)

APPENDIX D

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM REACTOR SITES TO DOE FACILITIES IN STANDARD TRANSPORT CASKS, TSCs, AND SOCs (BOTH WITH AND WITHOUT OVERPACKS)

TABLE OF CONTENTS

APPENDIX D

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM REACTOR SITES TO DOE FACILITIES IN STANDARD TRANSPORT CASKS, TSCs, AND SOCs (BOTH WITH AND WITHOUT OVERPACKS)

The purpose of this Appendix is to develop estimates of the cost of transporting spent fuel from reactor sites to DOE facilities in (i) standard transport casks, (ii) TSCs, (iii) SOCs used for a single shipment only, and (iv) SOCs used with a protective overpack, so that the extent of the benefits involved in shipping TSCs and SOCs over those for standard transport casks can be determined. The estimated capital and operating costs associated with the foregoing methods of shipment, and the estimated life cycle and unit costs of various shipment scenarios, are developed in the following sections.

1.0 ESTIMATED CAPITAL COSTS

1.1 COST OF TRANSPORT CASKS

For the purposes of this study, it was assumed that DOE-supplied transport casks would cost the same as a TSC. The cost of design and fabrication of TSCs has been previously discussed in Section 2.0 of Appendix A, and the cost of the first 10 such units (over which the design and development has been amortized) was estimated at $1.319-million (Table A-4). In addition to the costs shown in that section, additional costs would be required for auxiliary and support equipment. These include the following:

TABLE D-1

ESTIMATED COST OF AUXILIARY EQUIPMENT REQUIRED TO SUPPORT OPERATION OF A TSC

($000, 1987)

Description	Cost
Rail Car, Personnel Barrier & Tie Downs	$538
Impact Limiters	108
Lift Beam, Misc. Equipment & Special Tools	108
Total	$754

The foregoing costs were based on estimates provided by designer/vendors and escalated to 1987 dollars. A cask that is used solely in transport service usually has the auxiliary equipment dedicated to its use. Thus, the cost of a transport cask is estimated to be $2.073-million.

It should be pointed out here that a TSC or SOC used for storage of spent fuel would to have the auxilary equipment described in Table D-1 available to it whenever it is used in transport service. This means that while there may be scenarios where a TSC or SOC could be used to replace a transport cask, the auxiliary equipment described above would still be required.

1.2 COST OF SOC OVERPACKS

For the purposes of this study, it was assumed that an overpack for use with a SOC would cost about $0.38-million, and that the cost of design and development thereof would amount to about $2-million. It was further assumed that the latter cost would be spread over 10 units, thus giving a total cost of the overpack of $0.58-million. Here again, as in the case of the TSC, the auxiliary equipment described in Table D-1 would be required for the shipment of overpacks.

The weight of the overpack loaded with a SOC containing spent fuel was estimated to be 324,500 lbs; the empty overpack was estimated to weigh 92,500 lbs.

2.0 ESTIMATED TRANSPORT COSTS

The costs for transport of spent fuel from reactors to DOE facilities was estimated for three different distances (300 miles, 900 miles and 2300 miles) in order to obtain a range of expected costs. The following sections describe the development of the component costs.

2.1 FREIGHT RATES

PNL has recently developed truck and rail charges for spent fuel for a number of origin and destination combinations (Reference 1), based on the assumption that the casks would be transported at general commodity rates (Class 40). The rail freight rates contained in the PNL report were used to develop a relationship of distance to freight rate, as follows:

$$R_l = 0.1678\ D^{0.5815}$$

$$R_e = 0.1600\ D^{0.5790}$$

where R_l = loaded cask freight rate expressed in \$/CWT
R_e = empty cask freight rate expressed in \$/CWT
D = one-way distance

While the PNL freight rates were in 1986 dollars, they were not escalated inasmuch as the price index for rail freight has declined slightly during 1986; it was concluded that the 1986 values should be applicable for 1987 as well.

The freight rates determined using the foregoing relationships were as follows:

Distance (Miles)	Freight Rate (\$/CWT) Loaded	Empty
300	\$4.63	\$4.35
900	8.76	8.22
2300	15.12	14.14

In computing the total freight charges for an individual shipment, it was assumed that the railroads would apply a 250,000 lb minimum weight to a loaded cask shipment and a 225,000 lb. minimum weight to an empty cask shipment. However, for cases where the rail car, impact limiters, etc. were shipped to the reactor to pick up a loaded TSC or SOC, a 40,000 lb minimum weight and the empty cask freight rate was assumed to be acceptable to the railroads. (The foregoing conclusion was reached after discussing the matter with the Rockwell-Hanford traffic manager.) In cases where the empty overpack is returned to the reactor, a 132,500 lb. weight and the empty cask freight rate were assumed to be applicable.

2.2 SECURITY COSTS

Under existing NRC regulations, shipments of spent fuel must be escorted by armed guards. The cost for these escorts was developed using the following assumptions:

(1) Two men (a guard sergeant and an officer) would be located in the caboose during the entire loaded portion of the shipment. The sergeant would carry a rate of $12.56/hr and the officer a rate of $11.42/hr. Each would receive 16 hours of pay for each 24 hours involved in the shipment. The guards' pay would carry a 35 percent burden; a 13 percent general administrative cost would be applied to the salary rate plus burden; and a 5 percent profit would be applied to the sum of the foregoing. This produces a total of $615/day for the escorts. This cost was applied to the total elapsed time of the shipment plus a 16 hour layover, air travel at 500 mph, and 4 hours for ground travel time.

(2) Each of the guards would each receive a $25/day subsistence allowance.

(3) In addition to (2), above, the guards would receive $70 for hotel and taxi expenses on the return trip.

(4) A rail fare of $.085/mile per guard was assumed to be applicable to the shipment. Air fare was estimated at $0.30/mile per guard for the return trip.

(5) A security equipment charge of $12/day (total) was assumed to be applicable.

These costs were developed by escalating similar costs used to develop estimated transportation costs in the 1983 FIS Fee Report (Reference 2) by the applicable indexes. Using the above costs, the security costs associated with a single 300-mile shipment would amount to $5,273, for a 900-mile shipment would amount to $8,372, and for a 2300-mile shipment would amount to $11,160.

2.3 OPERATING COSTS

Most of the operating costs associated with the use of a transport cask, a TSC or a SOC have been included in the cost of operations at the reactor site (Appendix B) and at the DOE receiving facilities. Thus the only cost not otherwise covered is that for maintenance of the transport cask and the associated auxiliary support equipment.

The annual cost of maintenance of the transport cask and associated auxiliary equipment was estimated to be $60-thousand (1987 dollars). In cases where a TSC or SOC is used for a one-way shipment, no maintenance cost was ascribed to the cask, but the annual cost of maintaining the auxiliary equipment was estimated to be $10-thousand (1987 dollars). In cases where an overpack is used in a SOC shipment, the annual maintenance cost was assumed to be $35-thousand (1987 dollars).

3.0 LIFE CYCLE TRANSPORT COSTS AND UNIT COSTS

The total life cycle costs associated with the use of a single transport cask, or the equivalent number of TSCs or SOCs, for shipment of spent fuel from the reactors to DOE facilities were developed for the following cases:

Case I -- Transport in DOE-Supplied Transport Casks

Case II -- Transport in TSC Provided by Utility and Used in Repetitive Shipments of Other Fuel; TSC Provided by Utility on a Schedule That Permits DOE Avoidance of Purchase of a Transport Cask

Case III -- Transport in TSC Provided by Utility and Used in Repetitive Shipments of Other Fuel; TSC Provided by Utility on a Schedule That Does Not Permit DOE Avoidance of Purchase of a Transport Cask

Case IV -- Transport in TSCs or SOCs Provided by Utilities and Shipped One-Way Only; TSCs or SOCs Provided by Utilities on a Schedule That Permits DOE Avoidance of Purchase of a Transport Cask

Case V -- Transport in TSCs or SOCs Provided by Utilities and Shipped One-Way Only; TSCs or SOCs Provided by Utilities on a Schedule That Does Not Permit DOE Avoidance of Purchase of a Transport Cask

Case VI -- Transport in SOCs Provided by Utilities in Overpacks and Shipped One-Way Only; SOCs Provided by Utilities on a Schedule That Permits DOE Avoidance of Purchase of a Transport Cask

Case VII -- Transport in SOCs Provided by Utilities in Overpacks and Shipped One-Way Only; SOCs Provided by Utilities on a Schedule That Does Not Permit DOE Avoidance of Purchase of a Transport Cask

For each of the foregoing cases, life cycle costs were develop for transport over distances of 300 miles, 900 miles, and 2300 miles (one-way). These are designated as subcases A, B and C, respectively for each of the cases described above.

The life cycle costs and resulting unit costs for each of the foregoing cases are shown in Table D-2 through D-22. A summary of the unit costs is set forth in Table D-23. The figures set forth in the Tables were developed as follows:

(1) The total costs were assumed to be incurred over the period 1996 to 2023 inclusive. In 1996 and 1997 the costs of acquiring needed equipment would be incurred; during the period 1998 through 2022 the cost of operations would be incurred; and in 2023 the cost of decommissioning the transport cask and/or overpack would be incurred.

(2) The annual quantities shipped each year for 25 years were assumed to be as follows:

300 miles -- 176 MTU/year
900 miles -- 118 MTU/year
2300 miles -- 98 MTU/year

The foregoing were based on an average cask capacity of 9.26 MTU, an average cask availability of 300 days/yr., a total turnaround time of 72 hours for each round trip cask shipment, and the following rail speeds (Reference 1):

Distance	Miles/Day
0-300	47
301-1100	88
1101-1900	143
1901-2400	182

(3) The capital costs used were as follows:

(a) For cases involving the use of a DOE-supplied transport cask (Case I), the capital costs used was $2.073-million (see Section 1.1).

(b) For cases involving use of a TSC or SOC where commitments are made by utilities to deliver casks in sufficient quantities and on a schedule that permits DOE to avoid purchasing a transport cask (Cases II and IV), the capital cost used was $1.149-million ($0.754-million for auxiliary equipment plus $0.395-million for the pro rata share of the transport cask development costs).

(c) For cases involving the use of TSCs or SOCs were DOE cannot avoid the purchase of a transport cask even though the use of it may be displaced by TSCs or SOCs (Cases III and V), the capital cost used was $2.073-million (see Section 1.1).

(d) For cases involving the use of a SOC in an overpack where commitments are made by utilities to deliver casks in sufficient quantities and on a schedule that permits DOE to avoid purchasing a transport cask (Case VI), the capital cost used was $1.729-million ($0.754-million for auxiliary equipment, plus $0.395-million for the pro rata share of cask development costs for the displaced transport cask, plus $0.58-million for the overpack).

(e) For cases involving the use of SOCs in overpacks where DOE cannot avoid the purchase of a transport cask even though use if it may be displaced by TSCs or SOCs (Case VII), the capital cost used was $2.653-million.

(4) The operating costs used were as follows:

(a) For cases involving the use of a DOE-supplied transport cask, or TSCs used in repetitive shipments, (Cases I, II, and III) the annual operating cost used was $60-thousand.

(b) For cases involving the use of TSCs or SOCs (without an overpack) in one-way shipments (Cases IV and V), the annual operating cost used was $10-thousand.

(c) For cases involving the use of SOCs in overpacks (Cases VI and VII), the annual operating cost used was $35-thousand.

(5) The freight charges used were those set forth in Section 2.1 applied against the following weights:

(a) For cases involving the use a DOE-supplied transport cask, or TSCs used in repetitive shipments, (Cases I, II and III) -- 250,000 lbs loaded and 225,000 lbs empty.

(b) For cases involving the use of TSCs or SOCs (without an overpack) in one-way shipments (Cases IV and V) --250,000 lbs loaded and 40,000 lbs empty.

(c) For cases involving the use of SOCs in overpacks (Cases VI and VII) -- 324,500 lbs loaded and 132,500 lbs empty.

(6) The security (escort) charges used were those set forth in Section 2.2.

(7) The cost of decommissioning a DOE-supplied transport cask or SOC overpack after use was assumed to be 7% of the cost thereof, excluding development, design, certification and auxiliary equipment. No decommissioning cost was ascribed to auxiliary equipment or to TSCs (the latter has been estimated in Appendix H).

(8) The total costs were discounted by 3%/year to 1987 to get the total discounted costs.

(9) The unit costs were determined by dividing the total discounted costs by the total discounted amount (MTU) of spent fuel shipped, as follows:

Discounted Costs = Discounted (Unit Costs x MTU Shipped)

Discounted Costs = Unit Costs x Discounted MTU Shipped

$$\text{Unit Cost} = \frac{\text{Discounted Costs}}{\text{Discounted MTU Shipped}}$$

TABLE D-2
CASE IA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
300 MILES AWAY -- IN DOE-SUPPLIED TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1037	795		
1997	1,036					1036	771		
1998		60	406	100		566	409	176	127
1999		60	406	100		566	397	176	123
2000		60	406	100		566	385	176	120
2001		60	406	100		566	374	176	116
2002		60	406	100		566	363	176	113
2003		60	406	100		566	353	176	110
2004		60	406	100		566	342	176	106
2005		60	406	100		566	332	176	103
2006		60	406	100		566	323	176	100
2007		60	406	100		566	313	176	97
2008		60	406	100		566	304	176	95
2009		60	406	100		566	295	176	92
2010		60	406	100		566	287	176	89
2011		60	406	100		566	278	176	87
2012		60	406	100		566	270	176	84
2013		60	406	100		566	262	176	82
2014		60	406	100		566	255	176	79
2015		60	406	100		566	247	176	77
2016		60	406	100		566	240	176	75
2017		60	406	100		566	233	176	73
2018		60	406	100		566	226	176	70
2019		60	406	100		566	220	176	68
2020		60	406	100		566	213	176	66
2021		60	406	100		566	207	176	64
2022		60	406	100		566	201	176	63
2023					60	60	21		
TOTAL	2,073	1,500	10,150	2,500	60	16,283	8,920	4,400	2,280
DISC TOTAL	1,566	777	5,261	1,296	21	8,920			
% OF TOTAL DISC COST	18%	9%	59%	15%	0%	100%		UNIT COST	3.91

TABLE D-3

CASE IB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
900 MILES AWAY -- IN DOE-SUPPLIED TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1037	795		
1997	1,036					1036	771		
1998		60	517	107		684	494	118	85
1999		60	517	107		684	480	118	83
2000		60	517	107		684	466	118	80
2001		60	517	107		684	452	118	78
2002		60	517	107		684	439	118	76
2003		60	517	107		684	426	118	74
2004		60	517	107		684	414	118	71
2005		60	517	107		684	402	118	69
2006		60	517	107		684	390	118	67
2007		60	517	107		684	379	118	65
2008		60	517	107		684	368	118	63
2009		60	517	107		684	357	118	62
2010		60	517	107		684	347	118	60
2011		60	517	107		684	336	118	58
2012		60	517	107		684	327	118	56
2013		60	517	107		684	317	118	55
2014		60	517	107		684	308	118	53
2015		60	517	107		684	299	118	52
2016		60	517	107		684	290	118	50
2017		60	517	107		684	282	118	49
2018		60	517	107		684	274	118	47
2019		60	517	107		684	266	118	46
2020		60	517	107		684	258	118	44
2021		60	517	107		684	250	118	43
2022		60	517	107		684	243	118	42
2023					60	60	21		
TOTAL	2,073	1,500	12,925	2,675	60	19,233	10,449	2,950	1,529
DISC TOTAL	1,566	777	6,699	1,386	21	10,449			
% OF TOTAL DISC COST	15%	7%	64%	13%	0%	100%		UNIT COST	6.83

TABLE D-4
CASE IC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITES
2300 MILES AWAY -- IN DOE-SUPPLIED TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1037	795		
1997	1,036					1036	771		
1998		60	739	118		917	662	98	71
1999		60	739	118		917	643	98	69
2000		60	739	118		917	624	98	67
2001		60	739	118		917	606	98	65
2002		60	739	118		917	589	98	63
2003		60	739	118		917	571	98	61
2004		60	739	118		917	555	98	59
2005		60	739	118		917	539	98	58
2006		60	739	118		917	523	98	56
2007		60	739	118		917	508	98	54
2008		60	739	118		917	493	98	53
2009		60	739	118		917	479	98	51
2010		60	739	118		917	465	98	50
2011		60	739	118		917	451	98	48
2012		60	739	118		917	438	98	47
2013		60	739	118		917	425	98	45
2014		60	739	118		917	413	98	44
2015		60	739	118		917	401	98	43
2016		60	739	118		917	389	98	42
2017		60	739	118		917	378	98	40
2018		60	739	118		917	367	98	39
2019		60	739	118		917	356	98	38
2020		60	739	118		917	346	98	37
2021		60	739	118		917	336	98	36
2022		60	739	118		917	326	98	35
2023					60	60	21		
TOTAL	2,073	1,500	18,475	2,950	60	25,058	13,468	2,450	1,270
DISC TOTAL	1,566	777	9,575	1,529	21	13,468			
% OF TOTAL DISC COST	12%	6%	71%	11%	0%	100%		UNIT COST	10.61

TABLE D-5

CASE IIA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 300 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT PERMITS DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		60	406	100		566	409	176	127
1999		60	406	100		566	397	176	123
2000		60	406	100		566	385	176	120
2001		60	406	100		566	374	176	116
2002		60	406	100		566	363	176	113
2003		60	406	100		566	353	176	110
2004		60	406	100		566	342	176	106
2005		60	406	100		566	332	176	103
2006		60	406	100		566	323	176	100
2007		60	406	100		566	313	176	97
2008		60	406	100		566	304	176	95
2009		60	406	100		566	295	176	92
2010		60	406	100		566	287	176	89
2011		60	406	100		566	278	176	87
2012		60	406	100		566	270	176	84
2013		60	406	100		566	262	176	82
2014		60	406	100		566	255	176	79
2015		60	406	100		566	247	176	77
2016		60	406	100		566	240	176	75
2017		60	406	100		566	233	176	73
2018		60	406	100		566	226	176	70
2019		60	406	100		566	220	176	68
2020		60	406	100		566	213	176	66
2021		60	406	100		566	207	176	64
2022		60	406	100		566	201	176	63
2023					0				
TOTAL	1,149	1,500	10,150	2,500	0	15,299	8,201	4,400	2,280
DISC TOTAL	868	777	5,261	1,296	0	8,201			
% OF TOTAL DISC COST	11%	9%	64%	16%	0%	100%		UNIT COST	3.60

TABLE D-6

CASE IIB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 900 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT PERMITS DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		60	517	107		684	494	118	85
1999		60	517	107		684	480	118	83
2000		60	517	107		684	466	118	80
2001		60	517	107		684	452	118	78
2002		60	517	107		684	439	118	76
2003		60	517	107		684	426	118	74
2004		60	517	107		684	414	118	71
2005		60	517	107		684	402	118	69
2006		60	517	107		684	390	118	67
2007		60	517	107		684	379	118	65
2008		60	517	107		684	368	118	63
2009		60	517	107		684	357	118	62
2010		60	517	107		684	347	118	60
2011		60	517	107		684	336	118	58
2012		60	517	107		684	327	118	56
2013		60	517	107		684	317	118	55
2014		60	517	107		684	308	118	53
2015		60	517	107		684	299	118	52
2016		60	517	107		684	290	118	50
2017		60	517	107		684	282	118	49
2018		60	517	107		684	274	118	47
2019		60	517	107		684	266	118	46
2020		60	517	107		684	258	118	44
2021		60	517	107		684	250	118	43
2022		60	517	107		684	243	118	42
2023					0				
TOTAL	1,149	1,500	12,925	2,675	0	18,249	9,730	2,950	1,529
DISC TOTAL	868	777	6,699	1,386	0	9,730			
% OF TOTAL DISC COST	9%	8%	69%	14%	0%	100%		UNIT COST	6.36

TABLE D-7

CASE IIC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 2300 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT PERMITS DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		60	739	118		917	662	98	71
1999		60	739	118		917	643	98	69
2000		60	739	118		917	624	98	67
2001		60	739	118		917	606	98	65
2002		60	739	118		917	589	98	63
2003		60	739	118		917	571	98	61
2004		60	739	118		917	555	98	59
2005		60	739	118		917	539	98	58
2006		60	739	118		917	523	98	56
2007		60	739	118		917	508	98	54
2008		60	739	118		917	493	98	53
2009		60	739	118		917	479	98	51
2010		60	739	118		917	465	98	50
2011		60	739	118		917	451	98	48
2012		60	739	118		917	438	98	47
2013		60	739	118		917	425	98	45
2014		60	739	118		917	413	98	44
2015		60	739	118		917	401	98	43
2016		60	739	118		917	389	98	42
2017		60	739	118		917	378	98	40
2018		60	739	118		917	367	98	39
2019		60	739	118		917	356	98	38
2020		60	739	118		917	346	98	37
2021		60	739	118		917	336	98	36
2022		60	739	118		917	326	98	35
2023					0				
TOTAL	1,149	1,500	18,475	2,950	0	24,074	12,749	2,450	1,270
DISC TOTAL	868	777	9,575	1,529	0	12,749			
% OF TOTAL DISC COST	7%	6%	75%	12%	0%	100%		UNIT COST	10.04

TABLE D-8

CASE IIIA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 300 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT DOES NOT PERMIT DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		60	406	100		566	409	176	127
1999		60	406	100		566	397	176	123
2000		60	406	100		566	385	176	120
2001		60	406	100		566	374	176	116
2002		60	406	100		566	363	176	113
2003		60	406	100		566	353	176	110
2004		60	406	100		566	342	176	106
2005		60	406	100		566	332	176	103
2006		60	406	100		566	323	176	100
2007		60	406	100		566	313	176	97
2008		60	406	100		566	304	176	95
2009		60	406	100		566	295	176	92
2010		60	406	100		566	287	176	89
2011		60	406	100		566	278	176	87
2012		60	406	100		566	270	176	84
2013		60	406	100		566	262	176	82
2014		60	406	100		566	255	176	79
2015		60	406	100		566	247	176	77
2016		60	406	100		566	240	176	75
2017		60	406	100		566	233	176	73
2018		60	406	100		566	226	176	70
2019		60	406	100		566	220	176	68
2020		60	406	100		566	213	176	66
2021		60	406	100		566	207	176	64
2022		60	406	100		566	201	176	63
2023					0				
TOTAL	2,073	1,500	10,150	2,500	0	16,223	8,899	4,400	2,280
DISC TOTAL	1,566	777	5,261	1,296	0	8,899			
% OF TOTAL DISC COST	18%	9%	59%	15%	0%	100%		UNIT COST	3.90

TABLE D-9

CASE IIIB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 900 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT DOES NOT PERMIT DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		60	517	107		684	494	118	85
1999		60	517	107		684	480	118	83
2000		60	517	107		684	466	118	80
2001		60	517	107		684	452	118	78
2002		60	517	107		684	439	118	76
2003		60	517	107		684	426	118	74
2004		60	517	107		684	414	118	71
2005		60	517	107		684	402	118	69
2006		60	517	107		684	390	118	67
2007		60	517	107		684	379	118	65
2008		60	517	107		684	368	118	63
2009		60	517	107		684	357	118	62
2010		60	517	107		684	347	118	60
2011		60	517	107		684	336	118	58
2012		60	517	107		684	327	118	56
2013		60	517	107		684	317	118	55
2014		60	517	107		684	308	118	53
2015		60	517	107		684	299	118	52
2016		60	517	107		684	290	118	50
2017		60	517	107		684	282	118	49
2018		60	517	107		684	274	118	47
2019		60	517	107		684	266	118	46
2020		60	517	107		684	258	118	44
2021		60	517	107		684	250	118	43
2022		60	517	107		684	243	118	42
2023					0				
TOTAL	2,073	1,500	12,925	2,675	0	19,173	10,428	2,950	1,529
DISC TOTAL	1,566	777	6,699	1,386	0	10,428			
% OF TOTAL DISC COST	15%	7%	64%	13%	0%	100%		UNIT COST	6.82

TABLE D-10

CASE IIIC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 2300 MILES AWAY -- IN TSC PROVIDED BY UTILITY AND USED IN REPETITIVE SHIPMENTS OF OTHER FUEL; TSC PROVIDED BY UTILITY ON A SCHEDULE THAT DOES NOT PERMIT DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		60	739	118		917	662	98	71
1999		60	739	118		917	643	98	69
2000		60	739	118		917	624	98	67
2001		60	739	118		917	606	98	65
2002		60	739	118		917	589	98	63
2003		60	739	118		917	571	98	61
2004		60	739	118		917	555	98	59
2005		60	739	118		917	539	98	58
2006		60	739	118		917	523	98	56
2007		60	739	118		917	508	98	54
2008		60	739	118		917	493	98	53
2009		60	739	118		917	479	98	51
2010		60	739	118		917	465	98	50
2011		60	739	118		917	451	98	48
2012		60	739	118		917	438	98	47
2013		60	739	118		917	425	98	45
2014		60	739	118		917	413	98	44
2015		60	739	118		917	401	98	43
2016		60	739	118		917	389	98	42
2017		60	739	118		917	378	98	40
2018		60	739	118		917	367	98	39
2019		60	739	118		917	356	98	38
2020		60	739	118		917	346	98	37
2021		60	739	118		917	336	98	36
2022		60	739	118		917	326	98	35
2023					0				
TOTAL	2,073	1,500	18,475	2,950	0	24,998	13,447	2,450	1,270
DISC TOTAL	1,566	777	9,575	1,529	0	13,447			
% OF TOTAL DISC COST	12%	6%	71%	11%	0%	100%		UNIT COST	10.59

TABLE D-11
CASE IVA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
300 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY;
TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		10	253	100		363	262	176	127
1999		10	253	100		363	255	176	123
2000		10	253	100		363	247	176	120
2001		10	253	100		363	240	176	116
2002		10	253	100		363	233	176	113
2003		10	253	100		363	226	176	110
2004		10	253	100		363	220	176	106
2005		10	253	100		363	213	176	103
2006		10	253	100		363	207	176	100
2007		10	253	100		363	201	176	97
2008		10	253	100		363	195	176	95
2009		10	253	100		363	189	176	92
2010		10	253	100		363	184	176	89
2011		10	253	100		363	179	176	87
2012		10	253	100		363	173	176	84
2013		10	253	100		363	168	176	82
2014		10	253	100		363	163	176	79
2015		10	253	100		363	159	176	77
2016		10	253	100		363	154	176	75
2017		10	253	100		363	150	176	73
2018		10	253	100		363	145	176	70
2019		10	253	100		363	141	176	68
2020		10	253	100		363	137	176	66
2021		10	253	100		363	133	176	64
2022		10	253	100		363	129	176	63
2023					0				
TOTAL	1,149	250	6,325	2,500	0	10,224	5,571	4,400	2,280
DISC TOTAL	868	130	3,278	1,296	0	5,571			
% OF TOTAL DISC COST	16%	2%	59%	23%	0%	100%		UNIT COST	2.44

TABLE D-12

CASE IVB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
900 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY;
TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		10	322	107		439	317	118	85
1999		10	322	107		439	308	118	83
2000		10	322	107		439	299	118	80
2001		10	322	107		439	290	118	78
2002		10	322	107		439	282	118	76
2003		10	322	107		439	274	118	74
2004		10	322	107		439	266	118	71
2005		10	322	107		439	258	118	69
2006		10	322	107		439	250	118	67
2007		10	322	107		439	243	118	65
2008		10	322	107		439	236	118	63
2009		10	322	107		439	229	118	62
2010		10	322	107		439	222	118	60
2011		10	322	107		439	216	118	58
2012		10	322	107		439	210	118	56
2013		10	322	107		439	204	118	55
2014		10	322	107		439	198	118	53
2015		10	322	107		439	192	118	52
2016		10	322	107		439	186	118	50
2017		10	322	107		439	181	118	49
2018		10	322	107		439	176	118	47
2019		10	322	107		439	170	118	46
2020		10	322	107		439	166	118	44
2021		10	322	107		439	161	118	43
2022		10	322	107		439	156	118	42
2023					0				
TOTAL	1,149	250	8,050	2,675	0	12,124	6,556	2,950	1,529
DISC TOTAL	868	130	4,172	1,386	0	6,556			
% OF TOTAL DISC COST	13%	2%	64%	21%	0%	100%		UNIT COST	4.29

TABLE D-13

CASE IVC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
2300 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY;
TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	575					575	441		
1997	574					574	427		
1998		10	461	118		589	426	98	71
1999		10	461	118		589	413	98	69
2000		10	461	118		589	401	98	67
2001		10	461	118		589	389	98	65
2002		10	461	118		589	378	98	63
2003		10	461	118		589	367	98	61
2004		10	461	118		589	356	98	59
2005		10	461	118		589	346	98	58
2006		10	461	118		589	336	98	56
2007		10	461	118		589	326	98	54
2008		10	461	118		589	317	98	53
2009		10	461	118		589	307	98	51
2010		10	461	118		589	298	98	50
2011		10	461	118		589	290	98	48
2012		10	461	118		589	281	98	47
2013		10	461	118		589	273	98	45
2014		10	461	118		589	265	98	44
2015		10	461	118		589	257	98	43
2016		10	461	118		589	250	98	42
2017		10	461	118		589	243	98	40
2018		10	461	118		589	236	98	39
2019		10	461	118		589	229	98	38
2020		10	461	118		589	222	98	37
2021		10	461	118		589	216	98	36
2022		10	461	118		589	209	98	35
2023					0				
TOTAL	1,149	250	11,525	2,950	0	15,874	8,499	2,450	1,270
DISC TOTAL	868	130	5,973	1,529	0	8,499			
% OF TOTAL DISC COST	10%	2%	70%	18%	0%	100%		UNIT COST	6.69

TABLE D-14

CASE VA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 300 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY; TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		10	253	100		363	262	176	127
1999		10	253	100		363	255	176	123
2000		10	253	100		363	247	176	120
2001		10	253	100		363	240	176	116
2002		10	253	100		363	233	176	113
2003		10	253	100		363	226	176	110
2004		10	253	100		363	220	176	106
2005		10	253	100		363	213	176	103
2006		10	253	100		363	207	176	100
2007		10	253	100		363	201	176	97
2008		10	253	100		363	195	176	95
2009		10	253	100		363	189	176	92
2010		10	253	100		363	184	176	89
2011		10	253	100		363	179	176	87
2012		10	253	100		363	173	176	84
2013		10	253	100		363	168	176	82
2014		10	253	100		363	163	176	79
2015		10	253	100		363	159	176	77
2016		10	253	100		363	154	176	75
2017		10	253	100		363	150	176	73
2018		10	253	100		363	145	176	70
2019		10	253	100		363	141	176	68
2020		10	253	100		363	137	176	66
2021		10	253	100		363	133	176	64
2022		10	253	100		363	129	176	63
2023					0				
TOTAL	2,073	250	6,325	2,500	0	11,148	6,269	4,400	2,280
DISC TOTAL	1,566	130	3,278	1,296	0	6,269			
% OF TOTAL DISC COST	25%	2%	52%	21%	0%	100%		UNIT COST	2.75

TABLE D-15

CASE VB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
900 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY;
TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		10	322	107		439	317	118	85
1999		10	322	107		439	308	118	83
2000		10	322	107		439	299	118	80
2001		10	322	107		439	290	118	78
2002		10	322	107		439	282	118	76
2003		10	322	107		439	274	118	74
2004		10	322	107		439	266	118	71
2005		10	322	107		439	258	118	69
2006		10	322	107		439	250	118	67
2007		10	322	107		439	243	118	65
2008		10	322	107		439	236	118	63
2009		10	322	107		439	229	118	62
2010		10	322	107		439	222	118	60
2011		10	322	107		439	216	118	58
2012		10	322	107		439	210	118	56
2013		10	322	107		439	204	118	55
2014		10	322	107		439	198	118	53
2015		10	322	107		439	192	118	52
2016		10	322	107		439	186	118	50
2017		10	322	107		439	181	118	49
2018		10	322	107		439	176	118	47
2019		10	322	107		439	170	118	46
2020		10	322	107		439	166	118	44
2021		10	322	107		439	161	118	43
2022		10	322	107		439	156	118	42
2023					0				
TOTAL	2,073	250	8,050	2,675	0	13,048	7,254	2,950	1,529
DISC TOTAL	1,566	130	4,172	1,386	0	7,254			
% OF TOTAL DISC COST	22%	2%	58%	19%	0%	100%		UNIT COST	4.74

TABLE D-16

CASE VC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 2300 MILES AWAY -- IN TSCs OR SOCs PROVIDED BY UTILITIES AND SHIPPED ONE-WAY ONLY; TSCs OR SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,037					1,037	795		
1997	1,036					1,036	771		
1998		10	461	118		589	426	98	71
1999		10	461	118		589	413	98	69
2000		10	461	118		589	401	98	67
2001		10	461	118		589	389	98	65
2002		10	461	118		589	378	98	63
2003		10	461	118		589	367	98	61
2004		10	461	118		589	356	98	59
2005		10	461	118		589	346	98	58
2006		10	461	118		589	336	98	56
2007		10	461	118		589	326	98	54
2008		10	461	118		589	317	98	53
2009		10	461	118		589	307	98	51
2010		10	461	118		589	298	98	50
2011		10	461	118		589	290	98	48
2012		10	461	118		589	281	98	47
2013		10	461	118		589	273	98	45
2014		10	461	118		589	265	98	44
2015		10	461	118		589	257	98	43
2016		10	461	118		589	250	98	42
2017		10	461	118		589	243	98	40
2018		10	461	118		589	236	98	39
2019		10	461	118		589	229	98	38
2020		10	461	118		589	222	98	37
2021		10	461	118		589	216	98	36
2022		10	461	118		589	209	98	35
2023					0				
TOTAL	2,073	250	11,525	2,950	0	16,798	9,197	2,450	1,270
DISC TOTAL	1,566	130	5,973	1,529	0	9,197			
% OF TOTAL DISC COST	17%	1%	65%	17%	0%	100%		UNIT COST	7.24

TABLE D-17

CASE VIA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
300 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY;
SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS DOE
AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	865					865	663		
1997	864					864	643		
1998		35	395	100		530	383	176	127
1999		35	395	100		530	372	176	123
2000		35	395	100		530	361	176	120
2001		35	395	100		530	350	176	116
2002		35	395	100		530	340	176	113
2003		35	395	100		530	330	176	110
2004		35	395	100		530	321	176	106
2005		35	395	100		530	311	176	103
2006		35	395	100		530	302	176	100
2007		35	395	100		530	293	176	97
2008		35	395	100		530	285	176	95
2009		35	395	100		530	277	176	92
2010		35	395	100		530	269	176	89
2011		35	395	100		530	261	176	87
2012		35	395	100		530	253	176	84
2013		35	395	100		530	246	176	82
2014		35	395	100		530	239	176	79
2015		35	395	100		530	232	176	77
2016		35	395	100		530	225	176	75
2017		35	395	100		530	218	176	73
2018		35	395	100		530	212	176	70
2019		35	395	100		530	206	176	68
2020		35	395	100		530	200	176	66
2021		35	395	100		530	194	176	64
2022		35	395	100		530	188	176	63
2023					27	27	9		
TOTAL	1,729	875	9,875	2,500	27	15,006	8,182	4,400	2,280
DISC TOTAL	1,306	453	5,118	1,296	9	8,182			
% OF TOTAL DISC COST	16%	6%	63%	16%	0%	100%		UNIT COST	3.59

TABLE D-18

CASE VIB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES 900 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY; SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	865					865	663		
1997	864					864	643		
1998		35	501	107		643	465	118	85
1999		35	501	107		643	451	118	83
2000		35	501	107		643	438	118	80
2001		35	501	107		643	425	118	78
2002		35	501	107		643	413	118	76
2003		35	501	107		643	401	118	74
2004		35	501	107		643	389	118	71
2005		35	501	107		643	378	118	69
2006		35	501	107		643	367	118	67
2007		35	501	107		643	356	118	65
2008		35	501	107		643	346	118	63
2009		35	501	107		643	336	118	62
2010		35	501	107		643	326	118	60
2011		35	501	107		643	316	118	58
2012		35	501	107		643	307	118	56
2013		35	501	107		643	298	118	55
2014		35	501	107		643	289	118	53
2015		35	501	107		643	281	118	52
2016		35	501	107		643	273	118	50
2017		35	501	107		643	265	118	49
2018		35	501	107		643	257	118	47
2019		35	501	107		643	250	118	46
2020		35	501	107		643	242	118	44
2021		35	501	107		643	235	118	43
2022		35	501	107		643	229	118	42
2023					27	27	9		
TOTAL	1,729	875	12,525	2,675	27	17,831	9,647	2,950	1,529
DISC TOTAL	1,306	453	6,491	1,386	9	9,647			
% OF TOTAL DISC COST	14%	5%	67%	14%	0%	100%		UNIT COST	6.31

TABLE D-19

CASE VIC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
2300 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY;
SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT PERMITS DOE
AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	865					865	663		
1997	864					864	643		
1998		35	717	118		870	629	98	71
1999		35	717	118		870	610	98	69
2000		35	717	118		870	592	98	67
2001		35	717	118		870	575	98	65
2002		35	717	118		870	558	98	63
2003		35	717	118		870	542	98	61
2004		35	717	118		870	526	98	59
2005		35	717	118		870	511	98	58
2006		35	717	118		870	496	98	56
2007		35	717	118		870	482	98	54
2008		35	717	118		870	468	98	53
2009		35	717	118		870	454	98	51
2010		35	717	118		870	441	98	50
2011		35	717	118		870	428	98	48
2012		35	717	118		870	416	98	47
2013		35	717	118		870	403	98	45
2014		35	717	118		870	392	98	44
2015		35	717	118		870	380	98	43
2016		35	717	118		870	369	98	42
2017		35	717	118		870	358	98	40
2018		35	717	118		870	348	98	39
2019		35	717	118		870	338	98	38
2020		35	717	118		870	328	98	37
2021		35	717	118		870	318	98	36
2022		35	717	118		870	309	98	35
2023					27	27	9		
TOTAL	1,729	875	17,925	2,950	27	23,506	12,588	2,450	1,270
DISC TOTAL	1,306	453	9,290	1,529	9	12,588			
% OF TOTAL DISC COST	10%	4%	74%	12%	0%	100%		UNIT COST	9.91

TABLE D-20

CASE VIIA - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
300 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY;
SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,327					1,327	1,017		
1997	1,326					1,326	987		
1998		35	395	100		530	383	176	127
1999		35	395	100		530	372	176	123
2000		35	395	100		530	361	176	120
2001		35	395	100		530	350	176	116
2002		35	395	100		530	340	176	113
2003		35	395	100		530	330	176	110
2004		35	395	100		530	321	176	106
2005		35	395	100		530	311	176	103
2006		35	395	100		530	302	176	100
2007		35	395	100		530	293	176	97
2008		35	395	100		530	285	176	95
2009		35	395	100		530	277	176	92
2010		35	395	100		530	269	176	89
2011		35	395	100		530	261	176	87
2012		35	395	100		530	253	176	84
2013		35	395	100		530	246	176	82
2014		35	395	100		530	239	176	79
2015		35	395	100		530	232	176	77
2016		35	395	100		530	225	176	75
2017		35	395	100		530	218	176	73
2018		35	395	100		530	212	176	70
2019		35	395	100		530	206	176	68
2020		35	395	100		530	200	176	66
2021		35	395	100		530	194	176	64
2022		35	395	100		530	188	176	63
2023					27	27	9		
TOTAL	2,653	875	9,875	2,500	27	15,930	8,880	4,400	2,280
DISC TOTAL	2,004	453	5,118	1,296	9	8,880			
% OF TOTAL DISC COST	23%	5%	58%	15%	0%	100%		UNIT COST	3.89

TABLE D-21

CASE VIIB - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
900 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY;
SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,327					1,327	1,017		
1997	1,326					1,326	987		
1998		35	501	107		643	465	118	85
1999		35	501	107		643	451	118	83
2000		35	501	107		643	438	118	80
2001		35	501	107		643	425	118	78
2002		35	501	107		643	413	118	76
2003		35	501	107		643	401	118	74
2004		35	501	107		643	389	118	71
2005		35	501	107		643	378	118	69
2006		35	501	107		643	367	118	67
2007		35	501	107		643	356	118	65
2008		35	501	107		643	346	118	63
2009		35	501	107		643	336	118	62
2010		35	501	107		643	326	118	60
2011		35	501	107		643	316	118	58
2012		35	501	107		643	307	118	56
2013		35	501	107		643	298	118	55
2014		35	501	107		643	289	118	53
2015		35	501	107		643	281	118	52
2016		35	501	107		643	273	118	50
2017		35	501	107		643	265	118	49
2018		35	501	107		643	257	118	47
2019		35	501	107		643	250	118	46
2020		35	501	107		643	242	118	44
2021		35	501	107		643	235	118	43
2022		35	501	107		643	229	118	42
2023					27	27	9		
TOTAL	2,653	875	12,525	2,675	27	18,755	10,344	2,950	1,529
DISC TOTAL	2,004	453	6,491	1,386	9	10,344			
% OF TOTAL DISC COST	19%	4%	63%	13%	0%	100%		UNIT COST	6.77

TABLE D-22

CASE VIIC - COST OF TRANSPORT OF SPENT FUEL FROM REACTORS TO DOE FACILITIES
2300 MILES AWAY -- IN SOCs PROVIDED BY UTILITES IN OVERPACK AND SHIPPED ONE-WAY ONLY;
SOCs PROVIDED BY UTILITIES ON A SCHEDULE THAT DOES NOT PERMIT
DOE AVOIDANCE OF PURCHASE OF A TRANSPORT CASK

	COSTS ($000, 1987)							QUANTITIES (MTU)	
YEAR	CAPITAL COST	ANNUAL OPER'N COST	FREIGHT CHARGES	ESCORT CHARGES	DECOMM COSTS	TOTAL COSTS	DISC. TO 1987 @ 3%/Yr.	ANNUAL QUAN. SHIPPED	QUAN DISC @ 3%/YR TO 1987
1996	1,327					1,327	1,017		
1997	1,326					1,326	987		
1998		35	717	118		870	629	98	71
1999		35	717	118		870	610	98	69
2000		35	717	118		870	592	98	67
2001		35	717	118		870	575	98	65
2002		35	717	118		870	558	98	63
2003		35	717	118		870	542	98	61
2004		35	717	118		870	526	98	59
2005		35	717	118		870	511	98	58
2006		35	717	118		870	496	98	56
2007		35	717	118		870	482	98	54
2008		35	717	118		870	468	98	53
2009		35	717	118		870	454	98	51
2010		35	717	118		870	441	98	50
2011		35	717	118		870	428	98	48
2012		35	717	118		870	416	98	47
2013		35	717	118		870	403	98	45
2014		35	717	118		870	392	98	44
2015		35	717	118		870	380	98	43
2016		35	717	118		870	369	98	42
2017		35	717	118		870	358	98	40
2018		35	717	118		870	348	98	39
2019		35	717	118		870	338	98	38
2020		35	717	118		870	328	98	37
2021		35	717	118		870	318	98	36
2022		35	717	118		870	309	98	35
2023					27	27	9		
TOTAL	2,653	875	17,925	2,950	27	24,430	13,286	2,450	1,270
DISC TOTAL	2,004	453	9,290	1,529	9	13,286			
% OF TOTAL DISC COST	15%	3%	70%	12%	0%	100%		UNIT COST	10.46

TABLE D-23

SUMMARY OF SPENT FUEL TRANSPORT COSTS[a]

(1987 Dollars)

Cask Scenario	Unit Cost ($/kgU)[b] for Transport for Indicated Distances[c,d]		
	300 Miles	900 Miles	2300 Miles
Case I - DOE-Supplied Transport Cask	$3.91	$6.83	$10.61
Case II - TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	3.60 (0.31)	6.36 (0.47)	10.04 (0.57)
Case III - TSC Used in Repetitive Shipments; But DOE Does Not Avoid Purchase of Transport Cask	3.90 (0.01)	6.82 (0.01)	10.59 (0.02)
Case IV - TSC or SOC Used in One-Way Shipment; DOE Avoids Purchase of Transport Cask	2.44 (1.47)	4.29 (2.54)	6.69 (3.92)
Case V - TSC or SOC Used in One-Way Shipment; But DOE Does Not Avoid Purchase of Transport Cask	2.75 (1.16)	4.74 (2.09)	7.24 (3.37)
Case VI - Overpacked SOC Used in One-Way Shipment; DOE Avoids Purchase of Transport Cask	3.59 (0.32)	6.31 (0.52)	9.91 (0.70)
Case VII - Overpacked SOC Used in One-Way Shipment; But DOE Does Not Avoid Purchase of Transport Cask	3.89 (0.02)	6.77 (0.06)	10.46 (0.15)

[a] Intact fuel assemblies

[b] Averaged at a 3%/year net discount rate

[c] One-way distances shown

[d] Figures in parentheses are cost savings resulting from the use of utility-furnished TSC or SOC for transport instead of DOE-supplied transport cask

From the foregoing table it can be seen that if a TSC is supplied by a utility on a schedule that permits DOE to avoid the purchase of a standard transport cask, and DOE uses the TSC in repetitive shipments in place of the standard transport cask, savings ranging from $0.31 to $0.57/kgU shipped can be realized depending on the shipping distance involved. However, if the DOE is unable to avoid purchase of a standard transport cask essentially no savings are realized.

If a number of TSCs or SOCs are supplied by utilities and are used for a one-time shipment of contained spent fuel, and the DOE gets firm commitments to receive the casks on a schedule that permits it to avoid purchasing a standard transport cask, savings ranging from $1.47 to $3.92/kgU shipped can be realized depending on the shipping distance involved. Even if the SOCs are shipped in overpacks, savings ranging from $0.32 to $0.70/kgU shipped can be realized depending on the shipping distance involved. However, in order for DOE to avoid purchasing a single standard transport cask in both of these scenarios it would have to receive advance commitments to deliver 12 to 21 casks/year, or 300 to 525 casks over a 25-year period. This corresponds to annual shipments of 111 to 194 MTU and total shipments of 2,775 to 4,850 MTU over the 25-year period, and means that such amounts of spent fuel would have to be stored by utilities in TSCs or SOCs in order for them to be able to effect delivery of the required number of casks. On the other hand, if DOE is unable to avoid purchase of a standard transport cask, the foregoing savings would be reduced by $0.31/kgU to $0.55/kgU for both scenarios depending on the shipping distance involved.

It should be pointed out here that the foregoing savings resulting from the use of SOCs in overpacks was based on spreading the design, development and licensing cost of overpacks over 10 units. If this estimated $2.0-million expense were to be applied to a single overpack the cost of shipments in the overpacked SOC for cases where DOE could avoid the purchase of a standard transport cask would range from $0.28/kgU to $0.37/kgU more than shipments in a standard transport cask, and for cases where DOE could not avoid the purchase of a standard transport cask would amount to $0.58/kgU to $0.92/kgU more than shipments in a standard transport cask.

Thus, the savings involved through the use of TSCs or SOCs for shipments of spent fuel from reactors to DOE facilities are heavily dependent both on when a utility commits to turn the storage casks over to DOE for use and the schedule on which the turnover is effected. Clearly, the DOE must have a certain sized transport cask fleet available to meet its commitments for acceptance of spent fuel from the utilities. If the TSCs or SOCs are not available soon enough to meet the needs for a transport cask fleet, the fleet will otherwise have to be acquired by DOE regardless whether or not TSCs and SOCs are ultimately used for shipment.

The savings associated with the transporting of consolidated spent fuel from the reactor to DOE facilities are about 60 percent of those shown in Table D-23 for intact fuel assemblies.

4.0 REFERENCES FOR APPENDIX D

(1) G. W. McNair et al, Truck and Rail Charges for Shipping Spent Fuel and Nuclear Waste, PNL-5797, June 1986

(2) U. S. Department of Energy, Federal Interim Storage Fee Study for Civilian Spent Nuclear Fuel: A Technical and Economic Analysis, DOE/S-0023, July 1983

APPENDIX E

COST OF LAG STORAGE

APPENDIX E
COST OF LAG STORAGE

TABLE OF CONTENTS

APPENDIX E
COST OF LAG STORAGE

It was recognized that TSCs or SOCs that might be received from utilities could be used to provide some lag storage capacity at DOE facilities. Thus, the purpose of this Appendix was to develop an estimate of the cost of lag storage at DOE facilities, and the relationship between lag storage capacity and the cost of lag storage -- so that an assessment could be made of the savings that would result from the use of utility-delivered TSCs or SOCs for lag storage at DOE facilities.

While the designs performed to date on MRS and repository surface facilities have included facilities for lag storage, the cost of the lag storage facilities have not generally been shown as a separate line item. Moreover, such costs are not readily extracted from the overall facility costs. Therefore, for the purposes of this study, conceptual designs were developed for three different sizes of lag storage facilities, the capital and operating costs were estimated for each, and algorithms were developed relating capital and operating costs (separately) to capacity.

Lag storage is generally considered to be a storage capacity at the interface of major operations which mitigates the impacts of interruptions in the supply of materials to, or removal from, the operation. Thus, lag storage at the front end of a DOE facility (MRS or repository) can mitigate impacts of interruptions in supply of spent fuel from reactors--and it can also provide assurance that DOE can continue to accept spent fuel in the event of an interruption in operations at the DOE facilities. Lag storage at the front end of a repository can also mitigate impacts of interruptions in supply of spent fuel from an Integral MRS Facility.

For the purposes of this study it was assumed that lag storage near the receiving end of a MRS or repository facility should be about 750 MTU in the form of intact fuel assemblies. This represents 3-months storage capacity at a 3000 MTU/year receipt rate. However, designs were also developed for capacities of 500 MTU and 250 MTU.

1.0 DESIGN DESCRIPTION

The lag storage facility was assumed to be a hot cell having an inside width of 50 feet, a 5-foot wall thickness, and a length of 187 feet for 750 MTU capacity (130 foot length for 500 MTU, and 71 foot length for 250 MTU). The hot cell was assumed to be separated into two basic compartments by a 5-foot thick slab. The lower compartment is the storage compartment and contains an array of stainless steel pipes in which the fuel is stored. Access to each pipe is through cavities in the slab, and each such cavity has a plug so that the upper compartment can be occupied by personnel when all plugs are in place. The upper compartment of the hot cell is open ended inasmuch as it was assumed it would probably be the conduit between the cask unloading facility and the processing activity at a DOE facility.

It was assumed that cooling of the stored fuel would be by forced air circulation. Separate ventilation and air treatment facilities were provided for the upper and lower compartments of the hot cell.

2.0 CAPITAL COSTS

The estimates of the capital costs of 750 MTU, 500 MTU and 250 MTU capacity lag storage facilities are shown in Table E-1.

TABLE E-1

BREAKDOWN OF CAPITAL COSTS OF HOT CELL LAG STORAGE FACILITIES

($000, 1987)

Description	Unit Cost	750 MTU No. Units	750 MTU Total	500 MTU No. Units	500 MTU Total	250 MTU No. Units	250 MTU Total
Nuclear Grade Concrete	$ 2.1/yd^3	10,928	$22,949	7,793	$16,365	4,151	$ 8,717
Storage Cell		8,667		6,208		3,073	
Ventilation Bldg-Storage		1,361		976		615	
Ventilation Bldg-Loading		900		609		463	
Ordinary Concrete	$ .55/yd^3	561	309	340	187	199	109
Ventilation Bldg-Storage		398		232		119	
Ventilation Bldg-Loading		163		108		80	
Hot Cell Coatings	$ .025/ft^2	93,000	2,325	65,000	1,625	39,000	975
Storage Cell		58,000		40,000		22,000	
Ventilation Bldg-Storage		22,000		16,000		10,000	
Ventilation Bldg-Loading		13,000		9,000		7,000	
Lights	$ .500 ea	698	349	462	231	256	128
Storage Cell		354		240		122	
Ventilation Bldg-Storage		232		151		84	
Ventilation Bldg-Loading		112		71		50	
Shielding Windows							
5' Thick	$ 75 ea	18	1,350	12	900	6	450
2' Thick	$ 50 ea	16	800	10	500	7	350
Shielded Doors & Ceiling Doors	$ 15 ea	6	90	5	75	4	60
Air Lock Fixtures	$ 3 ea	2	6	2	6	2	6
Control Center Equipment (Vent)		-	250	-	175	-	100
Cranes, Hot Cell, 25 Ton	$ 400 ea	2	800	2	800	2	800
Storage Modules & Support							
PWR	$ 8.4 ea	1,085	9,114	722	6,065	362	3,041
BWR	$ 9.4 ea	683	6,420	457	4,296	227	2,134
Ventilation System Equipment			1,875		1,250		625
Subtotal			46,637		32,475		17,495
Equipment Installation							
(35% of Bare Equipment Costs)			1,932		1,378		882
(15% of Module Cost)			2,330		1,554		776
Subcontractor Overhead & Profit (45% of Labor for Equipment Only; Labor 50% of Installation Cost)			959		660		373
			51,858		36,067		19,526
General Contractor Overhead & Profit (18.65% of Equipment Only; Included in Unit Cost for Others)			3,927		2,667		1,435
			55,785		38,734		20,961
Engineering (15%)			8,368		5,810		3,144
Construction Management (10%)			5,579		3,873		2,096
			69,732		48,417		26,201
Contingency (20%)			13,946		9,683		5,240
	Total		$83,678		$58,100		$31,441

An algorithm was developed to describe the relationship between capacity and capital cost, as follows:

$$C_c = 3701 + 113.1(x) - .00865(x^2)$$

where C_c is the capital cost of a lag storage facility having a capacity to store x MTU of spent fuel. This results in an average cost of $104/kgU storage capacity over the 250-750 MTU capacity range (range of $100-$109/kgU).

3.0 OPERATING COSTS

The estimates of the cost of operation of the lag storage facilities described in Sections 1.0 and 2.0, above, are shown in Table E-2.

TABLE E-2
ESTIMATED ANNUAL OPERATING COST FOR LAG STORAGE FACILITIES
($000, 1987)

	Cost for Indicated Capacity		
Description	750 MTU	500 MTU	250 MTU
Labor & Supervision	$1,540	$1,255	$ 960
Miscellaneous Supplies	210	171	131
Maintenance Supplies	2,510	1,743	943
Electricity	2,120	1,288	754
Total	$6,380	$4,457	$2,788

An algorithm was developed to describe the relationship between capacity and operating cost, as follows:

$$C_o = 1373 + 5.152(x) + .002(x^2)$$

where C_o is the operating cost for a lag storage facility having a capacity to store x MTU of spent fuel. This results in an average cost of $7.18/kgU storage capacity per year over the 250-750 MTU capacity range (range of $6.20-$8.20/kgU). This amounts to about $129/kgU on a discounted cost basis.

4.0 TOTAL COSTS

From the cost estimates developed in Sections 2.0 and 3.0 of this Appendix E, it is apparent that the average cost of lag storage in hot-cell type facilities is about $233/kgU (1987 dollars). This assumes that such facilities are operated at 100 percent capacity (fully loaded) during the lifetime thereof. In practice, this will not be the case and, therefore, the foregoing costs represent the minimum costs that can be expected to be experienced for lag storage in hot-cell type facilities.

APPENDIX F

ESTIMATED COST FOR MRS MODULES

APPENDIX F
ESTIMATED COST FOR MRS MODULES

TABLE OF CONTENTS

APPENDIX F
ESTIMATED COST FOR MRS MODULES

The purpose of this Appendix is to develop an estimate of the costs and capacity for the concrete storage modules that are expected to be used at the MRS facility so that an assssment can be made of the value of a metal storage cask if it were used to substitute for a concrete module at the MRS.

1.0 ESTIMATED COSTS

The Ralph M. Parsons Company (Parsons) estimated the cost of a concrete storage module having a capacity for storing 16.2 MTU of consolidated rods at $220-thousand (1985 dollars) in connection with its design of an integral MRS facility (References 1 & 2). Parsons also estimated the cost of a concrete storage module having a capacity for storing 28.7 MTU (equivalent) of compacted structural parts at $120-thousand (1985 dollars). The combined cost of these modules (casks) for storing consolidated fuel was $17.8/kgU (1985 dollars) which when escalated resulted in a 1987 cost of $18.3/kgU. The foregoing costs do not include a component for the capital cost of the concrete module manufacturing facility.

In addition Parsons included a facility for manufacturing the concrete modules in the design of the Integral MRS facility. This facility was estimated by Parsons to cost $21.12-million (1985 dollars) which when escalated resulted in a 1987 capital cost of $23.16-million. It was recognized that if TSCs were received by DOE and used in place of some of the concrete modules that otherwise would have been used for storage, a higher cost per module would have to be allocated as a result of amortizing the $23.16-million cost of the module manufacturing facility over a fewer number of modules.

In this connection, it was assumed that 1500 MTU/year would be received into storage for a period of 10 years (15,000 MTU total). Under these conditions the allocation of the cost of the module manufacturing facility to the cost of modules would be $1.8/kgU, developed as follows:

Year	Storage Module Capacity (MTU) Annual Additions	Discounted 3%/Yr to Yr 0
0		
1	1,500	1,456
2	1,500	1,414
3	1,500	1,373
4	1,500	1,333
5	1,500	1,294
6	1,500	1,256
7	1,500	1,220
8	1,500	1,184
9	1,500	1,150
10	1,500	1,116
Total	15,000	12,796

$$\frac{\$23.16\text{-million}}{12{,}796\ \text{MTU}} = \$1.8/\text{kgU}$$

Calculations were made of the impact of reducing the number of storage modules required on the cost of the modules. The results are shown in Table F-1.

TABLE F-1

IMPACT OF REDUCING THE NUMBER OF CONCRETE MODULES REQUIRED FOR MRS ON THE COST OF THE MODULES ATTRIBUTABLE TO THE CAPITAL COST OF THE MODULE MANUFACTURING FACILITY

Reduction in Required Capacity (%)	Cost/kgU Attributable to Concrete Storage Modules	Added Cost/kgU for Concrete Modules Caused by Reduction in No. Modules Needed
0	$ 1.8	$ -
10	2.0	0.2
20	2.3	0.5
30	2.6	0.8
40	3.0	1.2
50	3.6	1.8
60	4.5	2.7
70	6.0	4.2
80	9.0	7.2
90	18.1	16.3

Thus the net savings involved in the use of TSCs delivered to DOE by a utility, as a storage module for MRS would amount to about $16.5/kgU stored in MRS.

In addition to the savings described above, the substitution of a TSC for a MRS concrete storage module would result in the elimination of the need to dispose of the MRS module at the end of its useful life. The TSC that replaced the module would have had to be disposed of in any event, thus the net amount of disposal costs would be reduced. A preliminary estimate was made of the cost of disposal of the MRS module, assuming that the inner metal containment vessel of the module and associated plug would be removed and packaged for disposal at a low level waste burial site, with the remainder of the concrete monolith being broken up and disposed of in a land fill. The following Table F-2 summarizes the estimated costs for disposal of MRS storage modules.

TABLE F-2

ESTIMATED COSTS FOR DISPOSAL OF MRS MODULES[a]

(1987 Dollars)

Description	Cost
Module Handling at MRS Facility	$ 1,000
Removal of Inner Vessel	15,120
Transport of Vessel to Barnwell	4,000
Disposal of Vessel at Barnwell	24,400
Breakup of Concrete Shell	10,080
Land and Transport to Land Fill	2,500
Disposal at Land Fill	2,000
Total	$ 59,100

[a] These costs cover disposal of MRS modules used to store consolidated fuel rods. Disposal of MRS modules used to store compacted structural parts can be expected to amount to about 55 percent of the above total ($32,500).

2.0 REFERENCES FOR APPENDIX F

(1) The Ralph M. Parsons Company et al, Conceptual Design Report --Integral Monitored Retrievable Storage (MRS) Facility, MRS-1, Contract No. DE-AC01-84RL10436, August 1985

(2) E. R. Johnson Associates, Inc., Results of Preliminary Analysis of Differences in MRS Facility Costs Between the DOE MRS Facility Design and That Contained in the Draft JAI PRDA Report, JAI-263, October 1985.

APPENDIX G

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM MRS TO REPOSITORY FACILITIES IN TSCs AND STANDARD TRANSPORT CASKS

APPENDIX G

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM MRS TO REPOSITORY FACILITIES IN TSCs AND STANDARD TRANSPORT CASKS

TABLE OF CONTENTS

APPENDIX G

ESTIMATED COSTS FOR TRANSPORT OF SPENT FUEL FROM MRS TO REPOSITORY FACILITIES IN TSCs AND STANDARD TRANSPORT CASKS

The purpose of this Appendix is to develop estimates of the cost of transporting containers of consolidated fuel from the MRS facility to a repository in (i) standard transport casks, and (ii) TSCs, so that the extent of the benefits involved in using TSCs could be assessed. The estimated capital and operating costs associated with the foregoing methods of shipment, and the estimated life cycle and unit costs associated with the shipment of three different packages to three different types of repositories, are developed in the following sections.

1.0 CAPACITY OF CASKS FOR TRANSPORTING PACKAGES OF CONSOLIDATED FUEL

It was recognized that consolidated spent fuel rods and compacted structural parts may be shipped from the MRS to the repository in one of basically three different forms, as follows:

(1) square cans--nominally 9-inches square

(2) sleeves--cylindrical thin-walled (0.25-inch) canisters having an outside diameter slightly smaller than the inside diameter of the repository container

(3) containers--for repository disposal.

For the purposes of this study, repository containers were assumed to have the following dimensions and capacities:

TABLE G-1

DIMENSIONS & CAPACITIES OF REPOSITORY CONTAINERS

Description	Containers for Consolidated Rods: Salt	Basalt	Tuff	Containers for Compacted Structural Parts
Outside Diameter (cm)	87.1	54.1	70	70
Inside Diameter (cm)	64.5	37.1	67.5	67.5
Length (cm)	410	410	410	410
Capacity (MTU)	5.52	1.84	2.76	27.5 equiv.

Either sleeves or containers will be shipped (not both), depending on whether the containerization operation is located at MRS or repository facilities. Square cans (from reactors and MRS storage) may also be shipped. However, it is assumed that in the case of tuff no sleeves will be shipped, only the tuff container, since it is already relatively thin-walled (1-inch). It is also assumed the compacted structural parts will be shipped in tuff-type containers.

For the purposes of this analysis, it was assumed that, absent any consideration of the use of TSCs for such shipments, the casks described in Reference (1) would be used to effect shipments of consolidated fuel from the MRS facility to the repository. It was recognized that there was really no "standard" DOE transport cask for this purpose, but that the cask described in Reference (1) could be expected to be reasonably representative of a "standard" cask for the purposes of this analysis. The use of TSCs for such shipments was also considered; these TSCs were assumed to be those used for reactor storage of intact fuel assemblies. An analysis was made of the capacity of TSCs for transporting cans as well as sleeves and canisters designed for the three different repository types. The results of this analysis as well as the capacities and weights of the casks described in Reference (1) are shown in Table G-2.

TABLE G-2

CAPACITIES & WEIGHTS OF CASKS FOR TRANSPORTING CONSOLIDATED SPENT FUEL FROM MRS TO REPOSITORY FACILITIES

	"Standard" Transport Casks[a]					TSCs			
	Capacity		Weight (CWT)		Cost[b]	Capacity		Weight (CWT)	
Type of Package Shipped	No. Pkgs.	(MTU)	Loaded	Empty	($000, 1987)	No. Pkgs.	(MTU)	Loaded	Empty
Containers - Salt	3	16.56	2,700	1,535	$2,867	1	5.52	2,400	2,000
Containers - Basalt	7	12.88	2,670	1,600	2,980	4	7.36	2,610	2,000
Containers - Tuff	3	8.28	2,530	1,965	3,090	2	5.52	2,300	2,000
Sleeves - Salt	4	22.08	2,765	1,941	3,199	3	16.56	2,600	2,000
Sleeves - Basalt	13	23.92	2,940	1,905	3,237	9	16.56	2,630	2,000
Square Cans	28	25.76	2,790	1,890	3,169	21	19.31	2,300	2,000

[a] Standard casks are those described in Reference (1)

[b] Escalated to 1987 dollars from costs shown in Reference (1)

2.0 ESTIMATED COSTS FOR TRANSPORT

Separate calculations were made of the cost of shipping spent fuel from MRS facilities to the repository in the form of repository containers, sleeves, and square cans--using:

(1) the standard transport casks described in Reference (1)

(2) TSCs for one-way shipments

(3) TSCs for repetitive shipments.

The cask requirements for these shipments are shown in Table G-3 along with supporting data.

TABLE G-3

CASK REQUIREMENTS FOR TRANSPORTING CONSOLIDATED FUEL FROM MRS TO REPOSITORY FACILITIES IN CONTAINERS, SLEEVES & CANS

Description	Containers for			Sleeves for		Cans for		
	Salt	Basalt	Tuff	Salt	Basalt	Salt	Basalt	Tuff
Fuel Content per Package (MTU)	5.52	1.84	2.76	5.52	1.84	0.92	0.92	0.92
No. Packages Annually @ 3000 MTU/Yr								
- Consolidated Rods	543	1,631	1,087	543	1,631	3,261	3,261	3,261
- Structural Parts[a]	109	109	109	109	109	109	109	109
Cask Capacity (No. Packages)								
- Standard Casks	3	7	3	4	13	28	28	28
- TSCs	1	4	2	3	9	21	21	21
No. Shipments Annually in								
- Standard Casks	218	270	399	172	162	153	153	153
- TSCs	598	463	598	236	236	210	210	210
Shipping Distance One-Way (miles)	1,300	2,600	2,400	1,300	2,600	1,300	2,600	2,400
Speed (MPD)	286	364	364	286	364	286	364	364
Cask Availability (DPY)	300	300	300	300	300	300	300	300
No. Shipments/Year/Cask	22.9	16.4	17.5	22.9	16.4	22.9	16.4	17.5
No. Casks Required								
- Standard Casks	10	17	23	8	10	7	10	9
- TSCs[b]	27	29	35	11	15	10	13	12

[a] Structural parts are packaged in tuff-type containers

[b] Number of TSCs required if used to replace entire fleet of standard casks. If TSC's were used for one-way shipment only and sufficient TSCs were available to replace fleet of standard casks, this number would represent sets of auxiliary equipment required for shipment.

In addition the following basic assumptions were used in connection with the transport cost calculations:

(1) It was assumed that the casks would be shipped by special train with four casks being involved for each shipment.

(2) The special train charges amounted to $46.76/mile, which represented the charges set forth in Reference (1), escalated to 1987 using the Rail Freight Index.

(3) The annual cask operating costs associated with the shipment were the same as those described in Section 2.3 of Appendix D.

(4) The freight charges associated with the shipments were determined using the algorithms developed in Section 2.1 of Appendix D.

(5) The security charges associated with the shipment were determined using the methodology described in Section 2.2 of Appendix D.

(6) Life cycle costs were determined over the 25 year period 1998-2022 and discounted at 3 percent/year to 1987. Unit costs were determined as described in Section 3.0 of Appendix D.

The following Table G-4 sets forth the unit costs for transporting spent fuel in the various packages from MRS to repository facilities in both standard transport casks and TSCs.

TABLE G-4

ESTIMATED COST OF TRANSPORTING SPENT FUEL FROM MRS TO REPOSITORY FACILITIES

MRS Facilities	Cost of Transport ($/kgU)		
	Standard Transport Casks	TSCs	
		One-Way Use	Repetitive Use
To Salt Repository			
- in Containers	$ 5.73	$ 9.58	$14.02
- in Sleeves	4.63	4.06	5.72
- in Cans	4.12	3.66	5.14
To Basalt Repository			
- in Containers	11.18	13.05	17.87
- in Sleeves	7.01	6.68	9.14
- in Cans	6.53	5.98	8.16
To Tuff Repository			
- in Containers	15.37	15.54	21.47
- in Cans	6.12	5.63	7.71

From the results shown in the table, it can be concluded that standard transport casks are less expensive to use for transporting packages of consolidated fuel from MRS to repository facilities than are TSCs when the latter are used to replace standard transport casks in repetitive shipments. Even if higher payload capacities (20-25%) were feasible for TSCs, there would be no savings involved over the use of a standard transport cask specifically designed for the payload to be shipped.

The one-way use of TSCs, if such should be available in sufficient quantities, can result in savings in the cost of transport over that involved with the use of standard casks in cases where the spent fuel is contained in sleeves or cans. Moreover, if higher payload capacities (20-25 percent) were feasible, savings would result in all cases with the exception of shipments involving spent fuel in salt repository containers. However, in order to replace a single standard cask it would be necessary to receive 23 TSCs/year for shipments to a salt repository, 17 TSCs/year for shipments to a basalt repository, or 18 TSCs/year for shipments to a tuff repository--for a period of 25 consecutive years (totals of 575 TSCs for salt, 425 TSCs for basalt, and 450 TSCs for tuff). Under such circumstances the magnitude of the savings involved in the use of TSCs would range from \$0.33-\$0.57/kgU using the payloads assumed for this study, and from \$0.74-\$2.94/kgU using payloads which were 20 percent higher.

For any of these savings to be realized, it would be necessary that utilities commit to provide TSCs early enough, and to deliver the TSCs on a schedule compatible with DOE needs, such that DOE does not have to otherwise commit to provide all or a portion of a fleet of rail casks for its use.

3.0 REFERENCES FOR APPENDIX G

(1) E. R. Johnson Associates, Inc., Assessment of the Use of a Multi-Purpose and Centralized Facility for the Disassembly and Packaging of Spent Nuclear Fuel to Support the Various Segments of the DOE Waste Management System, JAI-254, DOE Contract No. DE-AC01-84RW00037

APPENDIX H

ESTIMATED COSTS FOR SALVAGE OR DISPOSAL OF USED TSCs, SOCs AND CONCRETE STORAGE CASKS

APPENDIX H

ESTIMATED COSTS FOR SALVAGE OR DISPOSAL OF USED TSCs, SOCs AND CONCRETE STORAGE CASKS

TABLE OF CONTENTS

APPENDIX H

ESTIMATED COSTS FOR SALVAGE OR DISPOSAL OF USED TSCs, SOCs AND CONCRETE STORAGE CASKS

The purpose of this Appendix is to develop estimates of costs for salvage or disposal of storage modules at the end of their useful life. While these estimates have been based on decontamination, disassembly, etc. at the reactor, essentially identical costs are to be expected if such work were performed at DOE facilities.

1.0 METAL CASKS

A preliminary estimate was made of the cost of both salvage and disposal of metal storage casks (TSCs and SOCs). However, it should be pointed out here that there are uncertainties about the acceptability of nuclear equipment as salvage, even when thoroughly decontaminated.

In the case of prospective salvage, the cost of a thorough decontamination was estimated to require about 20 person-days, and to cost \$10,080. The cost of shipping the fully decontaminated cask to the salvage site 200 miles away was estimated to be \$7,740, assuming that a Class 37½ freight rate would apply. The value of the cask as scrap steel was estimated at \$25/ton, for a total of about \$2,500. Other metals (such as lead) would be appreciably more. Offsetting this prospectively higher value is the fact that the cask would either have to be delivered as a nominal 100-ton object or subject to expensive size reduction operation. In addition, the cost of handling the cask at the reactor site, after unloading, to the point of shipment to the salvage site was estimated to be about \$740 (11.75 person-hours). The net result of the foregoing is that if the salvage route is taken to dispose of the cask, the net cost is about \$16,060/cask (1987 dollars). If the decontamination turns out to be minimal, this cost could drop to as low as \$9,000/cask.

In the case of disposal of a cask without salvaging any of the materials of construction, the cost of handling the cask (including removal of loose contamination on the surface of the cask) was estimated to be \$1,764 (28 person-hours). The cost of shipping the cask to a disposal site 900 miles away was estimated to be $18,495 assuming that a class 37½ freight rate would apply. Assuming the cask (volume--520 cubic feet) would be buried in a low level waste burial ground on an as-received basis, the cost was estimated to be $35,084, broken down as follows:

Base Disposal Charge	$16,380
Surcharge (Weight)	13,108
Cask Handling Fee	800
Funds	3,973
Tax (2.4% of above)	823
Total	$35,084

The net result of the foregoing is that the cost of disposal of the cask is about $55,343. A summary of these costs is set forth in Table H-1.

TABLE H-1

ESTIMATED COSTS FOR DISPOSAL/SALVAGE OF METAL STORAGE CASKS

(1987 Dollars)

	Cost	
Description	Salvage	Disposal
Cask Handling at Reactor	$ 740	$ 1,764
Decontamination	10,080	-
Transport of Cask to Disposal or Salvage Site	7,740	18,495
Disposal at Barnwell	-	35,084
Salvage Value	(2,500)	-
Total	$16,060	$55,343

2.0 CONCRETE STORAGE CASKS

A preliminary estimate was also made of the cost of disposal of concrete storage casks. It was assumed that the inner metal containment vessel of the cask and associated plugs would be removed and packaged for disposal at a low level waste burial site. The remainder of the concrete monolith would be broken up and disposed of in a land fill. The following Table H-2 summarizes the estimated costs for disposal of concrete storage casks.

TABLE H-2

ESTIMATED COSTS FOR DISPOSAL OF CONCRETE STORAGE CASKS

(1987 Dollars)

Description	Cost
Cask Handling at Reactor	$ 462
Removal of Inner Vessel	3,024
Transport of Vessel to Barnwell	2,300
Disposal of Vessel at Barnwell	4,726
Breakup of Concrete Shell	6,640
Load and Transport to Land Fill	1,250
Disposal at Land Fill	1,000
Total	$19,402

Since the storage capacity of a concrete cask is 4.291 MTU (vs 9.26 MTU for a metal cask), the foregoing cost is essentially equivalent to about a $42,000 disposal cost for a metal storage cask.

3.0 CONCLUSIONS REGARDING MODULE DISPOSAL COSTS

Based on the preliminary cost estimates developed in the preceding sections it is reasonable to conclude that concrete casks may be less expensive to dispose of at the end of their useful life than metal casks, if the metal casks indeed need to be disposed of. However, if metal casks should prove to be salvageable, considerably lower disposal costs would result. Moreover, the equipment used to transfer spent fuel to and from the concrete casks will have to be decontaminated and disposed of (or salvaged) at the end of its useful life, and the cost of this activity would have to be accrued over the number of concrete casks serviced. Thus the cost of disposition of a metal cask can be expected to range between $26,000 less expensive ($2.81/kgU for casks storing intact fuel assemblies and 1.69/kgU for casks storing consolidated fuel), to being $13,000 more expensive ($1.40/kgU for casks storing intact fuel assemblies and $0.85/kgU for casks storing consolidated fuel) than concrete storage casks of equivalent capacity.

Some savings in disposal costs of both cask types might be realized by loading the metal casks or the inner vessel of the concrete casks with other low level wastes.

APPENDIX I

SENSITIVITY OF COSTS TO VARIATIONS IN THE CAPACITY AND FABRICATION COSTS OF METAL STORAGE CASKS

APPENDIX I

SENSITIVITY OF COSTS TO VARIATIONS IN THE CAPACITY AND FABRICATION COSTS OF METAL STORAGE CASKS

TABLE OF CONTENTS

APPENDIX I

TABLE OF CONTENTS (Continued)

APPENDIX I

SENSITIVITY OF COSTS TO VARIATIONS IN THE CAPACITY AND FABRICATION COSTS OF METAL STORAGE CASKS

The purpose of this Appendix is to determine the sensitivity of costs/savings associated with the use of metal storage casks in the utility and DOE spent fuel management systems to variations in the capacity of the casks and the cost of fabrication thereof. Conclusions are developed regarding the relative sensitivity of each of the components of cost considered in this study (i.e., at-reactor costs, transport costs, and costs/savings at DOE facilities) to these variations.

1.0 SENSITIVITY TO CHANGES IN THE TSC AND SOC CAPACITY

The TSCs and SOCs considered in the study were assumed to have a capacity for storing 21 PWR fuel assemblies or 46 BWR fuel assemblies (average of 9.26 MTU for intact fuel assemblies and 15.37 MTU for consolidated fuel). This cask capacity will be referred to as the base case in this sensitivity analysis. Two larger capacity casks were evaluated:

Case A - A TSC or SOC capacity of 26 PWR assemblies or 52 BWR assemblies (average of 11.16 MTU for intact fuel assemblies and 18.53 MTU for consolidated fuel)

Case B - A TSC or SOC capacity of 32 PWR assemblies or 76 BWR assemblies (average of 14.47 MTU for intact fuel assemblies and 24.02 MTU for consolidated fuel)

These cases were selected as being representative of future metal cask designs that could allow for more densely packed spent fuel assemblies. Case B is considered to be the upper bound of capacity for these metal casks.

In Appendix C it was assumed that there were fundamental similarities between the designs of the transport cask and the TSC or SOC. These metal casks were all assumed to have the same capacity (i.e., 21 PWR or 46 BWR assemblies). For the purpose of the sensitivity analysis it is assumed that if higher capacity TSCs and SOCs would be available for use in the waste management systems, correspondingly higher capacity transport casks would also be available.

Since this portion of the sensitivity analysis only considered impacts of changes in cask capacity, the cost of the casks was assumed to be the same as that used in Appendix C.

1.1 SENSITIVITY OF AT-REACTOR COSTS TO CHANGES IN THE CAPACITY OF METAL STORAGE CASKS

1.1.1 Sensitivity of At-Reactor Operations Costs to Changes in Cask Capacity

An analysis was performed of the impact of increased capacity metal casks on the costs of operation at a reactor site. For this analysis, it was assumed that the increased capacity casks were not dimensionally larger or appreciably heavier than the base case cask. Therefore, appreciably higher capacity handling equipment at the reactor would not be needed.

The at-reactor operations costs for receiving, loading and transfer to storage of increased capacity TSCs and SOCs were estimated. Operations costs for removal from storage, unloading, fuel inspection, and receiving and loading transport casks or overpacks for the increased capacity SOC options were also estimated.

Only activities involving the handling of individual spent fuel assemblies increased in cost for higher capacity metal casks. The cost per cask of these activities increased proportionately with the increased number of assemblies in the cask. However, it is important to point out that the unit cost ($/kgU) for these activities remained unchanged from the base case. The total unit costs for at-reactor operations decrease with increasing metal storage cask capacity. This is because the large majority of the operations involve handling the cask as a whole and the costs of these operations do not increase with increased cask capacity. The unit costs for at-reactor operations costs for each of the higher capacity metal cask options for intact and consolidated fuel are set forth in Tables I-1 through I-4. The percent decrease in at-reactor operations costs for handling TSCs or SOCs is somewhat less than the percent increase in cask capacity. However, it should be noted that the at-reactor operations costs are only a small portion of the total at-reactor costs. The cost of the casks is the large portion of the total at-reactor costs as will be seen in the next section. Therefore, even a large decrease in the at-reactor operations costs will not significantly change the total at-reactor costs.

TABLE I-1

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Increased Capacity Metal Casks -- Case A (26/52) Intact Fuel Assemblies)

		Average Cost ($/kgU, 1987)[a]			
	Section Reference[b]	TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.19	$0.19	$0.19	$ -[c]
(b) Cans	-	-	-	-	9.03
(c) Canning	3.1	-	-	-	0.52
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.42	0.42	0.42	3.49
(e) Equipment Rental	App A, 3.0	-	-	-	1.45
Subtotal		0.61	0.61	0.61	14.49
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.26	3.25
(b) Decanning	6.0	-	-	-	0.52
(c) Can Disposal	6.0	-	-	-	1.15
(d) Fuel Inspection	7.0	-	-	1.60	1.66
(e) Receiving of Transport Cask	1.0	-	-	0.19	0.22
(f) Loading of Transport Cask	8.0	-	-	0.45	0.48
(g) Equipment Rental	6.0	-	-	-	1.45
(h) Preparation of TSC or SOC for Shipment	5.0	0.10	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.62	-	-
Subtotal		0.10	0.62	2.50	8.73
Total		$0.71	$1.23	$3.11	$23.22

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 461 kgU/assembly, and a cask capacity of 26 assemblies; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 183 kgU/assembly, and a cask capacity of 52 assemblies. Concrete casks assumed to have a capacity for storing 9 PWR or 25 BWR assemblies.

[b] References are to Sections in Appendix B unless otherwise indicated. (Note: Costs developed in these sections were adjusted for increased capacity metal casks.)

[c] Included in the costs shown in (1)(d)

TABLE I-2

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Increased Capacity Metal Casks -- Case B (32/76) Intact Fuel Assemblies)

	Section Reference[b]	Average Cost ($/kgU, 1987)[a] TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.14	$0.14	$0.14	$ -[c]
(b) Cans	-	-	-	-	9.03
(c) Canning	3.1	-	-	-	0.52
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.38	0.38	0.38	3.49
(e) Equipment Rental	App A, 3.0	-	-	-	1.45
Subtotal		0.52	0.52	0.52	14.49
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.22	3.25
(b) Decanning	6.0	-	-	-	0.52
(c) Can Disposal	6.0	-	-	-	1.15
(d) Fuel Inspection	7.0	-	-	1.64	1.66
(e) Receiving of Transport Cask	1.0	-	-	0.14	0.22
(f) Loading of Transport Cask	8.0	-	-	0.40	0.48
(g) Equipment Rental	6.0	-	-	-	1.45
(h) Preparation of TSC or SOC for Shipment	5.0	0.08	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.53	-	-
Subtotal		0.08	0.53	2.40	8.73
Total		$0.60	$1.03	$2.92	$23.22

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 461 kgU/assembly, and a cask capacity of 32 assemblies; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 183 kgU/assembly, and a cask capacity of 76 assemblies. Concrete casks assumed to have a capacity for storing 9 PWR or 25 BWR assemblies.

[b] References are to Sections in Appendix B unless otherwise indicated. (Note: Costs developed in these sections were adjusted for increased capacity metal casks.)

[c] Included in the costs shown in (1)(d)

TABLE I-3

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Increased Capacity Metal Casks - Case A (26/52) Consolidated Fuel)

		Average Cost ($/kgU, 1987)[a]			
	Section Reference[b]	TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.11	$0.11	$0.11	$ -[c]
(b) Cans	-	-	-	-	-[d]
(c) Canning	3.1	-	-	-	-[d]
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.25	0.25	0.25	1.99
(e) Equipment Rental	App A, 3.0	-	-	-	1.26
Subtotal		0.36	0.36	0.36	3.25
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.16	1.83
(b) Decanning	6.0	-	-	-	-
(c) Can Disposal	6.0	-	-	-	-
(d) Fuel Inspection	7.0	-	-	0.48	0.50
(e) Receiving of Transport Cask	1.0	-	-	0.11	0.13
(f) Loading of Transport Cask	8.0	-	-	0.27	0.29
(g) Equipment Rental	6.0	-	-	-	1.26
(h) Preparation of TSC or SOC for Shipment	5.0	0.06	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.37	-	-
Subtotal		0.06	0.37	1.02	4.01
Total		$0.42	$0.73	$1.38	$ 7.26

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 770 kgU/can, and a cask capacity of 26 cans; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 306 kgU/can, and a cask capacity of 52 cans. Concrete casks assumed to have a capacity for storing 9 PWR cans or 25 BWR cans.

[b] References are to Sections in Appendix B unless otherwise indicated. (Note: Costs developed in these sections were adjusted for increased capacity metal casks.)

[c] Included in the costs shown in (1)(d)

[d] Consolidated fuel assumed to be canned already

TABLE I-4

SUMMARY OF ESTIMATED AT-REACTOR HANDLING COSTS ASSOCIATED WITH DRY STORAGE MODULES

(Increased Capacity Metal Casks - Case B (32/76) Consolidated Fuel)

	Section Reference[b]	Average Cost ($/kgU, 1987)[a]: TSC or SOC Destined For Shipment To DOE	SOC Shipped To DOE In Overpack	SOC Used For At-Reactor Storage Only	Concrete Cask
(1) Loading & Placement in AR Storage					
(a) Cask Receiving & Placement in Pool	1.0	$0.08	$0.08	$0.08	$ -[c]
(b) Cans	-	-	-	-	-[d]
(c) Canning	3.1	-	-	-	-[d]
(d) Loading & Transfer to Storage	2.0, 3.2, 3.3	0.23	0.23	0.23	1.99
(e) Equipment Rental	App A, 3.0	-	-	-	1.26
Subtotal		0.31	0.31	0.31	3.25
(2) Removal From AR Storage & Shipment Preparation					
(a) Removal from Storage & Unloading	4.0, 6.0	-	-	0.13	1.83
(b) Decanning	6.0	-	-	-	-
(c) Can Disposal	6.0	-	-	-	-
(d) Fuel Inspection	7.0	-	-	0.49	0.50
(e) Receiving of Transport Cask	1.0	-	-	0.08	0.13
(f) Loading of Transport Cask	8.0	-	-	0.24	0.29
(g) Equipment Rental	6.0	-	-	-	1.26
(h) Preparation of TSC or SOC for Shipment	5.0	0.05	-	-	-
(i) Overpacking of SOC for Shipment	9.0	-	0.32	-	-
Subtotal		0.05	0.32	0.94	4.01
Total		$0.36	$0.63	$1.25	$ 7.26

[a] Based on: 2/3 of the amount (kgU) of fuel being PWR fuel, with an average of 770 kgU/can, and a cask capacity of 32 cans; 1/3 of the amount (kgU) of fuel being BWR fuel, with an average of 306 kgU/can, and a cask capacity of 76 cans. Concrete casks assumed to have a capacity for storing 9 PWR cans or 25 BWR cans.

[b] References are to Sections in Appendix B unless otherwise indicated. (Note: Costs developed in these sections were adjusted for increased capacity metal casks.)

[c] Included in the costs shown in (1)(d)

[d] Consolidated fuel assumed to be canned already

1.1.2 Sensitivity of At-Reactor Life Cycle and Unit Costs to Changes in Cask Capacity

An analysis was performed of the impact of increased capacity metal casks on the life cycle and resulting unit costs involved with the use of the casks at the reactor site. The analysis was performed using the same methodology as was used for determining the at-reactor cask costs for the base case (as described in Appendix C). The number of additional metal storage casks needed each year was calculated by dividing the amount of fuel requiring storage each year by the cask capacity. The resulting number of metal storage casks was multiplied by the estimated cost of a cask to determine the total cask cost to the utility system for a given year. The calculations were made for the total number of years that additional at-reactor storage is projected to be required; this is dependent on when the DOE system begins receiving spent fuel. The following cases were evaluated for the on-time repository (1998) scenario:

Case No.	Type of Cask Used For AR Storage	Cask Capacity Number Of Assemblies (PWR/BWR)	Type Of Fuel	Method of Shipment to DOE Facilities
A1	TSC	(26/52)	Intact assemblies	In TSC
A2	TSC	(26/52)	Consolidated fuel	In TSC
A3	SOC	(26/52)	Intact assemblies	In DOE-furnished transport cask
A4	SOC	(26/52)	Consolidated fuel	In DOE-furnished transport cask
A5	SOC	(26/52)	Intact assemblies	In SOC; one-time use of SOC for shipment
A6	SOC	(26/52)	Consolidated fuel	In SOC; one-time use of SOC for shipment
A7	SOC	(26/52)	Intact assemblies	In SOC in overpack
A8	SOC	(26/52)	Consolidated fuel	In SOC in overpack
B1	TSC	(32/76)	Intact assemblies	In TSC
B2	TSC	(32/76)	Consolidated fuel	In TSC
B3	SOC	(32/76)	Intact assemblies	In DOE-furnished transport cask
B4	SOC	(32/76)	Consolidated fuel	In DOE-furnished transport cask
B5	SOC	(32/76)	Intact assemblies	In SOC; one-time use of SOC for shipment
B6	SOC	(32/76)	Consolidated fuel	In SOC; one-time use of SOC for shipment
B7	SOC	(32/76)	Intact assemblies	In SOC in overpack
B8	SOC	(32/76)	Consolidated fuel	In SOC in overpack

The impact of increased capacity metal casks on the total cost of metal casks at the reactor is significant. Fewer casks are needed to meet the storage requirements, thereby reducing the total cost of casks in the utility system. The results of the cost calculations for the TSC and SOC higher capacity cases are included in Tables I-5 through I-20. These tables list the at-reactor costs for spent fuel stored as intact fuel assemblies and in consolidated form in cans. The at-reactor operations costs are also included in the tables and added to the cask costs to provide total at-reactor costs. The unit costs are calculated (using a 3% discount rate) and also provided in the tables. Summaries of the at-reactor costs for Cases A and B are provided in Tables I-21 and I-22. The summary tables provide a comparison of the at-reactor costs (in $/kgU) for the base case, each of the increased capacity metal cask options, and the concrete cask option.

TABLE I-5
CASE AI -- COST OF TSCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	941	7		948	948	948	12	12
1988	106	160	5	4,601	34		4,635	4,500	4,414	51	50
1989	163	323	7	6,206	48		6,254	5,895	5,672	77	74
1990	126	449	6	5,198	41		5,239	4,794	4,526	58	54
1991	238	687	11	9,380	75		9,455	8,401	7,779	106	98
1992	286	973	13	10,881	89		10,970	9,462	8,595	123	112
1993	258	1231	12	9,923	82		10,005	8,379	7,466	108	96
1994	428	1659	19	15,518	129		15,647	12,723	11,120	174	152
1995	365	2024	16	12,924	109		13,033	10,288	8,821	144	124
1996	454	2478	20	16,020	136		16,156	12,382	10,414	174	146
1997	516	2994	23	18,242	157		18,399	13,690	11,295	192	158
1998	169	3163	8	6,318	54		6,372	4,604	3,726	61	49
1999	272	3435	12	9,450	82		9,532	6,685	5,308	95	76
2000	390	3825	17	13,311	116		13,427	9,143	7,120	133	103
2001			(3)			3	3	2	2		
2002			(39)			44	44	28	21		
2003			(89)			99	99	62	46		
2004			(41)			46	46	28	20		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			170	138,913	1,157	192	140,262	112,014	97,292	1,508	1,306
TOTAL DISC @3%				110,973	921	120		112,014			
UNIT COST/KG				$73.6	$.6	$.1		$74.3			
TOTAL DISC @5%				96,406	798	88			97,292		
UNIT COST/KG				$73.8	$.6	$.1			$74.5		

TABLE I-6
CASE A2 -- COST OF TSCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	941	7		948	948	948	12	12
1988	106	160	3	2,760	20		2,780	2,699	2,648	51	50
1989	163	323	4	3,600	27		3,627	3,418	3,290	77	74
1990	126	449	3	2,649	20		2,669	2,443	2,306	58	54
1991	238	687	6	5,226	40		5,266	4,679	4,332	106	98
1992	286	973	8	6,856	53		6,909	5,960	5,414	123	112
1993	258	1231	7	5,915	47		5,962	4,993	4,449	108	96
1994	428	1659	12	10,020	80		10,100	8,212	7,178	174	152
1995	365	2024	10	8,260	67		8,327	6,573	5,636	144	124
1996	454	2478	12	9,828	80		9,908	7,594	6,387	174	146
1997	516	2994	14	11,368	93		11,461	8,528	7,036	192	158
1998	169	3163	5	4,035	33		4,068	2,939	2,379	61	49
1999	272	3435	7	5,628	47		5,675	3,980	3,160	95	76
2000	390	3825	11	8,811	73		8,884	6,050	4,712	133	103
2001			(2)			2	2	1	1		
2002			(24)			27	27	17	13		
2003			(54)			60	60	37	28		
2004			(25)			28	28	17	12		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			103	85,897	687	117	86,701	69,089	59,926	1,508	1,306
TOTAL DISC @3%				68,470	546	73		69,089			
UNIT COST/KG				$45.4	$.4	$.0		$45.8			
TOTAL DISC @5%				59,400	472	54			59,926		
UNIT COST/KG				$45.5	$.4	$.0			$45.9		

TABLE I-7

CASE A3 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASES ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	5	4,780	34		4,814	4,674	4,585	51	50
1989	163	323	7	5,516	48		5,564	5,244	5,046	77	74
1990	126	449	6	4,620	41		4,661	4,265	4,026	58	54
1991	238	687	11	8,338	75		8,413	7,475	6,921	106	98
1992	286	973	13	9,672	88		9,760	8,419	7,648	123	112
1993	258	1231	12	8,820	82		8,902	7,455	6,643	108	96
1994	428	1659	19	13,794	129		13,923	11,321	9,895	174	152
1995	365	2024	16	11,488	109		11,597	9,155	7,849	144	124
1996	454	2478	20	14,240	136		14,376	11,018	9,267	174	146
1997	516	2994	23	16,215	157		16,372	12,182	10,051	192	158
1998	169	3163	8	5,616	54		5,670	4,096	3,315	61	49
1999	272	3435	12	8,400	82		8,482	5,949	4,723	95	76
2000	390	3825	17	11,832	116		11,948	8,136	6,336	133	103
2001			(3)			84	84	55	42		
2002			(39)			1,088	1,088	698	523		
2003			(89)			2,483	2,483	1,547	1,138		
2004			(41)			1,144	1,144	692	499		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			170	124,287	1,157	4,799	130,243	103,346	89,470	1,508	1,306
TOTAL DISC @3%				99,432	921	2,993		103,346			
UNIT COST/KG				$65.9	$.6	$2.0		$68.5			
TOTAL DISC @5%				86,470	798	2,202			89,470		
UNIT COST/KG				$66.2	$.6	$1.7			$68.5		

TABLE I-8
CASE A4 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	3	2,868	20		2,888	2,804	2,750	51	50
1989	163	323	4	3,824	27		3,851	3,630	3,493	77	74
1990	126	449	3	2,355	20		2,375	2,173	2,052	58	54
1991	238	687	6	4,644	40		4,684	4,162	3,854	106	98
1992	286	973	8	6,096	53		6,149	5,304	4,818	123	112
1993	258	1231	7	5,257	47		5,304	4,442	3,958	108	96
1994	428	1659	12	8,904	80		8,984	7,305	6,385	174	152
1995	365	2024	10	7,340	67		7,407	5,847	5,013	144	124
1996	454	2478	12	8,736	80		8,816	6,757	5,683	174	146
1997	516	2994	14	10,108	93		10,201	7,591	6,263	192	158
1998	169	3163	5	3,585	33		3,618	2,614	2,116	61	49
1999	272	3435	7	5,005	47		5,052	3,543	2,813	95	76
2000	390	3825	11	7,832	73		7,905	5,383	4,192	133	103
2001			(2)			38	38	25	19		
2002			(24)			454	454	291	218		
2003			(54)			1,021	1,021	636	468		
2004			(25)			473	473	286	206		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			103	77,510	687	1,985	80,182	63,755	55,262	1,508	1,306
TOTAL DISC @3%				61,972	546	1,238		63,755			
UNIT COST/KG				$41.1	$.4	$.8		$42.3			
TOTAL DISC @5%				53,879	472	911			55,262		
UNIT COST/KG				$41.3	$.4	$.7			$42.3		

TABLE I-9

CASE A5 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	5	4,780	34		4,814	4,674	4,585	51	50
1989	163	323	7	5,516	48		5,564	5,244	5,046	77	74
1990	126	449	6	4,620	41		4,661	4,265	4,026	58	54
1991	238	687	11	8,338	75		8,413	7,475	6,921	106	98
1992	286	973	13	9,672	88		9,760	8,419	7,648	123	112
1993	258	1231	12	8,820	82		8,902	7,455	6,643	108	96
1994	428	1659	19	13,794	129		13,923	11,321	9,895	174	152
1995	365	2024	16	11,488	109		11,597	9,155	7,849	144	124
1996	454	2478	20	14,240	136		14,376	11,018	9,267	174	146
1997	516	2994	23	16,215	157		16,372	12,182	10,051	192	158
1998	169	3163	8	5,616	54		5,670	4,096	3,315	61	49
1999	272	3435	12	8,400	82		8,482	5,949	4,723	95	76
2000	390	3825	17	11,832	116		11,948	8,136	6,336	133	103
2001			(3)			3	3	2	2		
2002			(39)			44	44	28	21		
2003			(89)			99	99	62	46		
2004			(41)			46	46	28	20		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			170	124,287	1,157	192	125,636	100,472	87,356	1,508	1,306
TOTAL DISC @3%				99,432	921	120		100,472			
UNIT COST/KG				$65.9	$.6	$.1		$66.6			
TOTAL DISC @5%				86,470	798	88			87,356		
UNIT COST/KG				$66.2	$.6	$.1			$66.9		

TABLE I-10

CASE A6 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	3	2,868	20		2,888	2,804	2,750	51	50
1989	163	323	4	3,824	27		3,851	3,630	3,493	77	74
1990	126	449	3	2,355	20		2,375	2,173	2,052	58	54
1991	238	687	6	4,644	40		4,684	4,162	3,854	106	98
1992	286	973	8	6,096	53		6,149	5,304	4,818	123	112
1993	258	1231	7	5,257	47		5,304	4,442	3,958	108	96
1994	428	1659	12	8,904	80		8,984	7,305	6,385	174	152
1995	365	2024	10	7,340	67		7,407	5,847	5,013	144	124
1996	454	2478	12	8,736	80		8,816	6,757	5,683	174	146
1997	516	2994	14	10,108	93		10,201	7,591	6,263	192	158
1998	169	3163	5	3,585	33		3,618	2,614	2,116	61	49
1999	272	3435	7	5,005	47		5,052	3,543	2,813	95	76
2000	390	3825	11	7,832	73		7,905	5,383	4,192	133	103
2001			(2)			2	2	1	1		
2002			(24)			27	27	17	13		
2003			(54)			60	60	37	28		
2004			(25)			28	28	17	12		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			103	77,510	687	117	78,314	62,590	54,405	1,508	1,306
TOTAL DISC @3%				61,972	546	73		62,590			
UNIT COST/KG				$41.1	$.4	$.0		$41.5			
TOTAL DISC @5%				53,879	472	54			54,405		
UNIT COST/KG				$41.3	$.4	$.0			$41.7		

TABLE I-11

CASE A7 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	5	4,780	34		4,814	4,674	4,585	51	50
1989	163	323	7	5,516	48		5,564	5,244	5,046	77	74
1990	126	449	6	4,620	41		4,661	4,265	4,026	58	54
1991	238	687	11	8,338	75		8,413	7,475	6,921	106	98
1992	286	973	13	9,672	88		9,760	8,419	7,648	123	112
1993	258	1231	12	8,820	82		8,902	7,455	6,643	108	96
1994	428	1659	19	13,794	129		13,923	11,321	9,695	174	152
1995	365	2024	16	11,488	109		11,597	9,155	7,849	144	124
1996	454	2478	20	14,240	136		14,376	11,018	9,267	174	146
1997	516	2994	23	16,215	157		16,372	12,182	10,051	192	158
1998	169	3163	8	5,616	54		5,670	4,096	3,315	61	49
1999	272	3435	12	8,400	82		8,482	5,949	4,723	95	76
2000	390	3825	17	11,832	116		11,948	8,136	6,336	133	103
2001			(3)			21	21	14	10		
2002			(39)			270	270	173	130		
2003			(89)			616	616	384	282		
2004			(41)			284	284	172	124		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			170	124,287	1,157	1,190	126,634	101,095	87,814	1,508	1,306
TOTAL DISC @3%				99,432	921	742		101,095			
UNIT COST/KG				$65.9	$.6	$.5		$67.0			
TOTAL DISC @5%				86,470	798	546			87,814		
UNIT COST/KG				$66.2	$.6	$.4			$67.2		

TABLE I-12
CASE A8 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
CAPACITY - (26/52)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC. AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	3	2,868	20		2,888	2,804	2,750	51	50
1989	163	323	4	3,824	27		3,851	3,630	3,493	77	74
1990	126	449	3	2,355	20		2,375	2,173	2,052	58	54
1991	238	687	6	4,644	40		4,684	4,162	3,854	106	98
1992	286	973	8	6,096	53		6,149	5,304	4,818	123	112
1993	258	1231	7	5,257	47		5,304	4,442	3,958	108	96
1994	428	1659	12	8,904	80		8,984	7,305	6,385	174	152
1995	365	2024	10	7,340	67		7,407	5,847	5,013	144	124
1996	454	2478	12	8,736	80		8,816	6,757	5,683	174	146
1997	516	2994	14	10,108	93		10,201	7,591	6,263	192	158
1998	169	3163	5	3,585	33		3,618	2,614	2,116	61	49
1999	272	3435	7	5,005	47		5,052	3,543	2,813	95	76
2000	390	3825	11	7,832	73		7,905	5,383	4,192	133	103
2001			(2)			14	14	9	7		
2002			(24)			165	165	106	79		
2003			(54)			370	370	231	170		
2004			(25)			171	171	104	75		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			103	77,510	687	720	78,917	62,966	54,682	1,508	1,306
TOTAL DISC @3%				61,972	546	449		62,966			
UNIT COST/KG				$41.1	$.4	$.3		$41.7			
TOTAL DISC @5%				53,879	472	330			54,682		
UNIT COST/KG				$41.3	$.4	$.3			$41.9		

TABLE I-13
CASE BI -- COST OF TSCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	941	8		949	949	949	12	12
1988	106	160	4	3,681	30		3,711	3,603	3,534	51	50
1989	163	323	6	5,346	45		5,391	5,082	4,890	77	74
1990	126	449	4	3,497	30		3,527	3,228	3,047	58	54
1991	238	687	8	6,885	60		6,945	6,171	5,714	106	98
1992	286	973	10	8,460	75		8,535	7,363	6,688	123	112
1993	258	1231	9	7,523	68		7,591	6,357	5,664	108	96
1994	428	1659	15	12,403	113		12,516	10,177	8,895	174	152
1995	365	2024	13	10,618	98		10,716	8,459	7,253	144	124
1996	454	2478	16	12,960	120		13,080	10,025	8,432	174	146
1997	516	2994	18	14,438	135		14,573	10,844	8,947	192	158
1998	169	3163	6	4,786	45		4,831	3,490	2,825	61	49
1999	272	3435	9	7,158	68		7,226	5,068	4,024	95	76
2000	390	3825	13	10,296	98		10,394	7,078	5,512	133	103
2001			(2)			2	2	2	1		
2002			(30)			35	35	22	17		
2003			(69)			80	80	50	37		
2004			(31)			36	36	22	16		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			132	108,992	993	153	110,138	87,987	76,442	1,508	1,306
TOTAL DISC @3%				87,101	791	95		87,987			
UNIT COST/KG				$57.7	$.5	$.1		$58.3			
TOTAL DISC @5%				75,687	685	70			76,442		
UNIT COST/KG				$58.0	$.5	$.1			$58.5		

TABLE I-14
CASE B2 -- COST OF TSCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN TSC
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	941	7		948	948	948	12	12
1988	106	160	2	1,858	15		1,873	1,818	1,784	51	50
1989	163	323	3	2,715	22		2,737	2,580	2,483	77	74
1990	126	449	3	2,673	22		2,695	2,467	2,328	58	54
1991	238	687	5	4,385	37		4,422	3,929	3,638	106	98
1992	286	973	6	5,184	45		5,229	4,510	4,097	123	112
1993	258	1231	5	4,270	37		4,307	3,607	3,214	108	96
1994	428	1659	9	7,596	67		7,663	6,231	5,446	174	152
1995	365	2024	8	6,680	60		6,740	5,320	4,562	144	124
1996	454	2478	9	7,452	67		7,519	5,763	4,847	174	146
1997	516	2994	11	9,031	82		9,113	6,781	5,595	192	158
1998	169	3163	4	3,264	30		3,294	2,380	1,926	61	49
1999	272	3435	6	4,884	45		4,929	3,457	2,744	95	76
2000	390	3825	8	6,480	60		6,540	4,453	3,468	133	103
2001			(1)			1	1	1	1		
2002			(18)			22	22	14	10		
2003			(41)			49	49	31	23		
2004			(19)			23	23	14	10		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			80	67,413	596	95	68,104	54,303	47,123	1,508	1,306
TOTAL DISC @3%				53,771	473	59		54,303			
UNIT COST/KG				$35.7	$.3	$.0		$36.0			
TOTAL DISC @5%				46,670	410	44			47,123		
UNIT COST/KG				$35.7	$.3	$.0			$36.1		

TABLE I-15

CASE B3 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	8		964	964	964	12	12
1988	106	160	4	3,824	30		3,854	3,742	3,671	51	50
1989	163	323	6	5,223	45		5,268	4,966	4,778	77	74
1990	126	449	4	3,108	30		3,138	2,872	2,711	58	54
1991	238	687	8	6,120	60		6,180	5,491	5,084	106	98
1992	286	973	10	7,520	75		7,595	6,552	5,951	123	112
1993	258	1231	9	6,687	68		6,755	5,657	5,040	108	96
1994	428	1659	15	11,025	113		11,138	9,056	7,915	174	152
1995	365	2024	13	9,438	98		9,536	7,528	6,454	144	124
1996	454	2478	16	11,520	120		11,640	8,921	7,503	174	146
1997	516	2994	18	12,834	135		12,969	9,650	7,962	192	158
1998	169	3163	6	4,254	45		4,299	3,106	2,514	61	49
1999	272	3435	9	6,363	68		6,431	4,510	3,581	95	76
2000	390	3825	13	9,152	98		9,250	6,299	4,905	133	103
2001			(2)			69	69	46	35		
2002			(30)			1,042	1,042	669	501		
2003			(69)			2,396	2,396	1,493	1,098		
2004			(31)			1,077	1,077	651	470		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			132	98,024	993	4,584	103,601	82,172	71,138	1,508	1,306
TOTAL DISC @3%				78,522	791	2,859		82,172			
UNIT COST/KG				$52.1	$.5	$1.9		$54.5			
TOTAL DISC @5%				68,349	685	2,104			71,138		
UNIT COST/KG				$52.3	$.5	$1.6			$54.5		

TABLE I-16
CASE B4 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN DOE TRANSPORT CASK
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	2	1,912	15		1,927	1,871	1,835	51	50
1989	163	323	3	2,868	22		2,890	2,724	2,622	77	74
1990	126	449	3	2,700	22		2,722	2,491	2,352	58	54
1991	238	687	5	3,900	37		3,937	3,498	3,239	106	98
1992	286	973	6	4,608	45		4,653	4,013	3,645	123	112
1993	258	1231	5	3,795	37		3,832	3,209	2,860	108	96
1994	428	1659	9	6,750	67		6,817	5,543	4,845	174	152
1995	365	2024	8	5,936	60		5,996	4,733	4,058	144	124
1996	454	2478	9	6,624	67		6,691	5,128	4,313	174	146
1997	516	2994	11	8,030	82		8,112	6,036	4,980	192	158
1998	169	3163	4	2,900	30		2,930	2,117	1,713	61	49
1999	272	3435	6	4,344	45		4,389	3,078	2,444	95	76
2000	390	3825	8	5,760	60		5,820	3,963	3,086	133	103
2001			(1)			23	23	15	11		
2002			(18)			406	406	261	195		
2003			(41)			926	926	577	424		
2004			(19)			429	429	260	187		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			80	61,083	596	1,784	63,462	50,481	43,773	1,508	1,306
TOTAL DISC @3%				48,895	473	1,112		50,481			
UNIT COST/KG				$32.4	$.3	$.7		$33.5			
TOTAL DISC @5%				42,545	410	818			43,773		
UNIT COST/KG				$32.6	$.3	$.6			$33.5		

TABLE I-17
CASE D5 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	8		964	964	964	12	12
1988	106	160	4	3,824	30		3,854	3,742	3,671	51	50
1989	163	323	6	5,223	45		5,268	4,966	4,778	77	74
1990	126	449	4	3,108	30		3,138	2,872	2,711	58	54
1991	238	687	8	6,120	60		6,180	5,491	5,084	106	98
1992	286	973	10	7,520	75		7,595	6,552	5,951	123	112
1993	258	1231	9	6,687	68		6,755	5,657	5,040	108	96
1994	428	1659	15	11,025	113		11,138	9,056	7,915	174	152
1995	365	2024	13	9,438	98		9,536	7,528	6,454	144	124
1996	454	2478	16	11,520	120		11,640	8,921	7,503	174	146
1997	516	2994	18	12,834	135		12,969	9,650	7,962	192	158
1998	169	3163	6	4,254	45		4,299	3,106	2,514	61	49
1999	272	3435	9	6,363	68		6,431	4,510	3,581	95	76
2000	390	3825	13	9,152	98		9,250	6,299	4,905	133	103
2001			(2)			2	2	2	1		
2002			(30)			35	35	22	17		
2003			(69)			80	80	50	37		
2004			(31)			36	36	22	16		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			132	98,024	993	153	99,170	79,408	69,105	1,508	1,306
TOTAL DISC @3%				78,522	791	95		79,408			
UNIT COST/KG				$52.1	$.5	$.1		$52.6			
TOTAL DISC @5%				68,349	685	70			69,105		
UNIT COST/KG				$52.3	$.5	$.1			$52.9		

TABLE I-18

CASE B6 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
ONE-TIME USE OF SOC FOR SHIPMENT
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	2	1,912	15		1,927	1,871	1,835	51	50
1989	163	323	3	2,868	22		2,890	2,724	2,622	77	74
1990	126	449	3	2,700	22		2,722	2,491	2,352	58	54
1991	238	687	5	3,900	37		3,937	3,498	3,239	106	98
1992	286	973	6	4,608	45		4,653	4,013	3,645	123	112
1993	258	1231	5	3,795	37		3,832	3,209	2,860	108	96
1994	428	1659	9	6,750	67		6,817	5,543	4,845	174	152
1995	365	2024	8	5,936	60		5,996	4,733	4,058	144	124
1996	454	2478	9	6,624	67		6,691	5,128	4,313	174	146
1997	516	2994	11	8,030	82		8,112	6,036	4,980	192	158
1998	169	3163	4	2,900	30		2,930	2,117	1,713	61	49
1999	272	3435	6	4,344	45		4,389	3,078	2,444	95	76
2000	390	3825	8	5,760	60		5,820	3,963	3,086	133	103
2001			(1)			1	1	1	1		
2002			(18)			22	22	14	10		
2003			(41)			49	49	31	23		
2004			(19)			23	23	14	10		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			80	61,083	596	95	61,774	49,428	42,999	1,508	1,306
TOTAL DISC @3%				48,895	473	59		49,428			
UNIT COST/KG				$32.4	$.3	$.0		$32.8			
TOTAL DISC @5%				42,545	410	44			42,999		
UNIT COST/KG				$32.6	$.3	$.0			$32.9		

TABLE I-19

CASE B7 -- COST OF SOCs FOR AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU)		NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACE-MENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
	ANNUAL	CUMULATIVE									
1987	24	54	1	956	8		964	964	964	12	12
1988	106	160	4	3,824	30		3,854	3,742	3,671	51	50
1989	163	323	6	5,223	45		5,268	4,966	4,778	77	74
1990	126	449	4	3,108	30		3,138	2,872	2,711	58	54
1991	238	687	8	6,120	60		6,180	5,491	5,084	106	98
1992	286	973	10	7,520	75		7,595	6,552	5,951	123	112
1993	258	1231	9	6,687	68		6,755	5,657	5,040	108	96
1994	428	1659	15	11,025	113		11,138	9,056	7,915	174	152
1995	365	2024	13	9,438	98		9,536	7,528	6,454	144	124
1996	454	2478	16	11,520	120		11,640	8,921	7,503	174	146
1997	516	2994	18	12,834	135		12,969	9,650	7,962	192	158
1998	169	3163	6	4,254	45		4,299	3,106	2,514	61	49
1999	272	3435	9	6,363	68		6,431	4,510	3,581	95	76
2000	390	3825	13	9,152	98		9,250	6,299	4,905	133	103
2001			(2)			15	15	10	8		
2002			(30)			230	230	148	111		
2003			(69)			529	529	330	242		
2004			(31)			238	238	144	104		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			132	98,024	993	1,012	100,030	79,945	69,499	1,508	1,306
TOTAL DISC @3%				78,522	791	631		79,945			
UNIT COST/KG				$52.1	$.5	$.4		$53.0			
TOTAL DISC @5%				68,349	685	465			69,499		
UNIT COST/KG				$52.3	$.5	$.4			$53.2		

TABLE I-20

CASE B8 -- COST OF SOCs FOR AT-REACTOR STORAGE OF CONSOLIDATED FUEL ASSEMBLIES --
REPOSITORY COMMENCES OPERATION IN 1998
SHIPMENT IN OVERPACKED SOC
CAPACITY - (32/76)
(50% of AR Storage Requirements Provided by Casks)

YEAR	AMOUNT FUEL STORED AR (MTU) ANNUAL	AMOUNT FUEL STORED AR (MTU) CUMULATIVE	NO. OF METAL CASKS	COST OF METAL CASKS ($000)	COST OF LOADING & PLACEMENT IN STORAGE ($000)	COST OF REMOVAL FROM STORAGE & PREPARATION FOR SHIPMENT ($000)	TOTAL ($000)	TOTAL DISC. AT 3% TO 1987 ($000)	TOTAL DISC.AT 5% TO 1987 ($000)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 3% (50% OF ANNUAL)	DISCOUNTED VALUE OF MTU STORED IN CASKS @ 5% (50% OF ANNUAL)
1987	24	54	1	956	7		963	963	963	12	12
1988	106	160	2	1,912	15		1,927	1,871	1,835	51	50
1989	163	323	3	2,868	22		2,890	2,724	2,622	77	74
1990	126	449	3	2,700	22		2,722	2,491	2,352	58	54
1991	238	687	5	3,900	37		3,937	3,498	3,239	106	98
1992	286	973	6	4,608	45		4,653	4,013	3,645	123	112
1993	258	1231	5	3,795	37		3,832	3,209	2,860	108	96
1994	428	1659	9	6,750	67		6,817	5,543	4,845	174	152
1995	365	2024	8	5,936	60		5,996	4,733	4,058	144	124
1996	454	2478	9	6,624	67		6,691	5,128	4,313	174	146
1997	516	2994	11	8,030	82		8,112	6,036	4,980	192	158
1998	169	3163	4	2,900	30		2,930	2,117	1,713	61	49
1999	272	3435	6	4,344	45		4,389	3,078	2,444	95	76
2000	390	3825	8	5,760	60		5,820	3,963	3,086	133	103
2001			(1)			8	8	5	4		
2002			(18)			138	138	89	67		
2003			(41)			315	315	196	144		
2004			(19)			146	146	88	64		
2005											
2006											
2007											
2008											
2009											
2010											
2011											
2012											
2013											
2014											
2015											
2016											
2017											
2018											
2019											
2020											
TOTAL			80	61,083	596	607	62,286	49,747	43,234	1,508	1,306
TOTAL DISC @3%				48,895	473	379		49,747			
UNIT COST/KG				$32.4	$.3	$.3		$33.0			
TOTAL DISC @5%				42,545	410	279			43,234		
UNIT COST/KG				$32.6	$.3	$.2			$33.1		

TABLE I-21

SENSITIVITY OF COSTS OF USE OF TSCs OR SOCs IN AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES TO INCREASES IN CASK CAPACITY[a]

($/kgU, 1987)[b]

	Unit Costs For Casks Of Indicated Capacity		
	Base Case 21 PWR/46 BWR[c] (9.26 MTU Capacity)	Case A 26 PWR/52 BWR (11.16 MTU Capacity)	Case B 32 PWR/76 BWR (14.47 MTU Capacity)
TSC Shipped Directly to DOE	$88.7	$74.3	$ 58.3
SOC One-Time Direct Shipment to DOE	79.6	66.6	52.7
SOC Shipped to DOE in Overpack	80.1	67.0	53.0
SOC Used for At-Reactor Storage Only	81.6	68.5	54.5
Concrete Cask[d]	55.0	55.0	55.0

[a]Assumed On-Time (1998) Repository

[b]Averaged at a 3%/year discount rate

[c]Base Case used in study (from Table C-33)

[d]For comparison with TSC and SOC costs (from Table C-33)

TABLE I-22

SENSITIVITY OF COSTS OF USE OF TSCs OR SOCs IN AT-REACTOR STORAGE OF CONSOLIDATED FUEL CANS TO INCREASES IN CASK CAPACITY[a]

($/kgU, 1987)[b]

	Unit Costs For Casks Of Indicated Capacity		
	Base Case 21 PWR/46 BWR[c] (15.37 MTU Capacity)	Case A 26 PWR/52 BWR (18.53 MTU Capacity)	Case B 32 PWR/76 BWR (24.02 MTU Capacity)
TSC Shipped Directly to DOE	$54.6	$45.9	$ 36.0
SOC One-Time Direct Shipment to DOE	49.5	41.6	32.8
SOC Shipped to DOE in Overpack	49.8	41.8	33.0
SOC Used for At-Reactor Storage Only	50.3	42.3	33.4
Concrete Cask[d]	27.7	27.7	27.7

[a]Assumed On-Time (1998) Repository

[b]Averaged at a 3%/year discount rate

[c]Base Case used in study (from Table C-34)

[d]For comparison with TSC and SOC costs (from Table C-34)

1.1.3 Discussion of Cost Comparisons

1.1.3.1 Comparison of Costs for At-Reactor Storage as Intact Fuel Assemblies

From Table I-21 it can be seen that the least costly option compared with the Case A higher capacity metal cask is the concrete cask. The concrete cask option is more than $11/kgU less expensive than the least costly SOC option. Of the three SOC options, the least costly is the one-time, one-way shipment of the SOC to a DOE facility. The next least costly SOC option is shipping the SOC in an overpack to a DOE facility. The most costly SOC option is the storage-only option, where a DOE-supplied transport cask is required to ship the spent fuel stored in the SOC to a DOE facility. The difference in cost between the most costly and least costly SOC options is small, less than $2/kgU. For Case A, the TSC option is the most costly option and is $6-8/kgU more than the SOC options.

For the Case B higher capacity metal casks, the SOC options are less costly than the concrete cask option. However, the TSC option remained more costly than the concrete cask option. It should be noted that the SOC options are only marginally less costly than the concrete cask option. There is also greater uncertainty in the cost estimated for the concrete casks. Because of this uncertainty, no conclusions should be drawn beyond the statement that at-reactor costs for high capacity TSCs and SOCs appear to be similar in magnitude to the costs of concrete casks.

1.1.3.2 Comparison of Costs for At-Reactor Storage as Consolidated Fuel

From the summary table for cases with consolidated fuel (Table I-22) it can be seen that the concrete cask is the least costly option compared with both Case A and Case B higher capacity metal casks. The concrete cask option is almost $14/kgU less than the least costly SOC option for Case A (26/52) capacity metal casks. The concrete cask option is $5/kgU less than the least costly SOC option for Case B (32/76) capacity metal casks. These results differ from the results for intact fuel assembly cases due to the additional cost for canning intact fuel to be stored in concrete casks. The cost penalty for canning intact fuel does not extend to the consolidated fuel cases. The costs for canning consolidated fuel were excluded from all consolidated fuel cases because it was assumed that consolidated fuel had already been canned prior to storage. Therefore, the costs for the concrete cask options for consolidated fuel are significantly lower than for intact fuel due to the exclusion of canning costs.

Like the cases for intact fuel, of the three SOC options for consolidated fuel; the least costly is the one-time, one-way shipment of the SOC to a DOE facility. The next least costly SOC option is shipping the SOC in an overpack to a DOE facility. The most costly SOC option is again the storage-only option. In all (32/76) cases, the TSC option is the most costly option.

1.2 SENSITIVITY OF SAVINGS WITHIN THE DOE SYSTEM TO CHANGES IN THE CAPACITY OF METAL STORAGE CASKS

The impact of increases in the capacity of metal storage casks on savings realized in the DOE system from the use of such higher capacity casks was determined. Impacts were determined for the transport of spent fuel from reactors to DOE facilities, replacement of lag storage capacity, replacement of MRS modules, and transport from MRS to repository facilities. These impacts are described in the following sections.

1.2.1 Sensitivity of Savings in the Cost of Transport from Reactors to DOE Facilities to Changes in Cask Capacity

The life cycle and resulting unit costs for the transport of spent fuel from a reactor to a DOE facility were calculated for cases where a TSC or SOC is used to replace a DOE transport cask in the transport fleet. For comparison purposes, the TSC or SOC and the DOE transport cask were all assumed to have the same increased capacities. It was also assumed that the total number of shipments/year over a given distance remained constant.

It was determined that the unit costs for transport decreased for the higher capacity casks whether they were DOE transport casks, TSCs or SOCs, because of the higher payloads involved. Table I-23 shows the results of the unit cost determinations. The results shown in the table demonstrate that there is a small cost savings associated with the use of a TSC over the DOE transport cask (well less than $1/kgU) in every case. This is because the cost of the TSC is not included in the total capital cost for that option. It is assumed that the utility paid for the TSC and, therefore, the TSC costs are

TABLE I-23

SENSITIVITY OF SAVINGS IN THE COST OF TRANSPORT FROM REACTORS TO DOE FACILITIES RESULTING FROM THE USE OF TSCs FOR TRANSPORT TO INCREASES IN CASK CAPACITY[a]

(1987 Dollars)

Cask Scenario	Unit Cost ($/kgU)[b] for Transport for Indicated Distances[c,d] 300 Miles	900 Miles	2300 Miles
Base Case (Cask Capacity: 21 PWR or 46 BWR assemblies)			
- DOE-Supplied Transport Cask	$3.91	$6.83	$10.61
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	3.60 (0.31)	6.36 (0.47)	10.04 (0.57)
Case A (Cask Capacity: 26 PWR or 52 BWR assemblies)			
- DOE-Supplied Transport Cask	3.25	5.67	8.80
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	2.99 (0.26)	5.28 (0.39)	8.33 (0.47)
Case B (Cask Capacity: 32 PWR or 76 BWR assemblies)			
- DOE-Supplied Transport Cask	2.50	4.37	6.79
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	2.30 (0.20)	4.07 (0.31)	6.43 (0.36)

[a] Intact fuel assemblies

[b] Averaged at a 3%/year net discount rate

[c] One-way distances shown; costs are for round trip

[d] Figures in parentheses are cost savings resulting from the use of utility-furnished TSC or SOC for transport instead of DOE-supplied transport cask

accounted for in total at-reactor costs. However, the cost of the DOE transport cask is included in the capital costs for that option. The cost savings of the TSC over the DOE-transport cask is small because the capital costs are only a small portion of the total life cycle transport costs. The majority of the life cycle transport costs consist of annual operating costs, freight charges, and escort charges which are the same for the TSC and DOE transport casks.

1.2.2 Sensitivity of Savings from Replacement of Lag Storage Capacity to Changes in Cask Capacity

The estimated savings to the DOE system resulting from the reduction in the amount of lag storage required at either the Integral MRS or repository facility is $233/kgU (assuming all lag storage capacity is in-cell storage), as described in Appendix E. It is recognized that if DOE determines the use of metal storage casks for lag storage is an acceptable alternative to in-cell storage, DOE could purchase SOCs for lag storage at a cost of about $735-thousand (1987 dollars), the estimated cost of the 50th unit. Therefore, the savings to the DOE system for the lag storage capacity provided by a TSC or SOC would be equivalent to the cost of a SOC. On a unit cost basis, the savings within the DOE system would go down as the capacity of the delivered TSCs or SOCs increases as shown in Table I-24. However, the savings on a per cask basis does not change with increasing capacity.

TABLE I-24

SENSITIVITY OF SAVINGS FROM REPLACEMENT OF IN-CELL LAG STORAGE CAPACITY WITH TSCs OR SOCs TO INCREASES IN CASK CAPACITY

TSC or SOC Capacity	At MRS or Repository With No MRS In System: Maximum No. Casks That Can Be Used For Lag Storage[a]	At MRS or Repository With No MRS In System: Savings ($/kgU, 1987): Delivered As Intact Fuel	At MRS or Repository With No MRS In System: Savings ($/kgU, 1987): Delivered As Consolidated Fuel	At Repository With MRS In System: Maximum No. Casks That Can Be Used For Lag Storage[b]	At Repository With MRS In System: Savings ($/kgU, 1987): Delivered As Intact Fuel	At Repository With MRS In System: Savings ($/kgU, 1987): Delivered As Consolidated Fuel
Base Cask (Cask Capacity: 21 PWR or 46 BWR assemblies or cans)	54 (32)	$79.4	$47.8	26	$75.9 (PWR) 56.7 (BWR)	$45.6 (PWR) 34.0 (BWR)
Cask A (Cask Capacity: 26 PWR or 52 BWR assemblies or cans)	45 (27)	65.9	39.7	21	61.3 (PWR) 50.1 (BWR)	36.8 (PWR) 30.1 (BWR)
Case B (Cask Capacity: 32 PWR or 76 BWR assemblies or cans)	35 (21)	50.8	30.6	17	49.8 (PWR) 34.3 (BWR)	29.9 (PWR) 20.6 (BWR)

[a] Numbers of casks that can be used to provide 500 MTU lag storage of intact spent fuel. Numbers in parentheses are numbers of casks that can be used to provide 500 MTU lag storage of consolidated fuel.

[b] Assumes cans of fuel rods are stored, 0.92/can. See note a.

1.2.3 Sensitivity of Savings from Replacement of MRS Modules to Changes in Cask Capacity

Savings can be realized by substituting TSCs or SOCs for MRS storage modules at the MRS facility. The savings involved is equivalent to the cost of the storage capacity replaced by the TSCs or SOCs. The savings involved in the use of the higher capacity casks was determined; a summary of the results is set forth in Table I-25. The savings for TSCs or SOCs delivered containing BWR spent fuel is less than TSCs or SOCs delivered containing PWR spent fuel in every case because of the added expense to replace the BWR fuel basket before the TSC or SOC can be used as a replacement for a MRS storage module. The results of the calculations show that there is no increase in savings (on a $/kgU basis) for higher capacity TSCs or SOCs delivered containing PWR spent fuel. However, there is a significant increase in savings or, more appropriately, a significant decrease in the cost penalty, for higher capacity TSCs or SOCs delivered containing BWR spent fuel. The increase in savings for higher capacity TSCs or SOCs delivered containing BWR spent fuel is because the replacement of the basket is assumed to be a fixed cost per cask that is not dependent on cask capacity. The unit cost is determined by dividing the cost per cask by the cask capacity (in kgU). Therefore, when the capacity of the cask is increased and the cost per cask for replacement of the BWR basket remains unchanged, the cost penalty (in $/kgU) goes down and the savings in the DOE system increases proportionately.

It should be noted that fewer high capacity casks would be required for whatever portion of the MRS storage capacity that is met through the use of TSCs or SOCs.

TABLE I-25

SENSITIVITY OF SAVINGS FROM REPLACEMENT OF MRS MODULES WITH TSCs OR SOCs TO INCREASES IN CASK CAPACITY

TSC Capacity	Maximum Number TSCs or SOCs Accepted At MRS	Savings ($/kgU, 1987)[a] Delivered As Intact Fuel	Delivered As Consolidated Fuel
Base Case (Cask Capacity: 21 PWR or 46 BWR assemblies or cans)	240	35.5 (PWR) 10.1 (BWR)	21.4 (PWR) 6.1 (BWR)
Case A (Cask Capacity: 26 PWR or 52 BWR assemblies or cans)	194	35.5 (PWR) 17.5 (BWR)	21.4 (PWR) 10.6 (BWR)
Case B (Cask Capacity: 32 PWR or 76 BWR assemblies or cans)	158	35.5 (PWR) 19.1 (BWR)	21.4 (PWR) 11.5 (BWR)

[a]Averaged at a 3%/year discount rate.

1.2.4 Sensitivity of the Cost of Transport from the MRS to a Repository to Changes in Cask Capacity

The impact of using higher capacity TSCs for the shipment of cans of consolidated spent fuel from a MRS facility to a repository on the cost of such shipments was estimated. It was expected that the higher capacity TSCs would be more efficient at this task than the base case TSC which has a 21 MRS can capacity. The life cycle transport costs were determined for TSCs used for repetitive shipments of MRS cans of consolidated fuel and having cask capacities for 26 MRS cans and 32 MRS cans. The transport cost for these higher capacity TSC cases were compared with the costs for a standard cask. Table I-26 provides a summary of the unit costs for transport from the MRS to three repository locations in TSCs of different capacities and in a standard transport cask. The unit costs are higher for the Case A (26 PWR/52 BWR assembly) capacity TSC than for the standard cask, thus, no transport cost savings can be realized by using this capacity TSC in place of a standard cask. For the Case B (32 PWR/76 BWR assembly) capacity TSC, the unit transport costs are about the same for the TSC and standard cask.

TABLE I-26

SENSITIVITY OF COSTS OF TRANSPORT FROM MRS TO REPOSITORY FACILITY TO INCREASES IN TSC CAPACITY[a]

	Cost of Transport ($/kgU, 1987)[b]			
Destination	Standard Transport Casks	Base Case TSC Capacity (21 PWR/46 BWR)	Case A TSC Capacity (26 PWR/52 BWR)	Case B TSC Capacity (32 PWR/76 BWR)
To Salt Repository in Cans	$4.12	$5.14	$4.49	$4.01
To Basalt Repository in Cans	6.53	8.16	7.14	6.38
To Tuff Repository in Cans	6.12	7.71	6.77	6.02

[a] Assumes TSC is used repetitively (i.e., that it is made part of the transport cask fleet and used to make repeated round trip shipments).

[b] Averaged at a 3%/year discount rate

2.0 SENSITIVITY TO CHANGES IN THE COST OF TSCs OR SOCs

The impact of changes in the cost for fabrication of metal storage casks on the cost of using the casks at the reactor site, and on the savings to the DOE system as a result of a utility delivering spent fuel to DOE in such casks, was determined. Two variants in the cost of TSCs were considered; TSCs that cost nominally $400-thousand more than the base case TSC, and TSCs that cost nominally $400-thousand less. This variation was applied to the cost of the initial cask procured for the base case TSC ($990-thousand) oe SOC ($880-thousand), as applicable. Variations in the cost of SOCs was not calculated separately, but the absolute changes caused by cost variations to TSCs would be applicable to SOCs as well. In calculating the impact of cask cost changes on at-reactor costs and costs in the DOE system, the same methodologies were used as are described in Appendices A, B, C, D, E, F, and G for the base case.

2.1 SENSITIVITY OF AT-REACTOR COSTS TO CHANGES IN THE COST FOR METAL STORAGE CASKS

2.1.1 Sensitivity of At-Reactor Operations Costs to Changes in Cask Cost

A change in the cost of TSCs or SOCs will have no impact on the at-reactor operations costs, since cask cost is not included in the cost of operation at the reactor site.

2.1.2 Sensitivity of At-Reactor Life Cycle and Unit Costs to Changes in Cask Cost

An analysis was performed of the impact of changes in the costs for metal storage casks on the life cycle and resulting unit costs involved with the use of the casks at the reactor site. The analysis was performed using the same methodology as was used for determining the at-reactor cask costs for the base case (as described in Appendix C). Two variants in the cost of TSCs were considered, one in which the cask cost $580-thousand and one in which the cask cost $1,380-thousand. The results of the analysis is set forth in Table I-27. From the results shown in the table, it can be seen that a $100-thousand change in cask cost causes a $8-9/kgU variation in at-reactor costs.

TABLE I-27

SENSITIVITY OF COSTS OF USE OF TSCs OR SOCs IN AT-REACTOR STORAGE OF INTACT FUEL ASSEMBLIES TO CHANGES IN CASK COST

($/kgU, 1987)[a]

	Unit Costs for Indicated Equipment or Activity					
	Casks	Loading Equipment	Loading & Placement In Storage	Removal From Storage & Preparation For Shipment	Total	Average Change In Unit Cost Per $100K Change In Cask Cost
On-Time Repository						
TSC Shipped Directly to DOE (1st Cask Cost $580-thousand)	$ 51.5	$ -	$ 0.7	$0.1	$ 52.2	
TSC Shipped Directly to DOE (Base Case -- 1st Cask Cost $990-thousand)	87.9	-	0.7	0.1	88.7	$8.9
TSC Shipped Directly to DOE (1st Cask Cost $1,380-thousand)	122.5	-	0.7	0.1	123.3	
5-Year Repository Delay						
TSC Shipped Directly to DOE (1st Cask Cost $580-thousand)	49.7	-	0.7	0.1	50.4	
TSC Shipped Directly to DOE (Base Case -- 1st Cask Cost $990-thousand)	84.5	-	0.7	-.1	85.3	8.6
TSC Shipped Directly to DOE (1st Cask Cost $1,380-thousand)	118.2	-	0.7	0.1	118.9	
10-Year Repository Delay						
TSC Shipped Directly to DOE (1st Cask Cost $580-thousand)	48.5	-	0.7	0.1	49.3	
TSC Shipped Directly to DOE (Base Case -- 1st Cask Cost $990-thousand)	82.8	-	0.7	0.1	83.4	8.4
TSC Shipped Directly to DOE (1st Cask Cost $1,380-thousand)	115.4	-	0.7	0.1	116.2	

[a]Averaged at a 3%/year discount rate

2.2 SENSITIVITY OF SAVINGS WITHIN THE DOE SYSTEM TO CHANGES IN THE COST OF METAL STORAGE CASKS

The change in savings within the DOE system which result from decreases and increases in the TSC cost was determined. Impacts on savings were determined for the transport of spent fuel from reactors to DOE facilities, replacement of lag storage capacity, replacement of MRS modules, and transport from MRS to repository facilities. These impacts are described in the following sections.

2.2.1 Sensitivity of Savings in the Cost of Transport from Reactors to DOE Facilities to Changes in Cask Cost

The impact on savings in the cost of transport between reactors and DOE facilities as a result of changes in the cost of metal storage casks and DOE transport casks were calculated. Changes in the cost of TSCs or SOCs did not impact the savings per se, since the cost of the cask was not included in the calculations. However, it was reasoned that if the cost of a TSC were to vary, the cost of a DOE transport cask would similarly vary. Therefore, as the cost of a DOE transport cask increased or decreased, the cost of transporting spent fuel in the cask would correspondingly increase or decrease -- while the cost of shipping in TSCs or SOCs would remain unchanged from the base case.

Life cycle costs for transport and the resulting unit costs therefor were calculated for two variants in the cost of the DOE transport cask, one in which the cask cost $580-thousand, and one in which the cask cost $1,380-thousand (excluding development costs and the cost of auxiliary equipment). The results of the unit costs obtained for transport in the DOE transport cask and a TSC for shipments having one-way distances of 300 miles, 900 miles and 2,300 miles are summarized in Table I-28. The impact on savings as a result of the use of SOCs would be the same as that shown for TSCs in the table.

TABLE I-28

SENSITIVITY OF SAVINGS IN THE COST OF TRANSPORT FROM REACTORS TO DOE FACILITIES RESULTING FROM THE USE OF TSCs FOR TRANSPORT TO CHANGES IN CASK COST

(1987 Dollars)

Cask Scenario	Unit Cost ($/kgU)[b] for Transport for Indicated Distances[c,d] 300 Miles	900 Miles	2300 Miles
1st Cask Cost $990-thousand[e]			
- DOE-Supplied Transport Cask	$3.91	$6.83	$10.61
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	3.60 (0.31)	6.36 (0.47)	10.04 (0.57)
1st Cask Cost $580-thousand[e]			
- DOE-Supplied Transport Cask	3.78	6.64	10.38
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	3.60 (0.18)	6.36 (0.28)	10.04 (0.34)
1st Cask Cost $1,380-thousand[e]			
- DOE-Supplied Transport Cask	4.04	7.02	10.83
- TSC Used in Repetitive Shipments; DOE Avoids Purchase of Transport Cask	3.60 (0.44)	6.36 (0.66)	10.04 (0.79)

[a] Intact fuel assemblies

[b] Averaged at a 3%/year net discount rate

[c] One-way distances shown

[d] Figures in parentheses are cost savings resulting from the use of utility-furnished TSC or SOC for transport instead of DOE-supplied transport cask

[e] Casks costs indicated include fabrication and administrative expenses only; no development costs are included in these figures but such were used in the determination of the unit costs shown in the table.

From the results shown in the table it can be seen that a $100-thousand change in the cost of DOE transport cask, there is a change in the savings resulting from the use of a TSC or SOC of $0.033/kgU for a 300-mile shipment, $0.048/kgU for a 900-mile shipment, and $0.056/kgU for a 2,300-mile shipment.

2.2.2 Sensitivity of Savings from Replacement of Lag Storage Capacity to Changes in Cask Cost

The savings in the DOE system from using a TSC or SOC for lag storage was determined to be equivalent to the cost of a TSC or SOC. Due to the significantly higher cost of in-cell storage it was felt that DOE would select an alternate means of providing the majority of lag storage capacity in the form of modules. Therefore, DOE could not be expected to pay more than the cost of a TSC or SOC for that storage.

If the TSC or SOC cost changes, the savings in the DOE system changes by an equivalent amount. In other words, if the cost of a TSC or SOC changes and the TSC or SOC remains the least expensive option for providing lag storage, then the savings that DOE would realize by receiving a TSC or SOC from a utility would be equivalent to the new cost of the TSC or SOC.

2.2.3 Sensitivity of Savings from Replacement of MRS Modules to Changes in Cask Cost

Changes in the TSC or SOC cask cost have no impact on the savings from substitution of TSCs or SOCs for MRS modules. The savings to the DOE system is determined by the cost of the MRS modules and the capacity of the TSCs or SOCs received into the DOE system. Neither the cost of the MRS modules nor the capacity of the TSC or SOC were assumed to change from the base case, therefore, no change in the amount of savings occurs.

2.2.4 Sensitivity of the Cost of Transport from the MRS to a Repository to Changes in Cask Cost

The capital costs used in the life cycle transport calculation for shipment of fuel from the MRS to a repository do not include the cost of the TSC itself. Only the costs for design and licensing and auxiliary equipment are included. It is assumed that the TSC is provided to DOE by a utility that has incurred the cost of the cask. Therefore, an increase in the TSC cost would have no impact on the life cycle transport costs from a MRS to a repository. (Note: It is assumed that the cost for a DOE standard cask for shipment from MRS to a repository does not change.)

3.0 SUMMARY OF SENSITIVITY ANALYSES

3.1 SENSITIVITY OF COSTS AT REACTOR SITE

The changes in costs in the utility spent fuel management system resulting from changes in the capacity and costs of the TSCs or SOCs used for spent fuel storage are summarized in Tables I-29 and I-30, respectively.

The costs shown were derived from the cost information developed in Appendices A, B, and C -- and Sections 1.1 and 2.1 of this Appendix I, plus calculations made using the cost information set forth therein.

TABLE I-29

SUMMARY OF SENSITIVITY OF COSTS OF USE OF TSCs FOR AT REACTOR STORAGE TO CHANGES IN TSC CAPACITY AND COST

(1987 Dollars)

	Unit Costs ($/kgU) for Indicated Cask Capacities					
	Intact Fuel Assemblies			Consolidated Fuel		
Cask Cost ($000)	21 PWR/46 BWR Assemblies	26 PWR/52 BWR Assemblies	32 PWR/76 BWR Assemblies	21 PWR/46 BWR Cans	26 PWR/52 BWR Cans	32 PWR/76 BWR Cans
$ 550	$ 50	$ 42	$ 33	$ 31	$ 26	$ 20
600	54	45	36	33	28	22
650	59	49	38	36	30	24
700	63	53	41	39	33	26
750	67	56	44	41	35	27
800	72	60	47	44	37	29
850	76	64	50	47	39	31
900	81	68	53	50	42	33
950	85	71	56	52	44	35
990	89	74	58	55	46	36
1,000	90	75	59	55	46	36
1,050	94	79	62	58	49	38
1,100	98	82	65	61	51	40
1,150	103	86	68	63	53	42
1,200	107	90	71	66	56	44
1,250	112	94	73	69	58	45
1,300	116	97	76	72	60	47
1,350	121	101	79	74	62	49
1,400	125	105	82	77	65	51

TABLE I-30

SUMMARY OF SENSITIVITY OF COSTS OF USE OF SOCs FOR AT REACTOR STORAGE TO CHANGES IN SOC CAPACITY AND COST

(1987 Dollars)

Cask Cost ($000)	Unit Costs ($/kgU) for Indicated Cask Capacities					
	Intact Fuel Assemblies			Consolidated Fuel		
	21 PWR/46 BWR Assemblies	26 PWR/52 BWR Assemblies	32 PWR/76 BWR Assemblies	21 PWR/46 BWR Cans	26 PWR/52 BWR Cans	32 PWR/76 BWR Cans
$ 550	$ 50	$ 42	$ 33	$ 31	$ 26	$ 21
600	55	46	36	34	29	22
650	59	49	39	37	31	24
700	63	53	42	39	33	26
750	68	57	45	42	36	28
800	72	61	48	45	38	30
850	77	64	51	48	40	32
880	80	67	53	50	42	33
900	81	68	54	51	43	34
950	86	72	57	53	45	35
1,000	90	76	60	56	47	37
1,050	95	79	63	59	50	39
1,100	99	83	66	62	52	41
1,150	104	87	69	65	54	43
1,200	108	91	72	67	57	45
1,250	113	94	75	70	59	46
1,300	117	98	78	73	61	48
1,350	122	102	81	76	64	50
1,400	126	106	83	78	66	52

3.2 SENSITIVITY OF SAVINGS IN THE DOE SYSTEM

The sensitivity of savings in the DOE spent fuel management system to changes in the capacity of the TSCs or SOCs received are summarized in Table I-31. The costs shown were derived from the cost information developed in Appendices D, E, F and G -- and Sections 1.2 and 2.2 of this Appendix I, plus calculations made using the cost information set forth therein.

TABLE I-31

SENSITIVITY OF SAVINGS REALIZED IN DOE SYSTEM AS A RESULT OF RECEIVING TSCs OR SOCs FROM UTILITIES CONTAINING INTACT FUEL ASSEMBLIES TO INCREASES IN CASK CAPACITY[a]

($/kgU, 1987)[b]

	Avoided Costs Resulting From Receipt of Casks of Indicated Capacities		
Activity	21 PWR/46 BWR Assemblies (9.26 MTU)	26 PWR/52 BWR Assemblies (11.16 MTU)	32 PWR/76 BWR Assemblies (14.47 MTU)
Transportation -- Reactors to DOE Facilities[c]	$0.31-0.57	$0.26-0.47	$0.20-0.36
Lag Storage[d]	79.4	65.9	50.8
MRS Modules	35.5 (PWR) 10.1 (BWR)	35.5 (PWR) 17.5 (BWR)	35.5 (PWR) 19.1 (BWR)
Transportation -- MRS to Repository	None	None	None

[a] Savings are not additive, i.e., savings associated with the receipt of an individual TSC or SOC is realized in connection with only one activity.

[b] Savings are expressed in $/kgU contained in the spent fuel delivered to DOE. Savings for consolidated fuel are approximately 60% of those shown in the table.

[c] Comparison is based on savings resulting from the use of utility-furnished TSCs in place of a DOE transport cask. However, the change in savings resulting from the use of higher capacity casks would also be the same for all of the SOC cases shown in Appendix C.

[d] In the case where the TSC or SOC is used to deliver spent fuel and then used for lag storage at a repository when there is also a MRS facility in the system, the avoided costs shown are reduced to about 96% of the values shown for PWR fuel and to about 72% for BWR fuel.

The following sets forth the conclusions that can be drawn from the table along with comments regarding the impact of changes in cask cost on the results shown in the table:

(1) The savings in transport costs between the reactors and the DOE facility decline slightly with increasing capacities of the TSCs, SOCs and DOE transport casks, but are small to begin with. These savings change by about 5% for each $100-thousand change in the cost of a cask.

(2) The savings in lag storage costs declines as the capacity of the TSC or SOC for intact fuel assemblies increases. This is because the savings to DOE are equal to the cost of the cask. When the cost is held constant, and the capacity is increased, the savings expressed as a unit of capacity declines. For each $100-thousand change in the initial cask cost, the savings shown in the table correspondingly change by 12.5 percent of the values shown.

(3) The savings in the cost of MRS modules are independent of the capacity or cost of the TSCs or SOCs used to replace them. The greater the capacity of the cask, the more it is worth as a MRS module. However, this value has to be distributed over the larger amount of fuel that is contained in the cask as received from the utility. Thus, the savings expressed in $/kgU received in the cask does not change for increased cask capacity. Changes in the cost for the cask also do not impact savings because the savings are the result of the cost of the MRS modules, and not the casks. However, in the case of TSCs or SOCs that are received containing BWR fuel, the cost of a new basket and the cost of disposal of the old one has to be deducted from the savings that would have been experienced if the basket had not needed to be replaced. This savings increases with increasing cask capacity inasmuch as it was assumed that the cost of a new basket and disposal of the old one would not increase, and thus the deduction for these items was distributed over a larger amount of fuel received. This resulted in increasingly smaller deductions for casks of higher capacity, and a correspondingly larger net savings.

(4) There were no savings that resulted from the use of the TSCs for transport of cans of consolidated fuel from the MRS to the repository within the range of cask capacities studied. Moreover, variations in the cost of the TSCs did not impact the transport costs since it was not included as an element of such cost.

APPENDIX J

PROSPECTS FOR USE OF TSCs IN CONNECTION WITH THE STORAGE AND HANDLING OF DEFENSE WASTES

TABLE OF CONTENTS

APPENDIX J

PROSPECTS FOR USE OF TSCs IN CONNECTION WITH THE STORAGE AND HANDLING OF DEFENSE WASTES

The purpose of this Appendix is to perform a preliminary evaluation of the feasibility of using TSCs in the storage and handling of West Valley and defense wastes.

1.0 USE OF TSCs FOR WEST VALLEY HIGH LEVEL WASTE

1.1 BACKGROUND

High level waste (HLW) from the reprocessing of spent nuclear fuel at West Valley will be solidified in canisters that are 3 meters (120") in length, and 61 cm (24") outer diameter. West Valley will begin production of these canisters in late 1989. Three hundred canisters of HLW will be produced during the eighteen months vitrification campaign. The canisters will be stored on-site in a building previously used for chemical processing. The current plan is to store the HLW canisters at West Valley until they can be delivered to a repository. The first delivery of HLW to a repository is scheduled for the year 2008.

Table J-1 provides the production schedule and the repository acceptance schedule for the West Valley HLW canisters (References 1 and 2). An assumption has been made that the West Valley canisters will be delivered to the repository on a priority basis, meaning they will be the first canisters delivered starting in the year 2008. This assumption is based on the expressed desire of DOE to remove the canisters from the site at the earliest opportunity. Based on the above assumption and the current plan of storing the HLW on-site, the canisters would be in storage for a minimum of seventeen years at West Valley before shipments to a repository.

Another option being considered by DOE is the transport of the canisters to an alternate storage site prior to the time that they could be delivered to a repository. This action would allow for earlier decommissioning of the West Valley site. INEL and Savannah River are among the possible alternative storage sites.

TABLE J-1

PRODUCTION SCHEDULE AND REPOSITORY ACCEPTANCE SCHEDULE FOR HLW CANISTERS

	Canister Production Schedule		Repository HLW Acceptance Schedule[f]		Inventory of In-Storage Canisters Cumulative Total		
Year	Defense HLW[a]	West Valley HLW[b]	First Repository	Second Repository	Defense HLW	West Valley	Combined
1990	405[d]	150			405	150	555
1991	405	150			810	300	1,110
1992	405				1,215	300	1,515
1993	405				1,620	300	1,920
1994	405				2,025	300	2,325
1995	405				2,430	300	2,730
1996	405				2,835	300	3,135
1997	540				3,375	300	3,675
1998	540				3,915	300	4,215
1999	540				4,455	300	4,755
2000	540				4,995	300	5,295
2001	540				5,535	300	5,835
2002	540				6,075	300	6,375
2003	240				6,315	300	6,615
2004	240				6,555	300	6,855
2005	240				6,795	300	7,095
2006	315				7,110	300	7,410
2007	315				7,440	300	7,740
2008	515		187[c]		7,955	113	8,068
2009	515		433[e]		8,150	0	8,150
2010	515		800		7,865	0	7,865
2011	515		800		7,580	0	7,580
2012	515		800		7,295	0	7,295
2013	515		800		7,010	0	7,010
2014	515		800		6,725	0	6,725
2015	515		800		6,440	0	6,440
2016	515		800		6,155	0	6,155
2017	515		800		5,870	0	5,870
2018	515		800		5,585	0	5,585
2019	465		480		5,570	0	5,570
2020	410				5,980	0	5,980
2021	410				6,390	0	6,390
2022	410				6,800	0	6,800
2023	410				7,210	0	7,210
2024	410				7,620	0	7,620
2025	380			800	7,200	0	7,200
2026				800	6,400	0	6,400
2027				800	5,600	0	5,600
2028				800	4,800	0	4,800
2029				800	4,000	0	4,000
2030				800	3,200	0	3,200
2031				800	2,400	0	2,400
2032				800	1,600	0	1,600
2033				800	800	0	800
2034				800	0	0	0
2035							
	16,000	300	8,300	8,000			

[a]For defense HLW there is a conversion factor of 0.5 MTU (equivalent heat)/canister

[b]For West Valley HLW there is a conversion factor of 2.13 (equivalent heat)/canister

[c]First 640 MTU HLW allocated to West Valley

[d]Defense HLW production schedule obtained from Table 7.1 of "Perspective on Methods to Calculate A Fee for Disposal of Defense High-Level Waste in Combined (Civilian/Defense) Repositories", DOE/RL-86-10

[e]433 canisters is a sum of 113 West Valley canisters and 320 defense HLW canisters.

[f]From the Draft Mission Plan Amendment, January 1987

1.2 POSSIBLE ROLE OF TSCs IN WEST VALLEY SYSTEM

As mentioned above, the 300 West Valley canisters will be stored in an existing building at West Valley which has been adapted for storage, and ultimately will be shipped to the repository for disposal. Storage will begin in about 1990, long before the possibility that excess TSCs would be made available from utilities or elsewhere. Thus, TSCs are not a candidate for canister storage at West Valley. However, the possibility of delays in repository startup may increase pressures for canister removal from West Valley prior to repository startup. This possibility creates a potential role for TSCs in both transport and storage of canisters of West Valley waste and, depending upon the timing, such casks could be available from utility storage service. Even without early closure of the West Valley site, TSCs could be used to transport HLW canisters from West Valley to the repository. By the year 2008, when shipments to a repository would begin, some utilities may be in a position to provide TSCs to West Valley for this purpose. However, the designs of TSCs for spent fuel storage and transport are not optimized for HLW canisters. The HLW canisters are shorter than spent fuel assemblies by about five feet, and only four canisters would fit into a TSC. Also the spent fuel assembly basket would have to be replaced with a basket sized for HLW canisters, resulting in a significant reduction in avoided costs to DOE.

At most only a few TSCs would be needed to deliver canisters to the repository at the acceptance rate of 800 canisters per year for both West Valley and defense HLW. In such cases DOE could offer a payment to utilities for savings in the transport cask cost less the added cost of a new basket, disposal of the replaced basket, and the added cost of transport resulting from the use of a less efficient cask than one specifically designed for the purpose.

2.0 USE OF TSCs FOR DEFENSE WASTE

2.1 BACKGROUND

HLW will be solidified in canisters at Savannah River, Hanford, and Idaho. Production for HLW canisters at Savannah River is planned to begin in 1990, at Hanford in 1997, and at Idaho in 2008. The canisters that are produced at Savannah River will be stored in vaults which consist of shielded, air-cooled buildings holding up to 1,000 canisters each (two years production). Delivery of the canisters to the DOE repository is scheduled to begin in the year 2008.

Table J-1 shows both the production schedule for the defense HLW canisters as well as the projected repository acceptance schedule. The inventory of HLW canisters in storage peaks at 8,150 in the year 2009. The inventory declines from 2009 thru 2019 during which time the first repository is accepting canisters at a rate greater than the production rate. The inventory peaks again at 7,620 in the year 2024 due to a gap of five years between the last year of acceptance at the first repository and the first year of acceptance at the second repository. The gap is caused by a decision to evenly distribute the number of canisters delivered to each repository.

2.2 POSSIBLE ROLE OF TSCs IN DEFENSE WASTE SYSTEM

A total project cost of $105-million was estimated for three storage modules (Reference 3). This represents a storage cost of $35,000 per canister. DOE could offer a payment for the savings in storage cost less the cost of a new basket and the cost of disposal of the old one. The payment would be contingent on a utility's commitment to a delivery schedule consistent with DOE needs for the storage capacity. The savings from reduced handling of the canisters that would be stored in TSCs would increase somewhat the payment DOE could offer. Payments for TSCs used to transport defense waste to the repository were discussed in Section 1.2 of this Appendix.

3.0 CONCLUSIONS REGARDING THE USE OF TSCs IN CONNECTION WITH WEST VALLEY AND DEFENSE WASTES

TSCs previously used by utilities could conceivably be used for storage and transport of HLW canisters. In the case of West Valley wastes, utility-owned TSCs would not be available in time for storage of canisters, unless those canisters were to be moved from West Valley and stored elsewhere prior to disposal. However, utilities with TSCs could be in a position to deliver the casks to DOE for the transport of West Valley wastes. In the case of defense HLW, starting in 1998 some utilities may be in a position to deliver TSCs to DOE for storage of canisters as well as transport. However, a factor that reduces the attractiveness of utility-owned TSCs for storage and transport of HLW canisters in the DOE system is the non-optimum size of the casks, i.e., about one-third of the cask capacity would not be used due to the shorter length of the HLW canisters compared to spent fuel assemblies. A cask optimally designed for HLW canisters would be significantly more cost effective. For example, an optimally sized 135 ton rail cask could transport up to 10 canisters, thereby reducing the number of casks (and shipments) needed to deliver canisters in TSCs at a rate that meets the repository acceptance schedule.

As additional information becomes available on the storage and transport plans for West Valley and defense HLW, avoided costs in the DOE system in connection with such wastes can be estimated more accurately and an appropriate incentive schedule developed for delivery of TSCs by utilities from at-reactor storage of spent fuel.

4.0 REFERENCES FOR APPENDIX J

(1) U. S. Department of Energy, Perspective on Methods to Calculate a Fee for Disposal of Defense High-Level Waste in Combined (Civilian/Defense) Repositories, DOE/RL-86-10, December 1986

(2) U. S. Department of Energy, Draft Mission Plan Amendment, DOE/RW-0128, January 1987

(3) U. S. Department of Energy, The Defense Waste Management Plan, DOE/DP-0015, June 1983

ORNL/Sub/86-SA094/2
ORNL/Sub/86-SA224/2
HR/JAI-289

INTERNAL DISTRIBUTION

1. C. R. Attaway
2. A. G. Croff
3-7. C. W. Forsberg
8-12. E. J. Frederick
13. I. G. Harrison
14. E. K. Johnson
15. D. S. Joy
16. S. B. Ludwig
17. L. G. Medley
18. J. R. Merriman
19. K. J. Notz
20. W. H. Pechin
21. J. E. Ratledge
22. R. R. Rawl
23. M. J. Rennich
24. T. H. Row
25. J. H. Saling
26. L. B. Shappert
27. M. W. Wankerl
28. R. G. Wymer
29. H. R. Yook
30. Central Research Library
31. Document Reference Section
32-33. Laboratory Records
34. Laboratory Records - RC

EXTERNAL DISTRIBUTION

DOE - ORO, P. O. Box E, Oak Ridge, TN 37831

35. Office of Assistant Manager, Energy Research and Development.

DOE - Office of Civilian Radioactive Waste Management, Forrestal Building, 1000 Independence Avenue, S.W., Washington, DC 20585

36. L. H. Barrett
37. A. B. Brownstein
38. J. H. Carlson
39. M. W. Frei
40. H. J. Hale
41. G. Hartkopf
42. S. H. Kale
43. K. A. Klein
44-47. T. D. Nguyen
48. D. E. Shelor
49. R. Stein
50. E. Svenson
51. E. Wilmot

DOE - Office of Nuclear Energy, 19901 Germantown Rd., Germantown, MD 20874

52. J. A. Tori

DOE - Chicago Operations Office, 9800 S. Cass Ave., Chicago, IL 60439

53. C. Boggs-Mayes

DOE - Idaho Operations Office, 785 DOE Place, Idaho Falls, ID 83402

54. M. J. Barainca

DOE - Nevada Operations Office, P. O. Box 14100, Las Vegas, NV 89114

55. L. Skousen

DOE - Oak Ridge Operations, P. O. Box E, Oak Ridge, TN 37831

56. P. J. Gross
57. M. M. Heiskell
58. S. S. Perkins

DOE - Richland Operations Office, P. O. Box 550, Richland, WA 99352

59. D. Kenyon

Pacific Northwest Laboratory, P. O. Box 999, Richland, WA 99352

60. G. H. Beeman
61. L. L. Clark
62. B. M. Cole
63. R. L. Engel
64. R. Heineman
65. P. N. McDuffie
66. R. W. McKee
67. G. W. McNair
68. M. R. Shay
69. M. White
70. T. Wood

Sandia National Laboratory, P. O. Box 5800, Albuquerque, NM 87185

71. G. Allen
72. A. W. Dennis

Battelle/OSTP, 505 King Ave., Columbus, OH 43201

73. D. Dippold
74. P. Hoffman
75. W. Pardue
76. R. W. Peterson
77. K. Yates

Edison Electric Institute, 1111 19th Street NW, Washington, D.C. 20036

78. S. Kraft, UNWMG

EG&G Idaho, Inc., P. O. Box 1625 Idaho Falls, ID 83415

79. J. Leatham

Electric Power Research Institute, P. O. Box 10412, Palo Alto, CA 94303

80. R. W. Lambert
81. R. Williams

E. K. Johnson Associates, Inc., 10461 White Granite Dr., Suite 204, Oakton, VA 22124

82. E. R. Johnson
83. N. B. McLeod

H&R Technical Associates, 575 Oak Ridge Turnpike, Oak Ridge, TN 37831

84-87. R. Emmett
88. W. R. Rhyne

LeBoeuf, Lamb, Leiby & McRae, 1333 New Hampshire, NW, Suite 1100, Washington, DC 20039

89. L. Trosten, NTG

Nuclear Assurance Corp., 6251 Crooked Creek Road, Suite 200, Norcross, GA 30092

90. W. J. Lee

Science Applications Int. Corp., 101 Convention Center Dr., Las Vegas, NV 89109

91. R. Morrisette

U.S. Council For Energy Awareness, 1776 I St., NW, Suite 400, Washington, D.C. 20006

92. J. R. Siegel

Weston, 955 L'Enfant Plaza, SW., Eight Floor, Washington, D.C. 20024

93. J. DiNunno
94. W. Wowak
95-334. Given distribution as shown in DOE/OSTI under UC-71 and UC-85 (240 copies, including those for NTIS.