EPRI

Feasibility Evaluation of Universal Container System

Presentation to

Nuclear Waste Technical Review Board

January 6, 1993

by

R. F. Williams

Electric Power Research Institute

HIGH LEVEL WASTE
AND
SPENT FUEL PROGRAM

based on

Research Project RP2717-14
performed by

E.R. Johnson Associates, Inc

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Summary

- Perspective on the universal container (UC) system
  - EPRI study overview
  - Simplified evaluation
- Major factors in evaluation
  - Waste package and engineered barrier system
  - Spent fuel acceptance, MRS, and transportation
  - Repository changes
  - At reactor storage
  - A phased approach to implementation
- Conclusion

Changes Leading to Universal Container System

- Consideration of more robust multi barrier waste disposal package could have major benefit
  - Potential for better public acceptance.
  - Potential simplification of MRS and transportation
- "Pre packaging" improves ability to ship fuel from shutdown reactors without use of the spent fuel pool.
- A sealed package has potential benefits in simplification of operations between the reactor and repository
- Adoption of ramp (decline) repository access permits larger packages to be considered
  - Steel cable and mine hoists limited waste package size with shaft access to repository

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Feasibility Evaluation
RP 2717-14

- Contractor- E.R. Johnson Associates. Inc
  - Barrie Mcleod and David Jones
  - Period of performance: June 1991 to July 1992
- Objectives:
  - Present a preliminary evaluation of universal container system
  - Identify issues to be addressed in a more detailed study
- Focus: Evaluation of the multi element storage container (MESC) and multi purpose cask (MPC). Economic evaluation, and thermal loading issues used the majority of the resources
  - The sealed MESC appeared to have major advantages because of time value of money and consistency with current storage practice.

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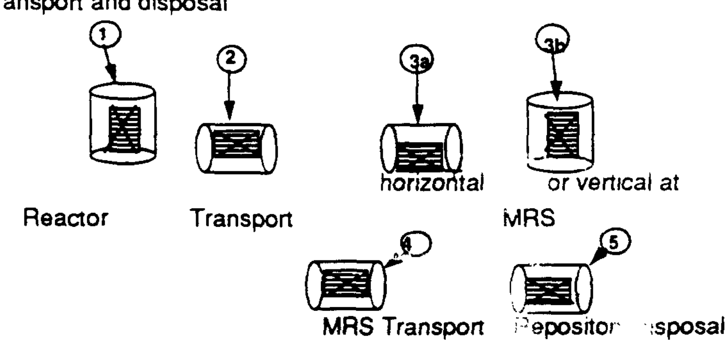
Universal Container-MESC option

- Concept- The thin wall sealed "MESC" package is a central "nugget" that helps minimize fuel handling and simplifies storage, transport and disposal



Different overpacks, 1-5. are supplied tailored to th- unction amples: Transportation-impac: resistance; storage -low cost shielc disposal-shield and corrosion resistance

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Lessons from Engineering Studies

- Don't be misled by apparent precision of estimates. **Scenarios, hardware concepts**, and **costs are highly uncertain**.
  - Difficult to project cost 5 years. Almost impossible over 40 years.
  - Three figures are carried to assist in checking consistency.
- We examined end of spectrum cases to obtain bounds on results.
  - 100% MPC and 100% MESC scenarios are examples.
- Lessons learned and insights from the study are **more** important than the detailed results.
  - Philosophy: Strike a balance and don't try to prove all conclusions with detailed assessment. But check details
- Purpose today to review results but **emphasize the lessons** from the cost and technical evaluation, **not the specific numerical results which will surely change** as the UC system is evolved.

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Simplified evaluation - An overview

- Waste package and engineered barrier system
  - Potential major cost increases anticipated
  - Challenge: how to minimize
- Spent fuel acceptance and transfer- MRS and transportation
  - Reduced shipments and simplified siting; total cost is small
- Repository system changes
  - Reduced number of packages. Significant changes in mining and operations.
- At reactor storage
  - Easier transfer, Improved ability to ship from shutdown reactors.
- A phased approach to implementation
  - Risks are different for UCS but appear manageable

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Waste System Costs

Cost category $ Billions	Adjusted Reference Repository System**	MESC	Savings	Item this mtg.
Development & Evaluation	$11.5	assume no change	.0	
Benefit Payments	.7	no change	.0	
MRS Facility	1.8	1.6	.2	3
Transportation	2.8	2.7	.1	
Repository Facilities	7.0	5.3	1.7	2
Waste package (Defense HLW)	.4	.4	.0	
Waste Package(spent fuel)	4.2.**	7.3	-3.1	1
subtotal DOE cost	$28.4	29.5	-1.1	
At reactor storage (post 1998)	.2	.0	.2	
Post shutdown reactor costs	2.600	.300	2.3	4
Total combined system cost	31.2	29.5	**$ 1.6**	

Note: Waste package cost adjusted from $ 1.4 Billion to $ 4.2 Billion for 3 inch DCI shielded, 1 cm Incoloy-825 2 **MTU waste package.
$1.6 Billion should be considered "breakeven" at this stage of study.

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Caveat

It was beyond the scope of this study to deal with the potential effect of the UC system on the roughly $ 11.5 Billion Development and Evaluation costs. About $ 5 Billion is spent.

D & E costs are heavily controlled by factors such as near term schedule, licensing, site characterization costs and exploratory shaft designs.

The present study focuses on hardware and operational costs of the at-reactor system, MRS, and transportation and repository system.

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1. Waste Package costs

Package Description	Capacity (MTU)	Unit Cost	Number	Total ($ Billions)
1. Thin wall Type 304 SS	2	$31,000	43,600	$ 1.4
2. Thin wall Incoloy 825	2	63,000	43,600	2.7
3. Partial shield Incoloy/DCI	2.	96,000	43,600	4.2
4. Incoloy / ceramic (C-14)	2.5	213,000	34,700	7.4

Note a: Typical changes to package since SCP

Note b: A $100 per kg fuel package. ($ 1 million 10 tons fuel) $ 8.6

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Waste Package Sizes

The MESC and MPC reference package designs evaluated in this study. Economy of scale is significant to cost. There is room for further optimization of both MPC and MESC.

Package Description.	Avg.Cap. MTU	Unit cost cost	Number for 86,000	Total cost $ Billion
Small MPC (9 PWR)	4.1	$ 600 K	21,000	12.5
Reference MPC (21PWR)	**8.7**	**680**	**9,940**	**$ 6.8**
Large MPC (32 PWR)	13.6	800	6,400	5.1
Smaller MESC (15 PWR)	6.7	680	12,900	8.8
Reference MESC (24 PWR)	**10.3**	**860**	**8,430**	**7.3**

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Universal Container-MPC option

- The multi purpose cask (MPC)-storage, transport, disposal
  - Initially more vulnerable to uncertainties that are resolved later in licensing. (Example: Future transport, future corrosion barrier)
  - MPC has higher initial capital cost ($ 1.5 Million to $ 500, 000)
- Study used cost bases consistent with German experience in serial cask production.
  - About 400 casks were produced for storing fuel for decommissioning the THTR pebble bed reactor at $ 5 per kg.
  - There is considerable room for optimization of the MPC and the transport overpack and repository disposal overpack.
- There are a spectrum of designs between the MESC and MPC that differ in the thickness of the inner containment boundary.

Universal Container-Spent Fuel Assemblies

- Observations
  - Transfer of spent fuel by "conventional means" is a permitted contract option. Truck casks will be required at some reactors. Intermediate size packages may be preferred at other stations.
  - Some assemblies have a few rods with small defects of little significance to transfer and disposal. Others may have defects of sufficient size to require special cannisters.
  - Intermodal transport (barge to rail) and intermodal loading (small cask to large cask transfer) likely to be the preferred solution for some situations.
- Options to assist in reducing the handling of individual assemblies
  - Small cask to large cask transfer- NP7459
  - High Integrity Impact Limiter-NP-7528

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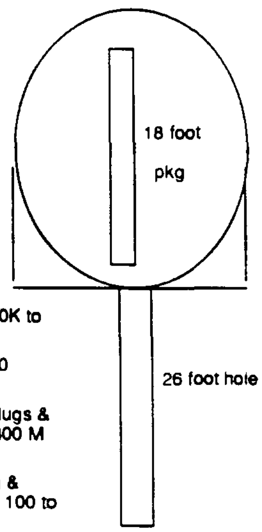
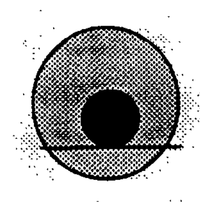
2. Repository Factors

22 Foot Diameter



Smaller diameter - Easier emplacement



- 150 Miles $ 500K to $ 1M per mile
  - $75 to 150 Million
  - Shields plugs & holes $ 300 M
  - Reduced tunnelling & backfill $ 100 to $ 200 M

- Potential cost only 30 to 40 % of ref
  - Savings $0.5 to $ 1.0 Billion

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Repository Factors

- Savings in many small items result in repository cost being reduced from $ 6.9 Billion to $ 5.3 Billion
  - The real cost effect requires more engineering study
- Partial list of key factors- To be resolved by detailed DOE design
  - What size package can be emplaced? 60, 100, 120 tons?
  - What tunnel diameter for the emplacement drifts?14 to 30 ft.
  - What thermal load, rock stress, period before backfill?
  - What mechanical requirements on package during handling?
  - What are operational effect of long period of repository heating?
- My personal engineering judgement- Savings can be made. Magnitude is very uncertain.

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3. Transportation and MRS

- Study results-
  - Total cost of MRS and Transportation about $ 4.2 Billion
  - Study suggests we might save about $ 300 Million
- Lessons and Observations
  - In this case a significant quantity of fuel(45%) was handled with conventional rail and truck casks, so conventional cask fleets and handling facilities were required. (1 MRS line)
  - At present transportation and MRS costs do not appear to be large enough to drive the total system cost tradeoffs.
  - The **effect on public acceptance** in terms of fewer shipments, and more robust disposal package is as significant as the cost in the opinion of this engineer.

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4. At Reactor Storage

- Background
  - Recent experience indicates the availability to shutdown the spent fuel pool and give up the Part 50 NRC reactor license has a strong effect on costs at shutdown reactors.
  - The ability to store at reactor and rapidly ship off site during the post shutdown period has a significant effect on costs
    - -- Inter utility equity issues suggest shutdown reactor fuel should not displace operating reactor fuel in the acceptance sequence.
  - Offsite shipment of shutdown reactor fuel at the presently allocated time was estimated to save $2.3 Billion. This results from roughly 1100 reactor years of reduced staffing from earlier closure of the spent fuel pool.

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5. Implementation Strategy

	Phase 1	Phase 2	Phase 3	Phase n
	1992-6	1996-2002	2003-10	

- Phase 1- Accept existing fuel types plus MPC plus MESC.
  - Move to license for storage and transportation. Set envelopes that will accommodate future changes
  - Accept the risk that some MESC and MPC may not be repository capable
- Phase II- A mark II design for MESC and MPC that is likely to be repository acceptable.
  - Reduced numbers of truck and conventional rail casks
- Phase III- Repository requirements confirmed.- Improved designs

Conclusion

- EPRI evaluation found the UC system attractive
- Major advantages included
  - Simplification and reduced handling due to sealed containers
  - Storage advantages at reactors and at MRS
  - Potential for repository savings
  - Savings in more rapid offsite transfer at shutdown reactors, with transfer not requiring the use of the spent fuel pool.
  - Minimization of the costs of the more robust package.
- Preliminary evaluation encouraged a DOE study, and adoption of the UC system as a spent fuel acceptance option.

Back Up charts

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Present Value of System Costs

Cost Category	1990 reference Repository System	adjusted ** Ref System	PV @3%.
Development & Evaluation	$ 11.5	$ 11.5	$ 8.4
Benefits Payments (State & local)	.7	.7	.3
MRS Facility	1.9	1.8	.9
Transportation	2.8	2.8	1.1
Repository (except waste package)	7.0	6.9	2.5
Waste Package	1.7	4.6**	1.5
Sub Total	$ 25.6	$ 28.4	$ 14.7
Utility at reactor storage	.2	.2	.1
Post shutdown Rx Costs	2.6	2.6	.9
Total	$ 28.4	$ 31.2	$ 15.7

**Note: Waste package cost adjusted from [illegible].4 Billion to $ 4.20 Billion to reflect the cost for 3 inch DCI shielded, 1 [illegible] Incoloy-825 2 MTU package.

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Waste System Costs

Cost category $ Millions	Adjusted Reference Repository System**	MESC UC System	Savings UC from Adj Ref.
Development & Evaluation	$11,508	asm no chge	0
Benefit Payments	657	no change	0
MRS Facility	1,862	1,664	198
Transportation	2,803	2,680	123
Repository Facilities	6,979	5,306	1,673
Waste package (Defense HLW)	400	400	0
Waste Package(spent fuel)	4,190 **	7,276	-3,086
subtotal DOE cost	$28,399	29,491	-1,092
At reactor storage (post 1998)	200	0	200
Post shutdown reactor costs	2,500	300	2,300
Total combined system cost	31,199	29,491	1,608

**Note: Waste package cost adjusted from $ 1.356 Billion to $ 4.190 Billion to reflect the cost for 3 inch DCI shielded, 1 cm incoloy-825 2 MTU waste package.

The overall incentive, $1.6 Billion in this case, could easily be viewed as near breakeven.

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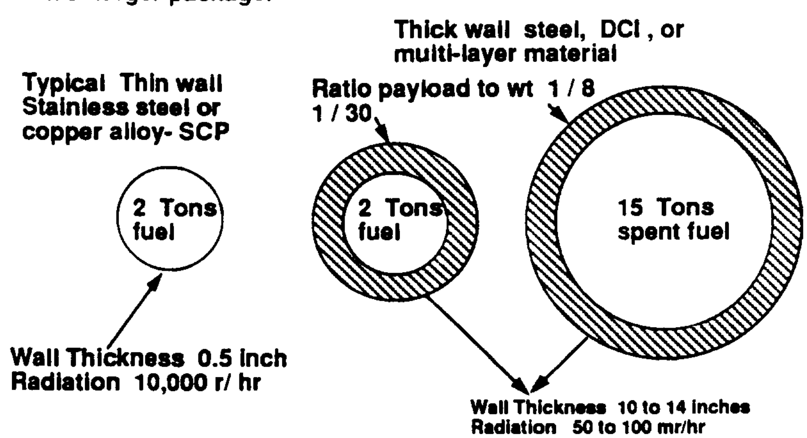
Package economy of size

When a more costly (or robust) package is considered, cost is reduced with a larger package.



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Technic Issue Areas

- Repository Thermal loading
  - Operational Issues- Access & Equipment in drifts
  - Thermal limits before backfill
  - Waste package and spent fuel temperature limits
    - -- UO2 temperature limit to avoid becoming U308
    - -- Cladding temperature limits
- Utility interface and MESC design criteria limits
  - Criticality / Burnup credit
  - Structural requirements/ g forces etc for transport
  - Closure- welding or bolting; welded currently licensed

Technical Issues-2

- Waste Package licensing validations
  - Corrosion lifetime/validation- Recall NAS review 1978-80 investigating borosilicate glass as a waste form.
  - Experimental validation methods
  - Analogs for metals and ceramics
  - Characterization of corrosion environment
- Mechanical Design/Structural loading
  - Storage, transport, disposal will add some requirement, likely increasing costs for storage.
  - HLW emplacement and accident loads:need TBD

Technical Issues-3

- System Integration related issues
  - Configuration management
  - Closure & welding

Appendix

Backup Information from the Feasibility Evaluation

R.F. Williams

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January 6, 1993

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Technical Issue Areas

- Repository Thermal loading
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Technical Issues-3

- System Integration related issues
  - Configuration management
  - Closure & welding

Backup information from the Feasibility Evalution

- Universal container technical issue areas
- Detailed cost breakdown-repository and MRS
- Text of Executive summary- EPRI study
- NP-7459 Conceptual Design for an Onsite Spent Fuel Transfer System, Sept 1991
- NP-7528 Conceptual design of a High integrity Impact limiter....September 1991

Repository and Waste Package Cost Factors

Federal Waste Mgmt Cost Category	Adj Ref. System	MPC System	MESC System
Waste Handling Building			
Construction	230	100	100
Operations	792	396	396
Decommissioning	22	10	10
subtotal	1,044	506	506
Surface support Facilities			
Radwaste	83	21	21
Maintenance	296	256	256
Other Facilities	1,539	1,540	1,540
subtotal	1,918	1,817	1,817
Subsurface Excavation			
Shaft and pillar	19	19	19
Emplacement Panels	553	365	349
Borehole development	491	142	142
Excavated Materials Hndl	63	43	41
General Maintenance	160	160	160
Spent fuel emplacement	233	123	112
Defense HLW emplace.	97	97	97
Performance Confirmation	4	4	4
Backfill shafts and ramps	12	12	12
Backfill Panels	139	89	89
subtotal	1,771	1,054	1,021
Underground Facilities			
Mining Equipt Maint	590	336	306
Other support Facilities	450	450	450
Utilities	141	141	141
Monitoring	236	236	236
subtotal	1,417	1,163	1,133
	=====	=====	=====
Grand Total Repository	6,979	5,369	5,306
Waste package/MPC/MESC	4,590	7,196	7,676

Summary of MRS and Transportation Cost Factors

Federal Waste Mgmt Cost Category	Adj Ref. System	MPC System	MESC System
MRS Scenario 1- 100% at reactor MESC or MPC			
Construction	354	282	282
Operation	1,484	845	974
Decommissioning	24	6	14
subtotal	1,862	1,133	1,270
Transportation Scenario 1- 100% at reactor MESC or MPC			
Shipping & Security Rx	513	324	284
From MRS	571	952	779
Cask/Overpack Capital Rx	373	114	307
from MRS	132	101	190
Cask/Overpack Maint.	243	64	52
from MRS	92	46	40
Cask Maint Facility	582	291	291
Defense HLW Transp	297	297	297
Subtotal	2,803	2,189	2,240

Summary of MRS and Transportation Cost Factors

MRS Scenario 2- 55% At Reactor

Federal Waste Mgmt Cost Category	Adj Ref. System	MPC System	MESC System
Construction	354	304	331
Operation	1,484	930	1,313
Decommissioning	24	9	20
subtotal	1,862	1,243	1,664

Transportation Scenario 2- 55% at Reactor

Federal Waste Mgmt Cost Category	Adj Ref. System	MPC System	MESC System
Shipping & Security Rx	513	513	513
From MRS	571	952	779
Cask/Overpack Capital Rx	373	129	181
from MRS	132	101	190
Cask/Overpack Maint.	243	128	243
from MRS	92	46	40
Cask Maint Facility	582	437	437
Defense HLW Transp	297	297	297
Subtotal	2,803	2,603	2,680

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RP2717-14

EXECUTIVE SUMMARY

Universal Container System

The purpose of this report is to present a preliminary evaluation of the Universal Container System (UC system), and to identify issues that must be addressed by the utility industry, the Department of Energy, and the U.S. Nuclear Regulatory Commission in order to permit a decision to be made regarding the universal container as a spent fuel storage and transfer, transport, and disposal alternative to the current spent fuel management and disposal system.

As presently envisioned, the UC system is an integrated system in which spent fuel assemblies would be loaded and sealed in multi-assembly containers at reactor sites or at the first DOE receiving facility. They would thereafter be stored, transported and finally placed in a repository for final disposal without ever reopening. This class of containers include the Multi-Purpose Cask (MPC), which is fully shielded, and the Multi-Element Sealed Canister (MESC), which makes interim use of various types of low cost shielding until just before final repository disposal.

The MPC form of the sealed multi-assembly container is a thick-walled, fully-shielded container, holding 6 to 10 MTU of spent fuel. The cask body can be made of lead and stainless steel, or monolithic ferritic steel, or ductile cast iron based on cost and transportation and disposal licensing considerations. The MPCs are similar to casks used for storage at Virginia Power, or for rail transport of spent fuel in the U.S. The MESC form of the sealed multi-assembly container is a relatively thin walled spent fuel storage basket containing 6 to 10 metric tons of spent fuel similar to the MESCs in the horizontal concrete storage module system (NUHOMS) or the vertical concrete storage cask (VCSC). For final disposal, the corrosion protected MPC and the shielded, corrosion protected MESC are placed horizontally in repository drifts, without the need for tunnel floor boreholes. Because of size and weight, both MPC and MESC disposal packages require a declining ramp for access to the repository emplacement horizon.

Evaluation of the UC system consisted of technical, operational, cost and institutional comparisons of the MPC and MESC versions of the UC with the current utility and DOE waste management and disposal system. The current system can be characterized as a series of system functions (storage, transport and disposal) in which the point of transfer between functions is, as a defacto design policy, the smallest common unit of waste, the individual fuel assembly. The containers needed for each function are thus optimized for that function alone, and are unloaded for transfer to the next step in the process. Until recently, the reference waste package was a small inexpensive, thin-walled container, designed for emplacement in borehole drilled in the floor of the repository emplacement drifts. Recently, more robust borehole packages have been considered.

Technical, Operational and Cost Comparison

The evaluated benefits of using the UC system include major reductions in waste item handlings, and improved integration between the utility and DOE systems and within the DOE system. In addition, the very robust UC waste packages represent a major improvement in the engineered barrier and have the prospect of reducing the impact of uncertainties in the natural barrier system. The offset of these benefits is some uncertainty as to the final licensability of the small fraction of containers/waste packages that must be loaded prior to the final licensing of the waste package.

With respect to costs, the aforementioned handling and operational improvements of the UC system result in a reduction of $2.0 to $2.9 billion in the total life cycle costs other than waste package costs. The UC system waste package costs exceed the borehole waste package costs by $2.6 to $3.1 billion, such that the net cost difference within the DOE portion of the system ranges from $0.3 billion in favor of the UC system to $1.1 billion in favor of the current system. However, when the $2.5 to $2.8 billion of estimated utility system savings with the UC system is included, the estimated overall system costs favor the use of the UC system by $1.4 billion to $3.1 billion which is 5% to 10% of total system costs. Within the UC system, the MPC system is less expensive than the MESC system by the order of about $1 billion. The bases for these overall cost differences are further described in the following.

Combined System Cost

The cost of the UC system was compared in nine major cost categories for a single repository system disposing of 86,700 MTU of spent fuel. The waste package cost in the reference system was adjusted to the midrange of current cost estimates for a nominal 2 MTU waste package with robust corrosion barriers. Results for one of several cases, the UC system fuel utilizing MESCs, are shown. The MESC option minimizes near term capital costs, and permits the selection of the shielding and corrosion barrier material to be delayed until after repository licensing.

Cost Category $ Millions	Adjusted Reference Repository System	MESC UC System	Savings UC From Adj. Ref.
Development & Evaluation	$11,508	Assume No Change	0
Benefit Payments	657	No Change	0
MRS Facility	1,862	1,664	198
Transportation	2,803	2,680	123
Repository Facilities	6,979	5,306	1,673
Waste Package (Defense HLW)	400	400	0
Waste Package (Spent Fuel)	4,190	7,276	-3,086
Subtotal DOE Cost	$28,399	$29,491	$-1,092
At-Reactor Storage (Post 1998)	150	0	150
Post Shutdown Reactor Costs	2,600	300	2,300
Total Combined System Cost	31,149	29,491	1,358

*Note: Waste package cost adjusted from $1.356 billion to $4.190 billion to reflect the cost for 3 inch DCI shielde[illegible] [illegible]om In[illegible]y-825 2 MTU waste package.

Repository, MRS, Transportation and At-Reactor Costs

Review of the total combined system cost shows that $2 to $3 billion savings in the non-waste-package portion of the DOE waste management system. There are potential reductions in mining costs, the costs of waste package emplacement and simplifications to the MRS and the transportation system. In addition, the ability to remove and store the spent fuel inventory from the pool of a reactor which has shutdown, and avoid the operating costs of the pool and the maintenance of the reactor operating license and staff, has a potential $2.3 billion advantage to utilities, although this potential avoided cost is 10 to 30 years in the future.

It should also be noted that the scope of this study did not permit evaluation of the effect of the UC system on potential development and evaluation costs. While approximately $5 billion in t[illegible] cost category has been spent in the period 1983 to 1992, approximately $6.5 b[illegible] [illegible]n remai[illegible] to be spent in securing a repository construction permit. It was [illegible]eyond the scope of the st[illegible]y to determine the effect of the UC system [illegible]n progra[illegible] [illegible]ont end costs such as site characterization, exploratory shaft facility, and license a[illegible] [illegible]cation.

Borehole Waste Package

The present borehole reference waste package design holds about 2 MTU spent fuel, and is a thin wall Type 304L stainless steel design with a wall 3/8 inch thick, diameter of 28 inches and a length of 16 feet. Total cost for 43,600 packages is $1.35 billion. This increases to $2.7 billion when fabricated from Incoloy-825, or $3.1 billion of high purity copper is used. To provide some shielding the adjusted reference system package shown above includes a 3 inch thick DCI shield, with the total package cost estimated at $96,000 or $4.190 billion for the current program. A recent presentation to the EPA Science Advisory Board showed a 2.5 MTU package with a ceramic layer at a unit cost of $213,000, or a total program cost of about $7.4 billion for a single repository system disposing 86,700 MTU spent fuel. Thus the cost uncertainty for the smaller (2 to 2.5 MTU) package is in the range of $1.35 to $7.4 billion depending on the corrosion barrier and shielding finally selected.

MESC and MPC Packages

The study evaluated a number of different capacity MPC and MESC waste packages, because the container cost per MTU decreases approximately as the inverse square root of the payload. The most economic waste package is thus the largest package that can be loaded, transported, emplaced, and not exceed repository thermal limits. The reference MPC and MESC operations had waste package costs of $6.8 and $7.3 billion respectively using DCI, a low cost structural shielding material. The robust MPC or MESC costs assume economies of scale are achieved with production of 250 casks per year, such that costs are reduced to about $500,000 for a nominal 100 ton metal cask, from about $900,000 for small procurements. The costs of the MESC and MPC are thus likely to be in the range of $6 to $9 billion, depending on whether the lower cost DCI can be licensed, whether shielding thickness can be reduced below 13 inches, the thickness and cost of the corrosion barrier, package weight and thermal limits, and other design tradeoffs.

The cost of an expensive alloy such as Incoloy-825 as a corrosion barrier has a large effect, particularly in small packages. The addition of a 1 cm Incoloy-825 as a corrosion barrier adds about $1.7 billion to the MPC or MESC system. The same 1 cm barrier on 43,600 2 MTU packages adds about $3.0 billion. Each reference package in this study has a 1 cm Incoloy-825 corrosion barrier.

Overall Operational and Cost Summary

In summary, the basic operational tradeoff that would be made when using MPC or MESC-based systems can be characterized as trading off the design and operational problems of remotely and repeatedly handling over 280,000 individual radioactive fuel assemblies, for the design and operational problems of the contact handling of less than 10,000 shielded large heavy packages. The corresponding cost tradeoff can be characterized as trading off the costs of repeatedly handling and containing many individual fuel assemblies, for the costs of fabricating large metal casks in a conventional (non-radiation) industrial environment. The overall cost conclusion, which reflects uncertainties in both the realization of system operational benefits. and the ultimate design and cost of waste packages and corrosion barriers. is that it is probable that total combined utility and DOE system costs will be less when MPC or MESC-based containers are used, as compared to the current adjusted reference system.

Technical and Programmatic Factors

Recognizing the uncertainties in the disposal system life cycle costs and schedule, the evaluation of advantages and disadvantages of the major features of the UC system can be equally important in arriving at a conclusion on the overall merit. There are a number of technical and programmatic factors that have received preliminary review.

Waste Package Thermal Limits

The thermal analysis indicates packages may require 30 to 50 years of post discharge cooling, part of which could be in the repository emplacement drift. before the repository drift can be closed and backfilled. Additional study of this issue is required because of the strong influence of repository thermal limits on feasible package size, and the significance of the larger package sizes to the preferred reactor storage system sizes.

Waste Package Performance Differences

It is believed that the very robust MPC/MESC waste package design assumed in this study, although more expensive, would also have superior disposal isolation performance in comparison with the smaller borehole package. The substantially unshielded borehole waste package thus appears considerably more vulnerable to major cost increases caused by an improving definition of performance requirements as waste package design and licensing progresses. Thus, a critical comparison of the waste packages should focus at least as much on the smaller unshielded waste package as on the MPC/MESC waste package.

Transition to the UC System

There is uncertainty in the final design of the MESC or MPC until the repository package is licensed. Present results indicate that because the majority of spent fuel is stored in water pools, the spent fuel inventory that will be packaged for dry storage prior to repository license approval will amount to 7,000 to 10,000 MTU. This is only 10 to 15% of the fuel that will ultimately be disposed. The remaining 85% can thus adopt the licensed repository waste package at the time of transfer to DOE or dry storage.

Operational Benefits

The operational benefits of sealed containers in storage, transport and disposal appear to have a high probability of realization, independent of any container changes that may be required as a result of waste package licensing, because these benefits derive primarily from the shielded container concept, as distinguished from its specific design.

Licensing Issues

The present NRC requirements for the waste package are specified in three different regulations for storage, transport and disposal, and administered by three different offices within NRC. Some streamlining of this activity for MPC or MESC UC licensing would be in the public interest in order that these potentially beneficial technologies would not be at a disadvantage in the safety review process.

Institutional Factors

Although it is a somewhat intangible factor, it appears that the simplicity of the MPC concept, including its massive robust nature and the intuitive association of robustness with safety, gives the MPC-based system the greatest prospect of public credibility. This factor may [illegible] the greatest significance to the public in the vicinity of MRS or repository sites. The sealed heavily shielded MESC may also reap these benefits to a somewhat sma[illegible] degree.

Conclusions and Recommendations

The results of this study indicate that the Universal Container system is inherently more simple and better integrated than the current system, and probably has a lower overall cost, particularly if there are further delays in repository startup. The Universal Container system also results naturally in a very robust waste package, enhancing the prospective performance of the engineered barrier and making overall barrier performance less sensitive to uncertainties in the natural barrier.

Although these results are promising, this evaluation is not claimed to be of sufficient depth to justify an immediate recommendation to adopt the Universal Container using MPCs or MESCs as a co-equal alternative within the current DOE program. Therefore, the primary recommendation from this work is that an early and more definitive evaluation be conducted to support a formal DOE decision on the adoption or rejection of the sealed container technologies as co-equal alternatives to the current system. This evaluation, which would include the specific issues identified above, would ideally include the participation of DOE transportation, storage, waste package and repository personnel. The resulting decision would provide a reasoned and documented basis for proceeding with, or rejecting these technologies. In the event of including either or both of these technologies as co-equals with the current system, the subsequent application of systems engineering principles will provide the systematic reasoned approach necessary to support the ultimate decision between MPC or MESC-based systems and the current system.

Conceptual Design for an On-Site Spent-Fuel Transfer System

NP-7459
Research Project 2813-25

Final Report, September 1991

Prepared by
TRANSNUCLEAR, INC.
Two Skyline Drive
Hawthorne, New York 10532

Principal Investigators
C. W. Pennington
T. J. Neider
G. V. Guerra
K. V. Margotta

Prepared for
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
R. W. Lambert

High Level Waste Program
Nuclear Power Division

REPORT SUMMARY

Conceptual Design for an On-Site Spent-Fuel Transfer System

Use of an on-site small-cask transfer system can enable many plants with restricted plant cask handling capability to store fuel in large, efficient storage systems. This project developed conceptual designs for both a wet and a dry transfer system and showed them to be technically feasible and cost-effective.

INTEREST CATEGORIES

Radioactive waste management
Light water reactor fuel

KEYWORDS

Spent-fuel storage
Radioactive waste management
Waste transport

BACKGROUND Utilities need to store spent fuel on site until DOE will accept it for disposal sometime after 1998. The technologies developed for storing fuel in a dry environment outside the reactor storage pool generally use very large, heavy casks or canisters in an effort to increase capacity and improve economics. However, because many plants have crane or space limitations, these efficient, large systems cannot be used. This project explores the feasibility of using a small-cask transfer system to overcome existing plant limitations.

OBJECTIVES

- To evaluate a range of potential designs for small-cask transfer systems.
- To produce conceptual designs for the preferred concepts and to perform operational and economic analysis in sufficient depth to determine feasibility.

APPROACH Researchers screened a range of wet and dry small-cask transfer systems for technical and economic feasibility. They then selected the most promising dry and wet concepts and developed conceptual designs for them. The designs were then analyzed for licensability, operational considerations, technical complexity, and cost. The designs were measured against criteria developed in a previous EPRI report, NP-6425, *Design Considerations for On-Site Spent-Fuel Transfer System*.

RESULTS Both the dry and the wet conceptual designs were judged technically and economically feasible and met the design criteria of report NP-6425. The wet system was deemed to be less complex and of slightly lower cost than the dry system. For the dry system, a top-loaded cask with a bottom unloading plug valve was designed. The most difficult design challenges were providing adequate seals during the transfer operation and keeping the weight of the four-element PWR transfer cask below the desired 30-t limit.

EPRI PERSPECTIVE Although this small-cask transfer system was designed to move fuel from a storage pool to dry storage, the concept has the potential for much broader application. Utilities may use it to provide their dry storage system with recovery capability in case the reactor is shut down or decommissioned. Additionally, the concept may be used to transfer fuel from on-site storage casks to DOE transport casks at the time DOE begins to receive fuel. DOE may also have use for the concept as a tool to enable earlier or more flexible access to an approved monitored retrievable storage site. To verify the overall practicality of the concept, follow-up work, including detailed design, fabrication, and demonstration, is recommended.

PROJECT

RP2813-25

Project Manager: Ray Lambert

Nuclear Power Division

Contractor: Transnuclear, Inc.

For further information on EPRI research programs, call EPRI Technical Information Specialists (415) 855-2411.

Section 11

CONCLUSIONS

Small cask on-site fuel transfer systems can offer utilities an economical, safe and licensable method for taking advantage of large storage casks. Both the dry system and the wet system can allow a utility to use large spent-fuel storage casks economically.

The transfer systems are particularly applicable to plants which have restricted crane capacity, or where other major plant modifications would be required to load the large storage casks directly.

Both systems meet the requirements of EPRI Report NP-6425, "Design Considerations for On-Site Spent-Fuel Transfer Systems." However, this report concludes that the target 30-ton weight limit recommended in NP-6425 for a standard size be increased to between 35 and 40 tons, so that the transfer cask's capacity can be economically optimized.

The evaluations of the designs indicate that the wet system is preferred over the dry system. However, any final design selection may realistically depend on the individual utility's operational preferences and the unique facility features that already exist at each plant.

Conceptual Design of a High-Integrity Impact Limiter for Use in Shipment of Dual-Purpose Spent-Fuel Casks

NP-7528
Research Project 2813-11

Final Report, September 1991

Prepared by
APPLIED SCIENCE & TECHNOLOGY
16630 Sagewood Lane
Poway, California 92064

Principal Investigator
R. E. Nickell

Contributions by
HANSEN & HAELSIG ASSOCIATES
11655 Southeast Fiftieth Place
Bellevue, Washington 98006

Principal Investigators
R. T. Haelsig
L. J. Hansen

Prepared for
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
R. F. Williams

High Level Waste Program
Nuclear Power Division

REPORT SUMMARY

Conceptual Design of a High-Integrity Impact Limiter for Use in Shipment of Dual-Purpose Spent-Fuel Casks

The high-integrity impact limiter (HIIL) is designed to assist in qualification of a storage cask for use in transportation of spent fuel from a utility site to DOE. The HIIL system will provide an additional safety margin during transportation by enclosing the storage cask in a cocoon composed of multiple layers of energy-absorbing material surrounded by a high-strength stainless steel shell. Further, the HIIL includes mechanical design features to permit rapid loading, impact limiter attachment, and tie down of storage casks onto a railroad car.

INTEREST CATEGORIES

Light water reactor fuel
Radioactive waste management

KEYWORDS

Spent fuels
Waste transport
Impact testing
Materials testing

BACKGROUND Storage and transportation casks are massive structures designed to withstand fire, punctures, and impact loads from handling and shipment. The shipment of spent fuel from a dry storage cask requires returning the cask to the reactor building and reloading the spent fuel into a specially designed and licensed transportation cask. The HIIL is intended to assist in qualification of storage casks for single-time shipment to DOE facilities by providing additional protection of the casks against failure during highly unlikely design basis accidents specified for transportation licensing by NRC in 10 CFR 71. If fuel can be shipped in a storage cask with the HIIL, there are potential reductions in cask handling operation and maintenance costs as well as worker radiation exposures.

OBJECTIVES To design and evaluate the protective capability and economic feasibility of an impact limiter system that will withstand both the forces of a design basis transportation accident and more severe extra-regulatory accidents.

APPROACH The project team evaluated the feasibility of including additional protective features in an impact limiter that completely encloses the cask. Team members designed the HIIL to provide additional assurance of impact limiter performance and thus assist in gaining regulatory approval for transportation of spent-fuel storage casks on a single-shipment basis. In addition, the team conducted a preliminary thermal analysis, investigated the feasibility of mechanical features for rapid loading, and considered the use of two materials for the HIIL—polyurethane foam and aluminum honeycomb.

RESULTS The conceptual mechanical design shows the feasibility of a rapid rail car loading, unloading, and impact limiter attachment. Preliminary thermal analysis indicates that field temperatures are within acceptable limits with the HIIL attached when the cask thermal load is below 10 KW. Both the polyurethane foam and aluminum honeycomb impact limiter designs feature system costs that are in an acceptable range for multiple shipments amortized over a 10-year campaign. Although the HIIL is more costly than the present impact limiters, it may be justified based on use in multiple storage cask shipments when DOE begins accepting spent fuel.

EPRI PERSPECTIVE Separate economic analyses outside the study indicate that HIIL system capital costs of $1 million may be amortized by savings in cask handling costs based on six shipments per year over a 10-year period. Thus, either the aluminum honeycomb system costing $700,000 or the polyurethane foam system costing $400,000 may be attractive for a long-term shipping campaign conducted by DOE or a utility. The alternative to this system is other small-cask-to-large-cask transfer equipment or the return of the storage cask to the fuel pool. NRC approval through a licensing demonstration project is required before the HIIL concept can be used. Related EPRI research includes report NP-7389, *Aluminum Honeycomb Impact Limiter Study.*

PROJECT

RP2813-11

Project Manager: Robert F. Williams

Nuclear Power Division

Contractor: Applied Science & Technology

For further information on EPRI research programs, call EPRI Technical Information Specialists (415) 855-2411.

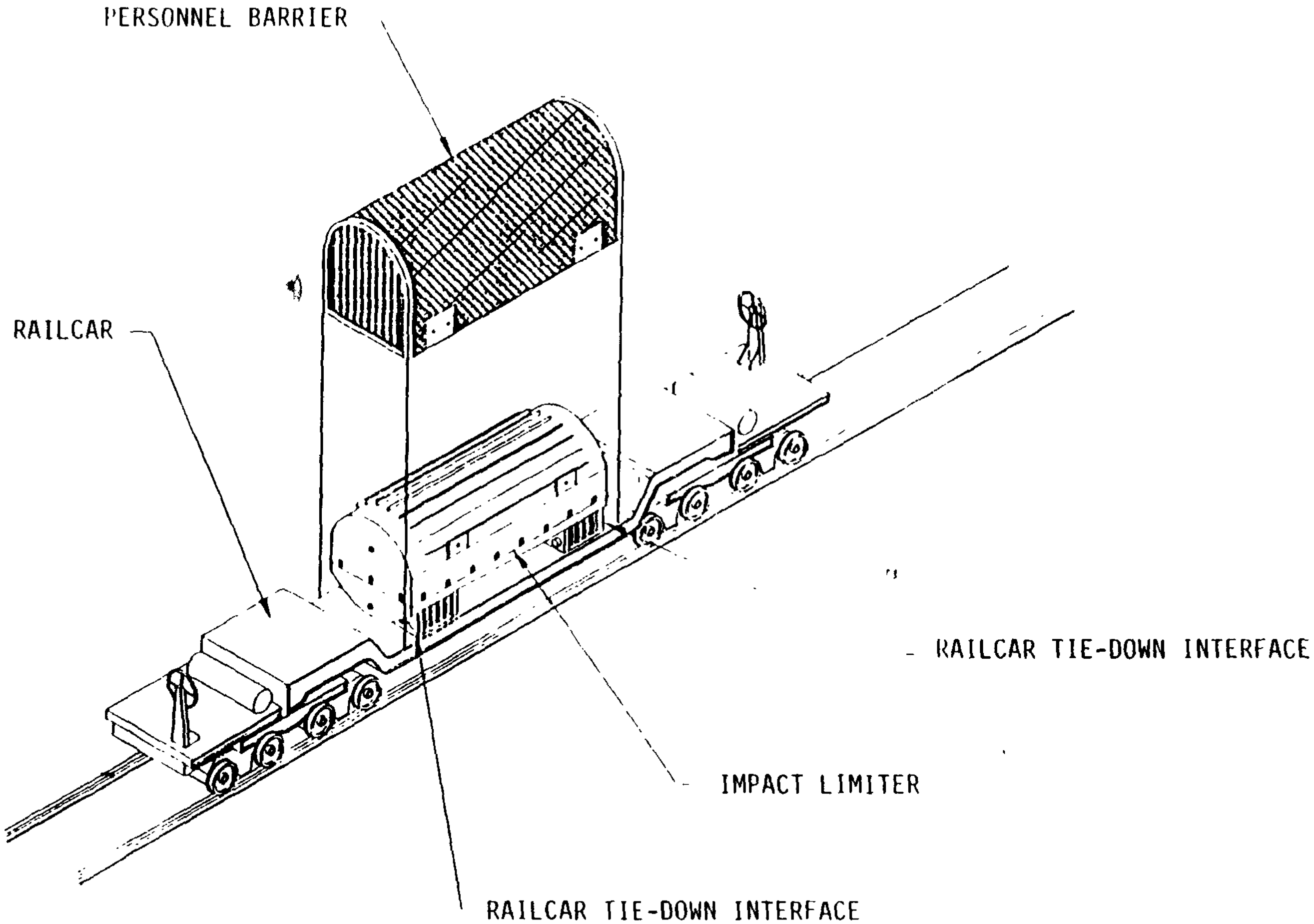

Figure 5-1. Total Packaging System

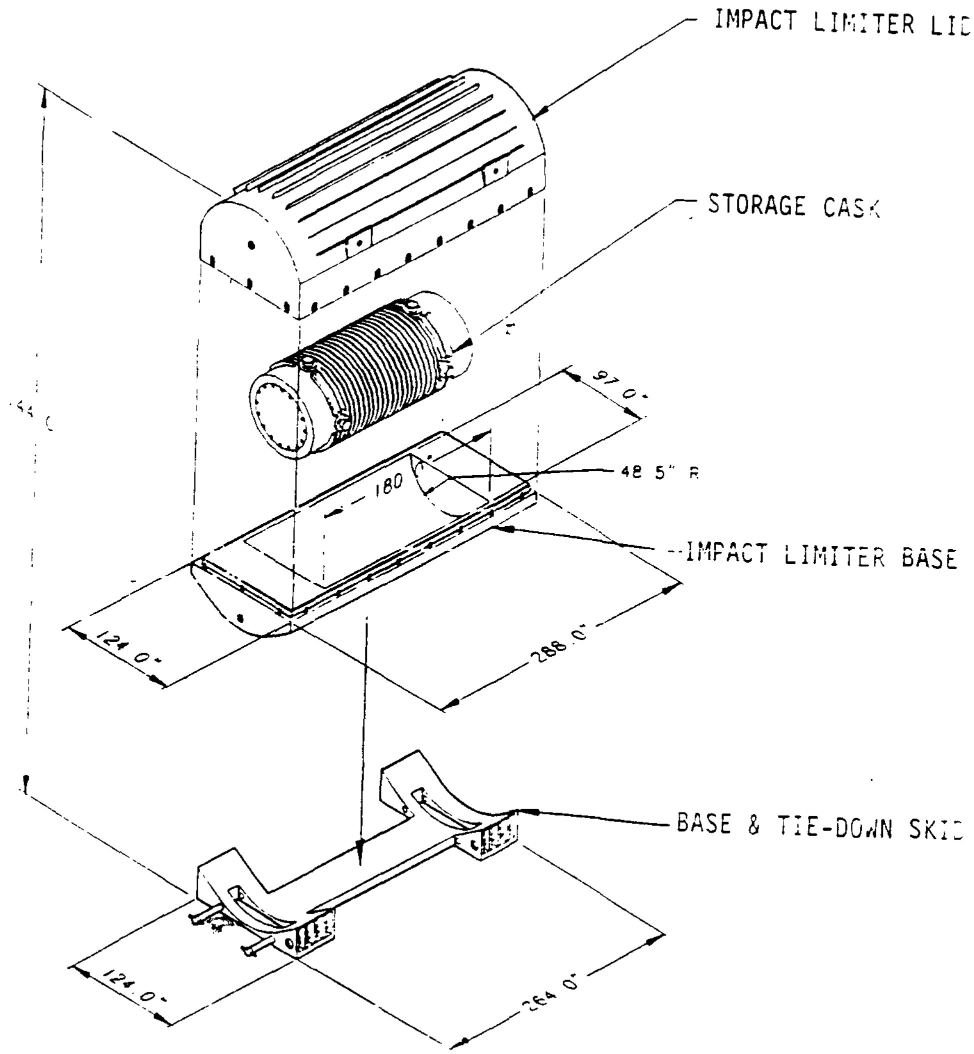

Figure 5-2. Impact Limiter Basic Dimensions and Skid Interface

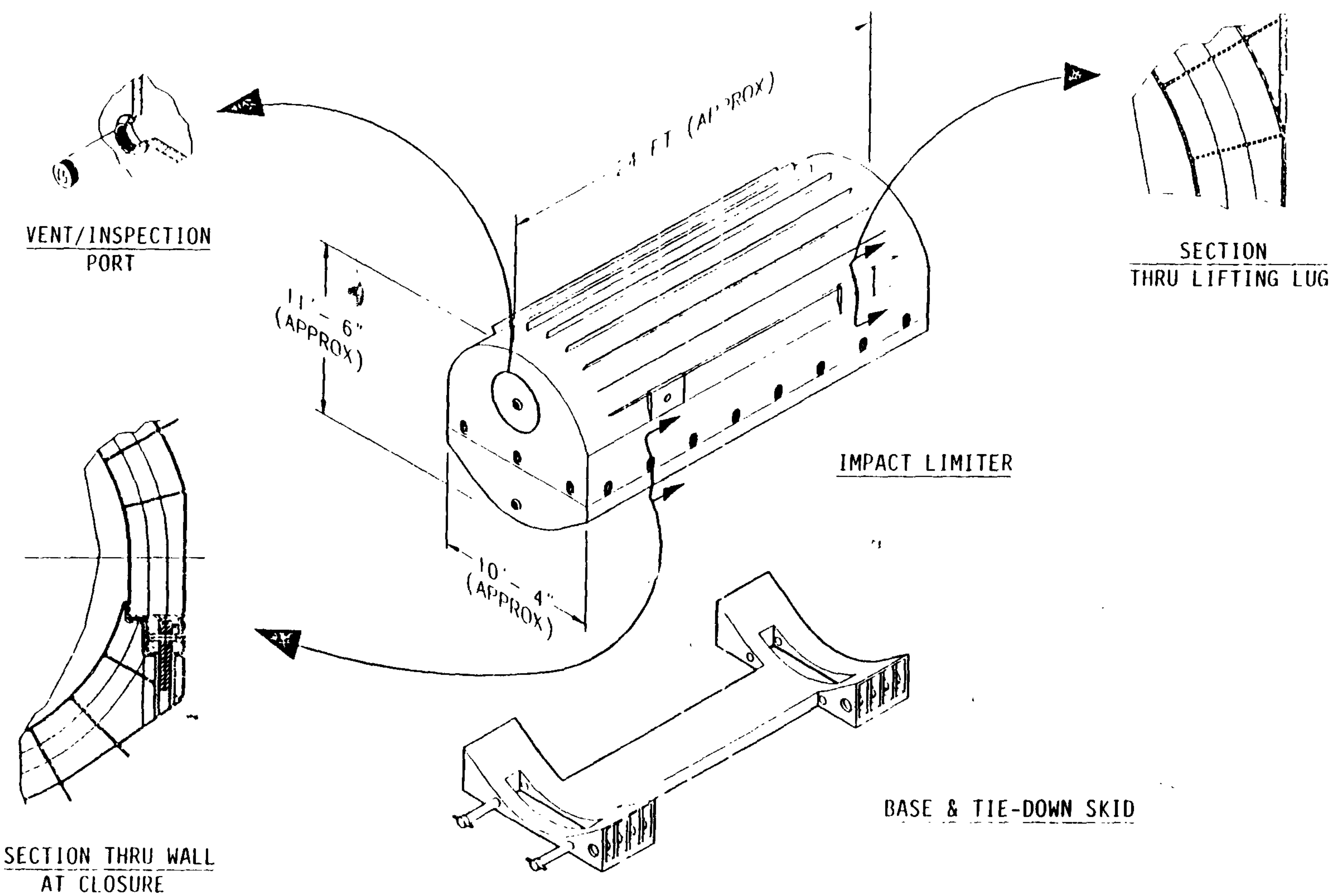

Figure 5-3. Impact Limiter Cross Section/Closure Detail