JUN 23 1987

MEMORANDUM FOR: The File

FROM: Richard H. Odegaarden, SGTB, NMSS

SUBJECT: GA TECHNOLOGIES - DHLW CASK

DISTRIBUTION w/o encl:
Meeting Attendees
NMSS r/f
SGTB r/f
CEMacDonald
Meeting Notebook
NRC PDR w/encl

Attendees

GA	DOE	SANDIA	NRC
A. Zimmer	K. G. Golliher	M. M. Madsen	R. H. Odegaarden
R. E. Nickell	Frank P. Falci	Jerry M. Freedmen	H. W. Lee
Rob Grenier			Ross Chappell
Maria A. Kopioy			W. H. Lake
			C. E. Williams

Introduction

A meeting was held at the request of GA Technologies (GA) at Silver Spring, Maryland, on June 2, 1987, concerning the design of a new legal weight truck cask for defense high level waste (DHLW).

Discussion

GA made a Vu-Graph presentation (attached) of a proposed new legal weight truck cask for DHLW. The cask cavity would contain glassified DHLW in a stainless steel canister (24" OD by 118"). The canister (3/8" thick) would be remotely welded shut after loading, the DHLW would contain about 500 A_2 quantities of plutonium. The canister and contents weigh about 5,500 pounds.

The cask is constructed of stainless steel (49½" OD by 162") and is provided with honeycomb impact limiters on the top and bottom sides. Honeycomb also protects the lid and a impact limiter is provided between the lid and the contents. The radial thickness of the side impact limiters is about 8 inches. The top (notched) and bottom of the cask is provided with a stainless steel (2-inch thick) annular impact limiters. The cask cavity (32½" ID by 118½") may contain a removable depleted uranium, stainless steel encased, shield liner. The cask lid is secured with 24, 1½" diameter bolts and sealed with two viton O-rings. The space between the O-rings has a penetration to permit leak testing of the lid cover/cask body seal. The cask is provided with one sealed penetration (gas sample port). The gross weight of the cask is about 48,300 pounds.

Some aspects of the cask structural design were discussed as follows:

1. Half scale model tests for 30-ft free drop and puncture - The staff points out that the cask and the scale model should be fabricated in accordance with acceptable welding criteria such as those specified in NUREG/CR-3019 (By LLNL) and under a NRC approved Q. A. program.

2. One foot free drop - The one foot free drop test condition is a regulatory requirement. Therefore, the application should show the cask meets this requirement under the Normal Transport Condition.

3. Buckling - Based on cask dimensions, buckling appears unlikely. However, it is the responsibility of the applicant to show that cask will not buckle elastically or inelastically, under both normal or accident transport conditions. It was suggested to the applicant that ASME code case N-284 may be used to develop the buckling criteria.

4. Impact limiter - The application should provide force vs. displacement curves of the impact limiter for the drop orientations considered in the Safety Analysis Report (SAR). The curves may be developed either by direct testing or by appropriate analysis.

5. Tie-down device - Tie-down device which is a part of the package should be designed to withstand the 2-5-10 g forces specified in the regulations to be applied at the package centroid. The applicant was discouraged to use design criteria other than this regulatory requirement.

6. Inelastic analyses - The staff pointed out the complexity and difficulties with regard to inelastic analyses. Considerable time and effort would be needed to demonstrate that the analyses are reasonable and correct and that the underlying assuptions are technically sound. In addition, there are no established acceptance criteria for shipping containers based on inelastic analyses. Consequently, the applicant must justify the technical adequancy of the acceptance criteria used with the analysis. The staff indicated that a static inelastic analysis would not be acceptable. The staff also indicated that the application should consider oblique impact angles and slapdown. As an alternative to inelastic analysis, the staff suggested that an elastic analysis of the cask be performed and be used with Regulatory Guides 7.6 and 7.8.

7. Containment - The staff indicated that safety should not depend upon the particle size distribution of small fragment (powdered) contents that may be produced under accident conditions because of the uncertainties surrounding this approach. It was suggested that the applicant explore the possibility of designing the canisters to be

leak tight under the 30-ft free drop and puncture condition and thus provides a second containment barrier. The staff also suggested that the applicant investigate the effects on leak rate due to lateral movement of lid under impact and puncture and recompression of seal after decompression. The LLNL report on seals by R. Langland was also mentioned during the discussion.

An application could be submitted within two months.

Original signed by
Richard H. Odegaarden

Richard H. Odegaarden, Project Manager
Transportation Branch
Division of Safeguards and
Transportation, NMSS

Enclosure:
As stated

OFC	:SGTB	:SGTB	:SGTB	:	:	:	:
NAME	:RHODEGAARDEN rw	:HWLEE	:CRCHAPPELL	:	:	:	:
DATE	:06/18/87	:06/18/87	:06/23/87	:	:	:	:

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INTRODUCTION

- DOE
  - — K. GOLLIHER — DOE DHLW PROJECT MANAGER
- GA TECHNOLOGIES
  - — A. ZIMMER — PROJECT MANAGER
  - — M. KOPLOY — STRUCTURAL ANALYST
  - — R. GRENIER — NUCLEAR WASTE MANAGEMENT ENGINEERING MANAGER
  - — R. NICKELL — CONSULTANT ON STRUCTURAL CRITERIA
- SANDIA NATIONAL LABORATORIES
  - — M. MADSEN — TASK LEADER

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DHLW CASK

- PURPOSE OF MEETING: NRC FEEDBACK ON TECHNICAL APPROACH
  - — DESCRIBE CASK AND DESIGN APPROACH
  - — PRESENT TECHNICAL APPROACH TO CERTIFICATION
  - — IDENTIFY KEY TECHNICAL ELEMENTS
  - — ACROSS THE TABLE DISCUSSION

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AGENDA
DEFENSE HIGH-LEVEL WASTE CASK DESIGN

PRESENTATION TO NRC
JUNE 2, 1987

1. INTRODUCTION	A. ZIMMER	5 MIN
2. CASK DESIGN DESCRIPTION	A. ZIMMER	10 MIN
3. SARP SUMMARY	A. ZIMMER	10 MIN
4. TEST PROGRAM	A. ZIMMER/ M. MADSEN	10 MIN
5. TECHNICAL APPROACH		
• HYPOTHETICAL ACCIDENT CONDITION STRUCTURAL DESIGN BASIS		
— STRUCTURAL CRITERIA	R.E. NICKELL	15 MIN
— ANALYSIS AND TEST RESULTS	M. KOPLOY	15 MIN
• TIEDOWN DESIGN	M. KOPLOY	5 MIN
• SINGLE CONTAINMENT DESIGN	A. ZIMMER	5 MIN
6. DISCUSSION	ATTENDEES	

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CASK DESIGN DESCRIPTION

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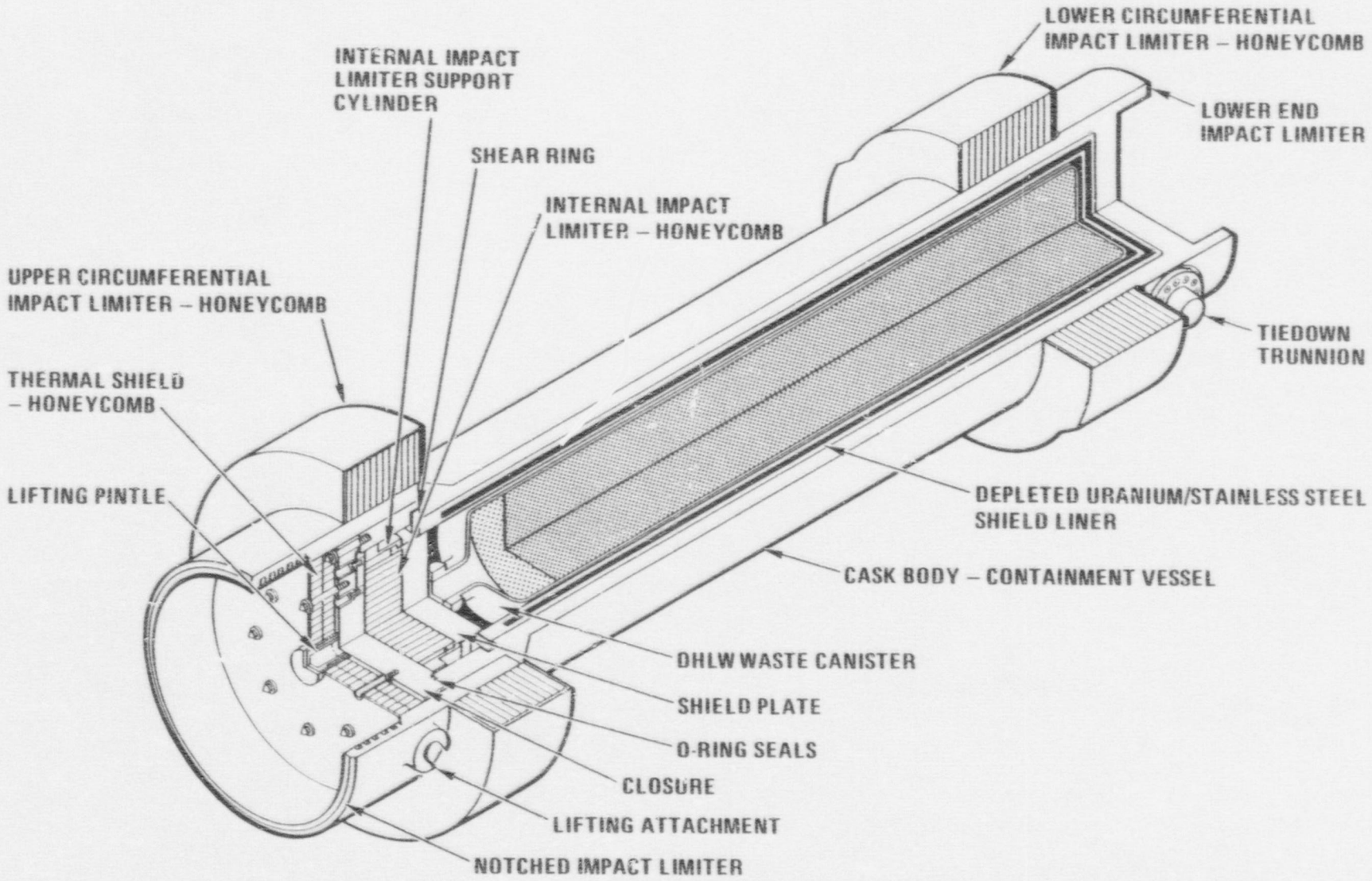
5-26-87



DHLW cask cutaway

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DHLW CASK IS A LEGAL WEIGHT TRUCK TYPE B PACKAGING

- PROVIDES SHIELDING AND CONTAINMENT UNDER NORMAL AND HYPOTHETICAL ACCIDENT CONDITIONS
- WEIGHS LESS THAN 80,000 LB LEGAL WEIGHT LIMIT

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DHLW CASK IS DESIGNED TO BE VERSATILE, EFFICIENT, AND HAVE IMPROVED SAFETY PERFORMANCE

- VERSATILITY FEATURE
  - — CASK CAN ACCOMMODATE DIFFERENT WASTE FORMS BY USE OF REMOVABLE SHIELD LINER
- EFFICIENCY FEATURES
  - — FULLY REMOTE HANDLING CAPABILITY REDUCES PERSONNEL EXPOSURE
  - — TRUNNIONS ARE USED FOR TIEDOWN AND ARE REPLACEABLE
  - — INTEGRAL IMPACT LIMITERS REDUCE HANDLING TIME
- SAFETY FEATURES
  - — INTEGRAL IMPACT LIMITERS
    - REDUCE PERSONNEL EXPOSURE
    - NON-COMBUSTIBLE
    - WILL NOT SEPARATE IN AN IMPACT
  - — THERMAL BARRIER PROTECTS SEALS
  - — INTERNAL IMPACT LIMITER PROTECTS CLOSURE FROM IMPACT OF CONTENTS
  - — LEAKAGE TEST PORT VERIFIES SEAL INTEGRITY

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DHLW CONTAINMENT BOUNDARY PROVIDES RUGGED BARRIER TO RELEASE OF WASTE

- TYPE 304 STAINLESS STEEL CONSTRUCTION
- 3 TO 4 IN. THICK CASK BODY WALL
- 4.75 IN. THICK BOLTED CLOSURE
- VITON O-RING SEALS
- GAS SAMPLING PORT IN CLOSURE

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DHLW DESIGNED TO TRANSPORT DEFENSE HIGH-LEVEL WASTE

- GLASS MATRIX IN A WELDED STAINLESS STEEL CANISTER
- GLASS MATRIX STABLE (NON-GAS GENERATING)

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UPPER BOUND OF DWPF WASTE IS DHLW CASK DESIGN BASIS

CANISTER/GLASS VOLUME	27 FT^3
100% FILLED CANISTER	5468 LB
TOTAL ACTIVITY	275,600 CURIES
DECAY HEAT	815 WATTS

SIGNIFICANT RADIONUCLIDES	GAMMA	NEUTRON
	Ba-137m	Cm-244
	Eu-154	
	Cs-134	
	Co-60	
	Rh-106	
	Pr-144	
	Sb-125	

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SARP SUMMARY

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DHLW SARP FOLLOWS REG. GUIDE 7.9 FORMAT (PROPOSED REVISION 2)

CHAPTER 1	GENERAL INFORMATION
CHAPTER 2	STRUCTURAL EVALUATION
CHAPTER 3	THERMAL EVALUATION
CHAPTER 4	CONTAINMENT EVALUATION
CHAPTER 5	SHIELDING EVALUATION
CHAPTER 6	CRITICALITY EVALUATION
CHAPTER 7	OPERATING PROCEDURES
CHAPTER 8	ACCEPTANCE TESTS AND MAINTENANCE PROGRAM
CHAPTER 9	QUALITY ASSURANCE

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ANALYSIS SHOWS THAT TEMPERATURES ARE BELOW DESIGN LIMITS

LOCATION	MAX TEMP (°F)		DESIGN LIMIT (°F)	
	NORMAL	ACCIDENT	NORMAL	ACCIDENT
SURFACE IN SHADE	117	NA	180	NA
SEALS	169	368	400	400
WASTE	253	440	572	572

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CASK INTEGRITY EXCEEDS REGULATORY CONTAINMENT CRITERIA

	ANSI N14.5 ALLOWABLE LEAKAGE	DESIGN CAPABILITY
NORMAL CONDITIONS OF TRANSPORT	1.5×10^{-3} atm-cm^3/S	LEAKTIGHT
ACCIDENT CONDITIONS	5.5×10^{-3} atm-cm^3/S	7.5×10^{-7} atm-cm^3/S

- BASES
  - — SINGLE CONTAINMENT CASK DESIGN
  - — SOURCE TERM BASED ON FULL SCALE CANISTER TESTS
  - — GLASS MATRIX AND CANISTER PROVIDES CONFINEMENT OF WASTE PARTICLES

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CASK SHIELDING PROVIDES MARGIN AGAINST ALLOWABLE DOSE RATES

	DOSE RATE			
	NEUTRON	GAMMA	TOTAL	LIMIT
NORMAL CONDITIONS OF TRANSPORT				
CANISTER SURFACE, REM/HR	<0.5	7600	7600	NA
CASK SURFACE, MREM/HR	24.0	220	46.0	200
2 M FROM TRANSPORTER, MREM/HR	4.0	2.7	6.7	10
INHABITED AREA, MREM/HR	0.42	0.3	0.72	2
HYPOTHETICAL ACCIDENT CONDITIONS				
1 M FROM CASK SURFACE, MREM/HR	<10.0	<100.0	<110.0	1000

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CRITICALITY CRITERIA CONFORM TO 10CFR71 FISSILE CLASS 1 REQUIREMENTS

- K_{EFF} = 0.22
  - — INFINITE ARRAY OF WASTE CANISTERS
  - — NON-FLOODED MORE REACTIVE

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TEST PROGRAM

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CASK DESIGNED BY TEST AND ANALYSIS

- TESTS SHOW THAT CASK MEETS REGULATIONS DURING STRUCTURAL HYPOTHETICAL ACCIDENT CONDITIONS
  - CASK CONTAINMENT IS MAINTAINED
  - CASK STRUCTURAL INTEGRITY IS MAINTAINED
  - CASK SHIELDING EFFECTIVENESS IS MAINTAINED
- PERFORM MODEL TESTING TO CONFIRM THAT ANALYSIS IS CONSERVATIVE

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CASK CONTAINMENT IS VERIFIED BY TEST

- HEDL MOCKUP LEAK TESTS PROVIDE RELATIONSHIP BETWEEN CLOSURE SEAL DECOMPRESSION AND LEAKAGE
- HALF-SCALE MODEL TESTS PROVIDE INFORMATION ON ACTUAL SEAL DECOMPRESSION AFTER 30-FT FREE DROP AND 40-IN. PUNCTURE EVENTS
- ACTUAL SEAL DECOMPRESSION IS COMPARED AGAINST THE FULL-SCALE LEAK TESTS TO DETERMINE LEAK RATE OF CASK SEALS

DHLW CASK
HALF-SCALE MODEL TESTING

MARCELLA M. MADSEN

SANDIA NATIONAL LABORATORIES
ALBUQUERQUE, NEW MEXICO

87TM6000.29

EXTENSIVE TEST SERIES ENVELOPES MOST SEVERE ORIENTATION FOR DROP AND PUNCTURE EVENTS

ORIENTATION	REGULATORY SEQUENCE	TEMPERATURE	TEST DATE
BOTTOM END DROP	NA	AMBIENT	MARCH 13, 1986
CLOSURE END DROP	1	-20°F	APRIL 19, 1986
GAS SAMPLE/LEAK CHECK PORT PUNCTURE	1	AMBIENT	MAY 1, 1986
SIDE DROP I	2	AMBIENT	JUNE 27, 1986
CLOSURE PUNCTURE	2	AMBIENT	JULY 11, 1986
CG OVER BOTTOM CORNER DROP	NA	AMBIENT	AUGUST 22, 1986
SIDE DROP II	NA	AMBIENT	SEPT 11, 1986

PROTOTYPIC HALF-SCALE MODEL FABRICATED FOR IMPACT TESTING

- TESTING AT SANDIA COYOTE CANYON DROP FACILITY
- HALF-SCALE ALLOWS DIRECT SCALING OF CRITICAL COMPONENTS AND PROVIDES SPACE FOR INSTRUMENTATION
- SPARE PARTS INSTALLED WHEN PRIOR TEST DAMAGE WOULD SIGNIFICANTLY AFFECT RESULTS
- COMPREHENSIVE QA IMPLEMENTED WITH DETAILED TEST PLAN DOCUMENTING PROCEDURES AND TEST RESULTS

EXTENSIVE INSTRUMENTATION IS USED TO VERIFY ANALYSIS AND CONFIRM THE DESIGN

- STRAIN GAGES
- ACCELEROMETERS
- STRAIN GAGED CLOSURE BOLTS
- DISPLACEMENT TRANSDUCERS

DIMENSIONAL INSPECTION RECORDS MEASUREMENTS

- ASSEMBLED CASK
- INDIVIDUAL COMPONENTS
- CLOSURE SEAL COMPRESSION

RADIOGRAPHY AND LEAK TESTING DOCUMENT SHIELDING AND CONTAINMENT PERFORMANCE

- RADIOGRAPHS INSPECT
  - SHIELDING LINER
  - CASK BODY WELDS
- HELIUM LEAK TEST CHECKS
  - CASK BODY WELDS
  - CLOSURE SEALS
  - GAS SAMPLE AND LEAK CHECK PORT WELDS

DHLW FULL-SCALE CLOSURE SEAL LEAKAGE TESTS CONDUCTED AT WESTINGHOUSE HANFORD

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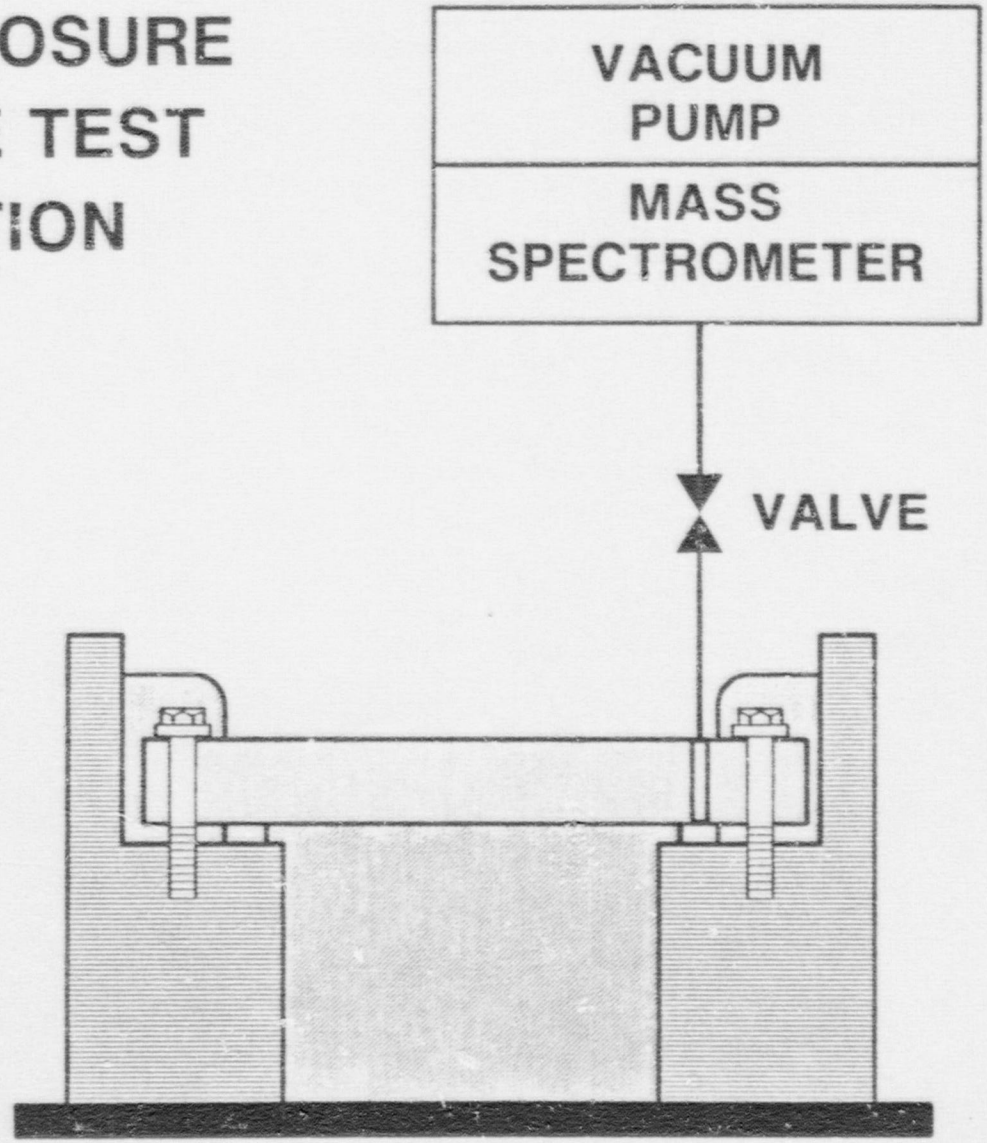
FULL-SCALE CLOSURE SEAL LEAKAGE TEST CONFIGURATION



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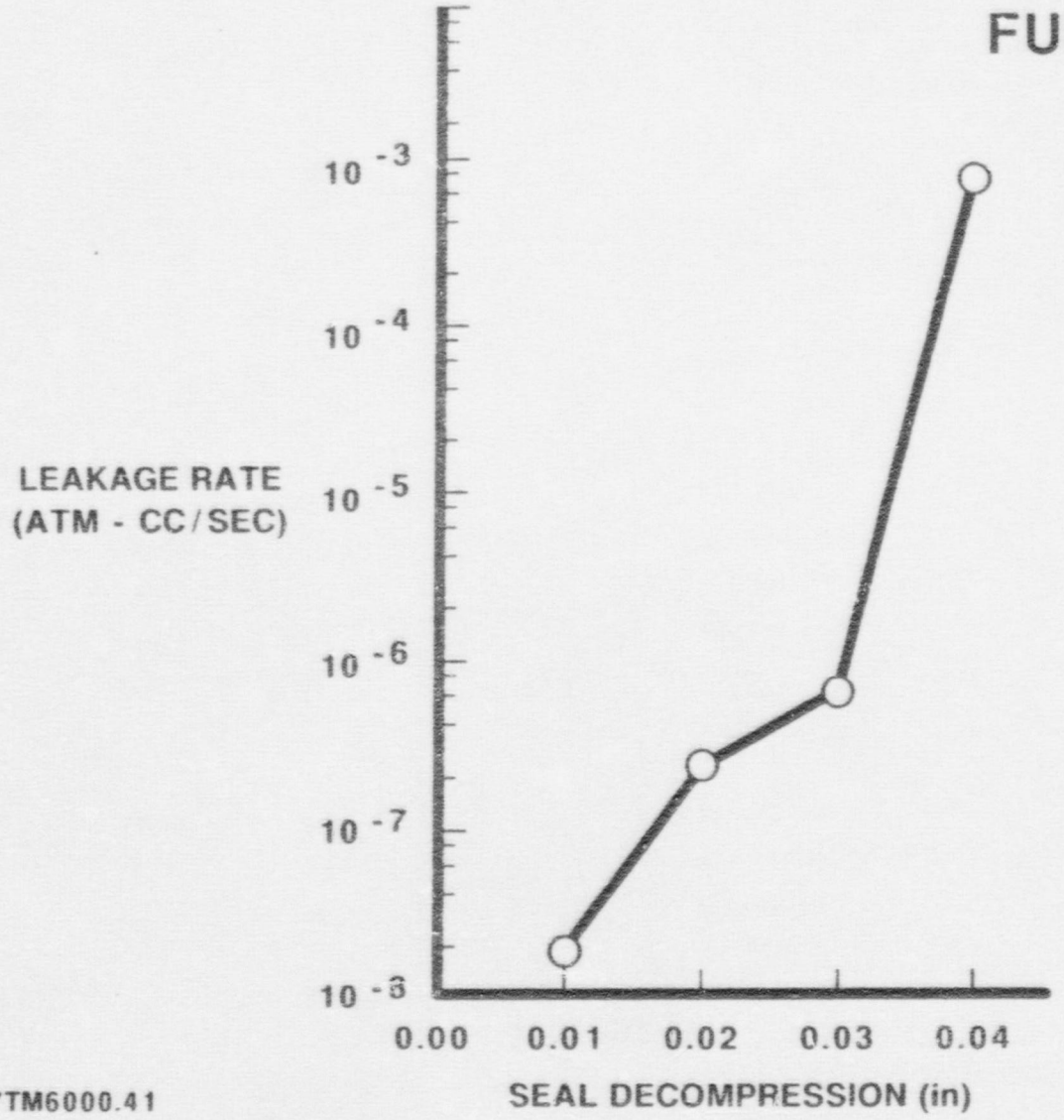
FULL-SCALE CLOSURE SEAL LEAKAGE TEST DATA



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TECHNICAL APPROACH

HYPOTHETICAL ACCIDENT CONDITION STRUCTURAL DESIGN BASIS

STRUCTURAL CRITERIA

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DHLW CASK STRUCTURAL DESIGN CRITERIA ARE BASED UPON ESTABLISHED PRINCIPLES

- ELASTIC ANALYSIS CRITERIA OF REG. GUIDE 7.6 FOR BULK OF CONTAINMENT BOUNDARY
- FOR NORMAL CONDITION ONE-FOOT DROP, NO SUBSTANTIAL REDUCTION IN PACKAGING EFFECTIVENESS
- FOR HYPOTHETICAL ACCIDENT FREE DROPS
  - — SCALE-MODEL TESTING, PLUS
  - — BENCHMARKED ELASTIC-PLASTIC ANALYSIS

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DHLW CASK DESIGN SATISFIES LOADING CONDITION/COMBINATION REQUIREMENTS

- GENERAL REQUIREMENTS, 10CFR71
- LOAD COMBINATIONS
  - — 10CFR71
  - — NRC REGULATORY GUIDE 7.8

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ELASTIC-PLASTIC ANALYSIS APPROACH IS BASED UPON QUALITY ASSURANCE PRINCIPLES

- CODES USED FOR PRE-DROP-TEST PREDICTIONS
  - — PREDICT PERFORMANCE OF SOLID IMPACT LIMITERS
- VALIDATION
  - — WIDELY-USED ELASTIC-PLASTIC FINITE ELEMENT SOFTWARE
  - — TWO CODES — DYNA2D AND HONDO-II — COMPARED ON TYPICAL HYPOTHETICAL ACCIDENT ANALYSIS
  - — DYNA3D, HONDO-II USED FOR SCALE MODEL DROP TEST PREDICTIONS
- APPLICATION
  - — INTERPRETATION OF DROP TEST RESULTS
  - — SATISFACTION OF ELASTIC-PLASTIC DESIGN CRITERIA AT SPECIFIC LOCATIONS IN CONTAINMENT BOUNDARY

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CONTAINMENT CLOSURE COMPONENTS SATISFY ELASTIC DESIGN CRITERIA

- NO PERMANENT AXIAL DEFORMATION OF CLOSURE BOLTS
  - — DIFFERENTIAL THERMAL EXPANSION STRETCHING STRESSES TREATED AS PRIMARY STRESSES
  - — SEAL SURFACE BEARING STRESSES LIMITED TO YIELD LEVEL
  - — TRANSIENT AND PERMANENT DEFLECTION/ DEFORMATION LIMITED TO ALLOWABLE VALUES DETERMINED BY TEST

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ELASTIC DESIGN CRITERIA USED FOR MOST OF CONTAINMENT BOUNDARY

STRESS CATEGORY	NORMAL CONDITIONS	HYPOTHETICAL ACCIDENT CONDITIONS
PRIMARY MEMBRANE STRESS INTENSITY	S_m	LESSER OF { $2.4\ S_m$; $0.7\ S_u$ }
PRIMARY MEMBRANE + BENDING STRESS INTENSITY	$1.5\ S_m$	LESSER OF { $3.6\ S_m$; S_u }
RANGE OF PRIMARY + SECONDARY STRESS INTENSITY	$3.0\ S_m$	NOT APPLICABLE
BEARING STRESS	S_y	SEAL SURFACES, S_y S_u ELSEWHERE
PURE PRIMARY SHEAR STRESS	$0.6\ S_m$	$0.42\ S_u$

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ELASTIC-PLASTIC DESIGN CRITERIA USED FOR SOME CONTAINMENT BOUNDARY LOCATIONS

STRESS CATEGORY	HYPOTHETICAL ACCIDENT CONDITIONS
PRIMARY MEMBRANE STRESS INTENSITY	$S_y + 1/3\ (S_{uT} - S_y)$
PRIMARY MEMBRANE + BENDING STRESS INTENSITY	GREATER OF $\begin{cases} 0.7\ S_{uT} \\ S_y + 1/3\ (S_{uT} - S_y) \end{cases}$
RANGE OF TOTAL STRESS INTENSITY	DUCTILE TEARING STRAIN LIMITS
BEARING STRESS	SEAL SURFACES, S_y S_{uT} ELSEWHERE
PURE PRIMARY SHEAR STRESS	$0.42\ S_{uT}$

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CONTAINMENT BOUNDARY BOLTING STRESS ALLOWABLES ARE BASED UPON ELASTIC DESIGN

STRESS CATEGORY	NORMAL CONDITIONS	HYPOTHETICAL ACCIDENT CONDITIONS
ELASTIC ANALYSIS		
MEMBRANE STRESS DUE TO INTERNAL PRESSURE	S_m	NOT APPLICABLE
MEMBRANE STRESS	$2.0\ S_m$	LESSER OF $\begin{cases} S_y \\ 0.7\ S_u \end{cases}$
MEMBRANE + BENDING STRESS	$3.0\ S_m$	S_u
PURE SHEAR	$0.6\ (2.0\ S_m) = 1.2\ S_m$	LESSER OF $\begin{cases} 0.6\ S_y \\ 0.42\ S_u \end{cases}$
ELASTIC-PLASTIC ANALYSIS		
MEMBRANE STRESS	--	LESSER OF $\begin{cases} S_y \\ 0.7\ S_{uT} \end{cases}$
MEMBRANE + BENDING STRESS	--	S_{uT}
PURE SHEAR	--	LESSER OF $\begin{cases} 0.6\ S_y \\ 0.42\ S_{uT} \end{cases}$

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OTHER FAILURE MODES ARE EVALUATED USING WELL-ESTABLISHED DESIGN CRITERIA

- BRITTLE FRACTURE
  - — CONTAINMENT BOUNDARY CONSTRUCTED OF AUSTENITIC STAINLESS STEEL WITH LIMITED CARBON CONTENT
  - — DU LINER HELD IN PLACE, DID NOT FRACTURE FOLLOWING 30-FOOT DROP TESTS
- FATIGUE
  - — ASME CODE, SECTION III, NB–3222.4
- BUCKLING
  - — STRESSES LIMITED TO 2/3 OF CRITICAL BUCKLING STRESS
  - — DUCTILE TEARING STRAIN LIMIT ALSO IMPOSED

ANALYSIS AND TEST RESULTS

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EXTENSIVE TESTING AND ANALYSES DEMONSTRATE STRUCTURAL PERFORMANCE DURING HYPOTHETICAL ACCIDENT CONDITIONS

	TESTS	ANALYSES
30-FT FREE DROPS	✓ (5)	✓ (4)
PUNCTURE	✓ (2)	✓
THERMAL		✓
IMMERSION		✓

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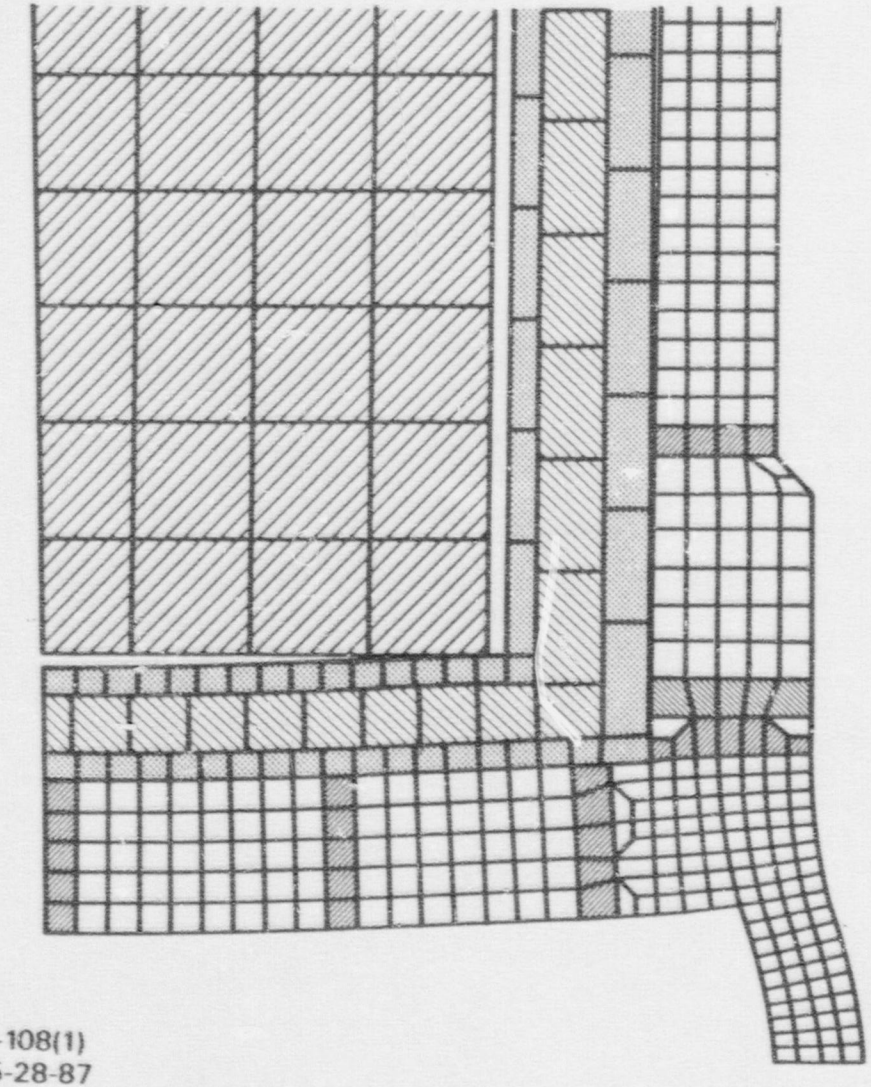
ELASTIC-PLASTIC METHODS USED TO PREDICT BEHAVIOR OF SOLID IMPACT LIMITER



- CODES WIDELY USED IN INDUSTRY
  - — HONDO II, DYNA2D, DYNA3D,

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1/2-SCALE TESTS VERIFY THE ABILITY TO SURVIVE DROP AND PUNCTURE EVENTS

- NO RUPTURING, TEARING, OR BUCKLING
- NO SIGNIFICANT DEFLECTION IN SEAL AREA
- NO DETECTABLE CHANGE IN SEAL LEAKAGE
- NO CRACKS DETECTED IN DU SHIELD LINER AT MINIMUM AND ROOM TEMPERATURE
- NO DETECTABLE LEAKAGE OF THE WELDMENTS
- THERMAL BARRIER REMAINED IN PLACE

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DYNA2D AND HONDO II RESULTS COMPARED WELL

CRITICAL SECTION	STRESS TYPE	MAXIMUM STRESS	
		DYNA2D (VAX)	HONDO II (UNIVAC)
1 – CENTER OF BOTTOM OF CASK	P_m	24	25
	σ_{EFF}, OUTER	42	41
	σ_{EFF}, INNER	37	37
2 – EDGE OF CASK BOTTOM	P_m	33	33
	σ_{EFF}, OUTER	40	40
	σ_{EFF}, INNER	36	34
3 – BOTTOM OF CASK SIDE	P_m	27	26
	σ_{EFF}, OUTER	42	41
	σ_{EFF}, INNER	38	37
3A – BOTTOM OF CASK SIDE	P_m	29	31
	σ_{EFF}, OUTER	49	48
	σ_{EFF}, INNER	66	61
4 – BOTTOM OF CASK SIDE ABOVE SHOULDER	P_m	25	26
	σ_{EFF}, OUTER	32	34
	σ_{EFF}, INNER	35	30
5 – CASK SIDE 24 IN. FROM BOTTOM	P_m	27	30
	σ_{EFF}, OUTER	26	27
	σ_{EFF}, INNER	33	33
6 – CASK BOTTOM BETWEEN CENTER AND EDGE	P_m	22	21
	σ_{EFF}, OUTER	42	40
	σ_{EFF}, INNER	37	36

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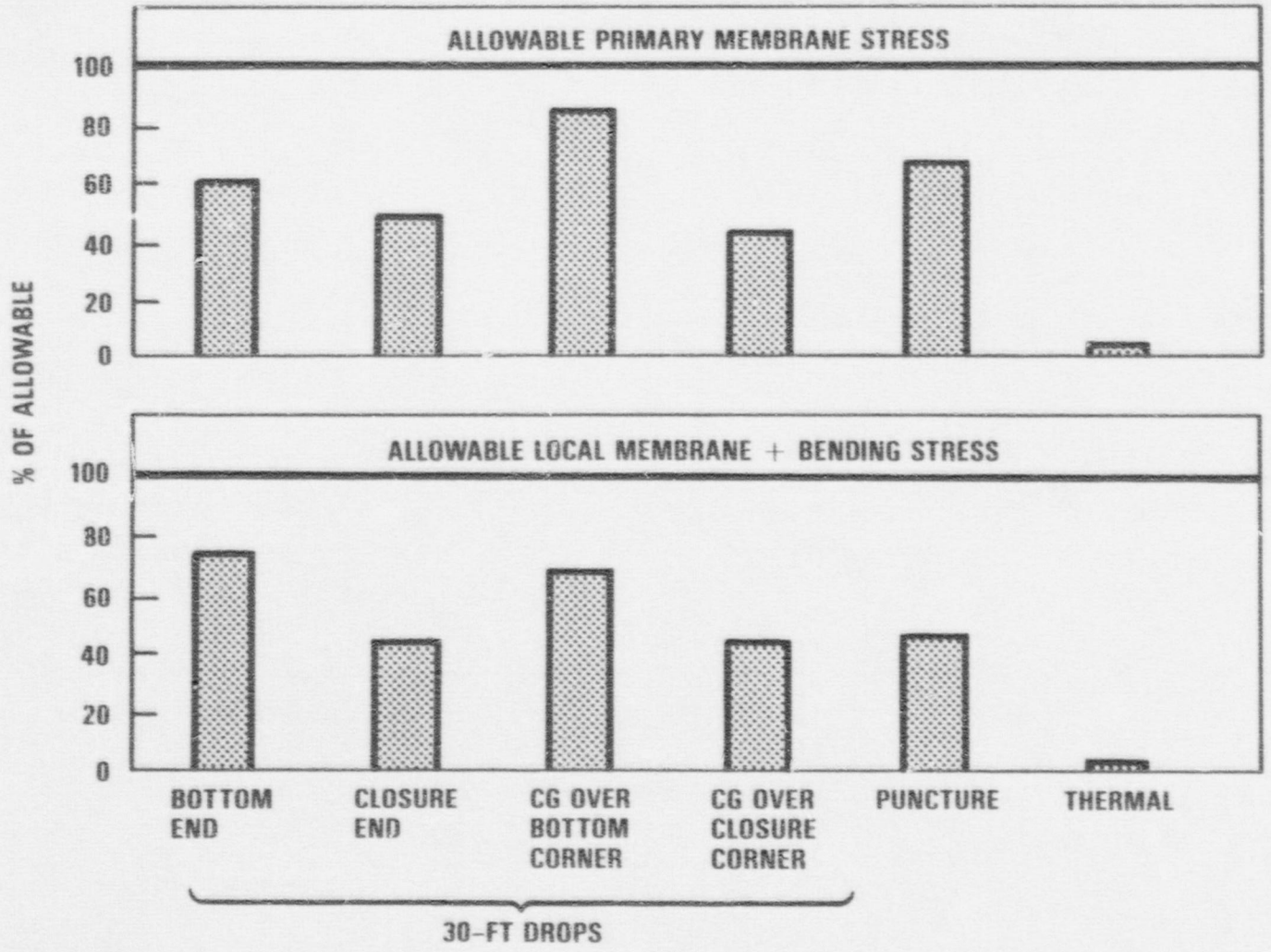
ANALYSIS SHOWS CASK WILL NOT RUPTURE OR TEAR DURING HYPOTHETICAL ACCIDENT CONDITIONS



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ANALYSES SHOW SEALING INTEGRITY IS MAINTAINED

- BOLTS DO NOT YIELD
- SEAL COMPRESSION IS CONSISTENT WITH ALLOWABLE LEAK RATES*

*FULL SCALE SEAL MOCK-UP TESTS

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ACCELERATIONS AND DURATIONS COMPARE WELL

ACCELEROMETER NUMBER	LOCATION	BOTTOM-END DROP			CLOSURE-END DROP		
		TEST	ANALYSIS	ANALYSIS/ TEST RATIO	TEST	ANALYSIS	ANALYSIS/ TEST RATIO
ACCELERATION							
1 AND 2	CASK BODY	530 g	773 g	1.46	275 g	334 g	1.21
3	CLOSURE	--	1822 g	--	475 g	1410 g	2.97*
4	SHIELD SLEEVE	940 g	928 g	0.99	288 g	460 g	1.6
5	CONTENTS	890 g	838 g	0.94	93 g	242 g	2.6*
DURATION							
1 AND 2 AVERAGE	TIME BEFORE CASK BODY REBOUNDS	4.65 msec	4.8 msec	1.03	9.4 msec	10 msec	1.06

*LARGE DIFFERENCE DUE TO CONTENTS BEING CONSERVATIVELY MODELED AS A SOLID HOMOGENEOUS ELASTIC MATERIAL; DURING TEST, CANISTER PINTLE BUCKLED AND ABSORBED MUCH OF ITS OWN ENERGY.

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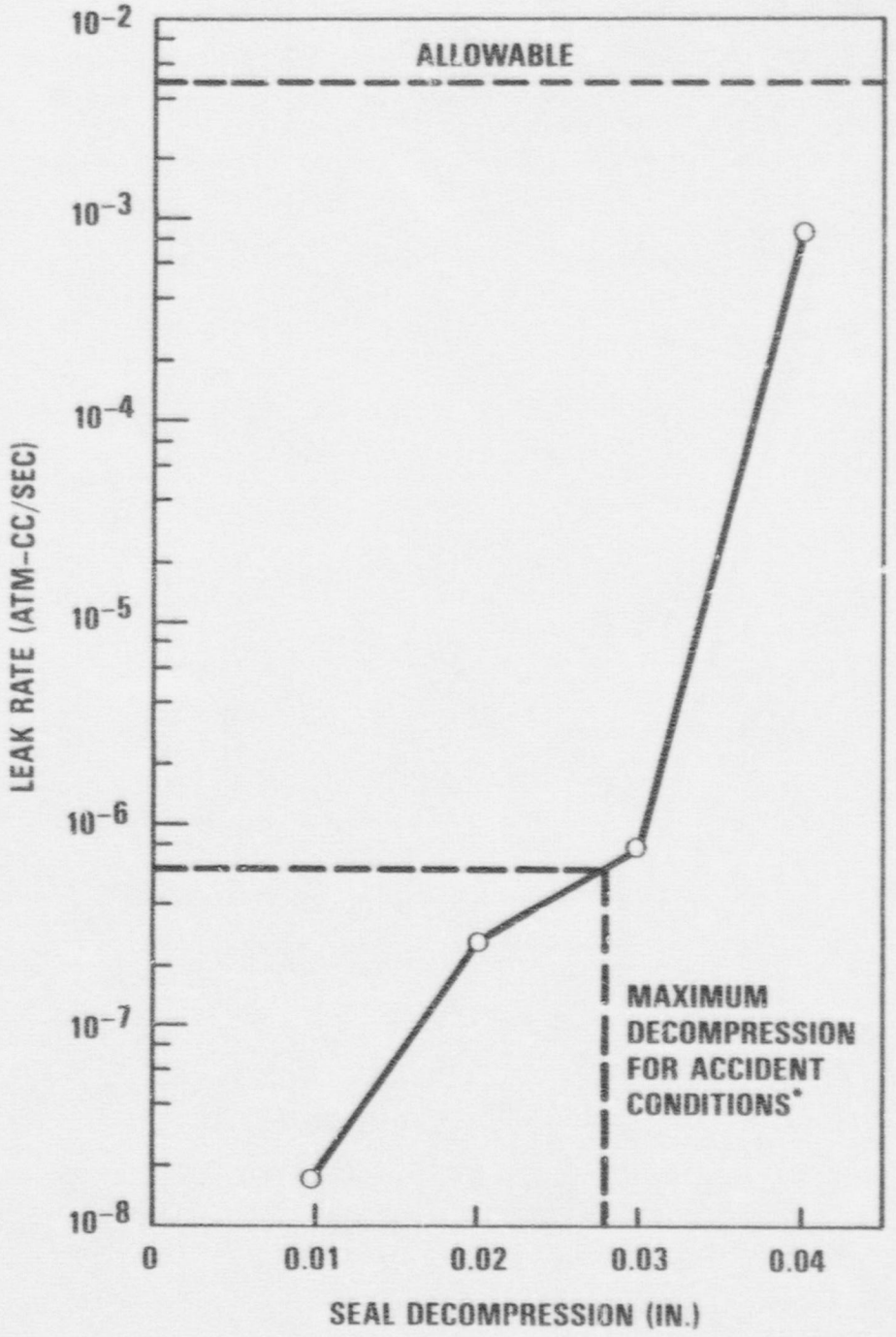
SEAL TEST DATA DEMONSTRATES SIGNIFICANT DESIGN MARGIN



*TRANSIENT DURING THERMAL EVENT

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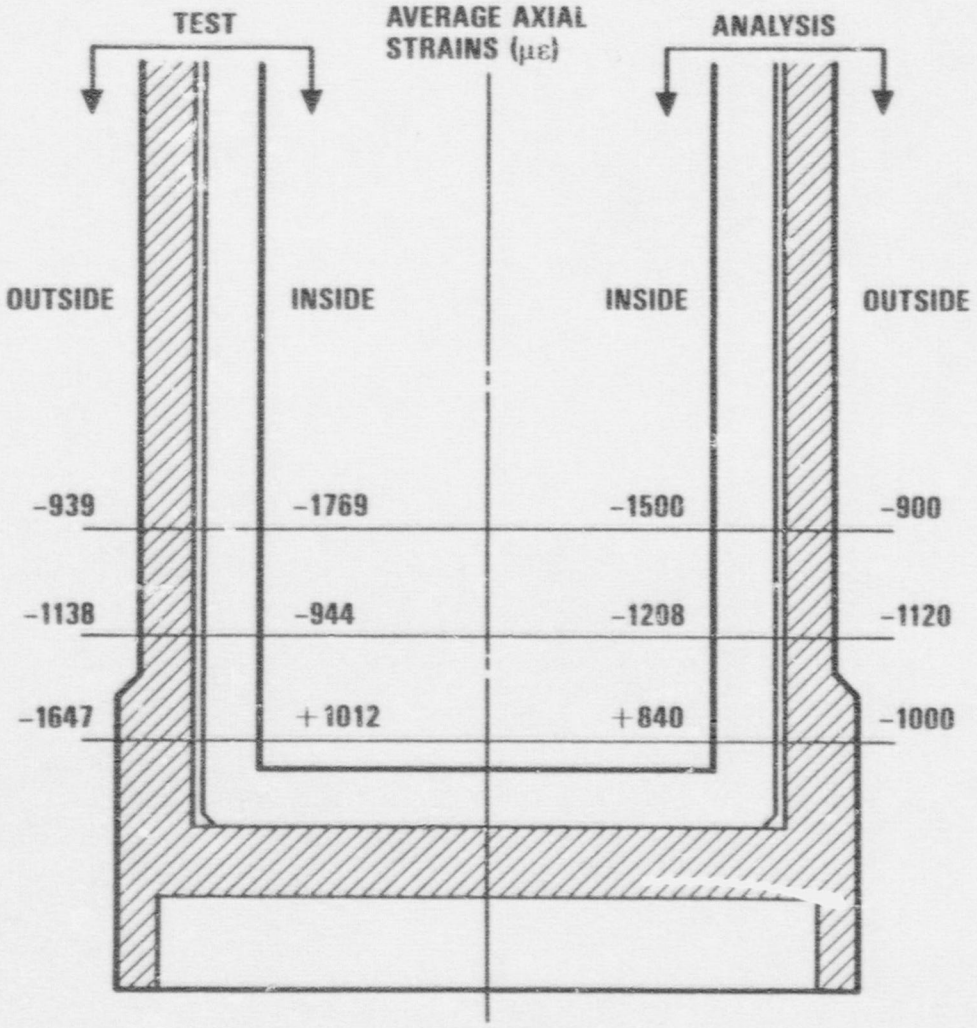
STRAINS COMPARE WELL



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STRAINS IN CASK BODY DURING BOTTOM END DROP

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TEST DATA VERIFY ANALYTICAL APPROACH

	TEST	ANALYSIS
CLOSURE END DROP		
--CLOSURE--	500 με	1450 με
CG OVER BOTTOM CORNER DROP		
--BOTTOM OF CASK BODY--	3300 με	3460 με

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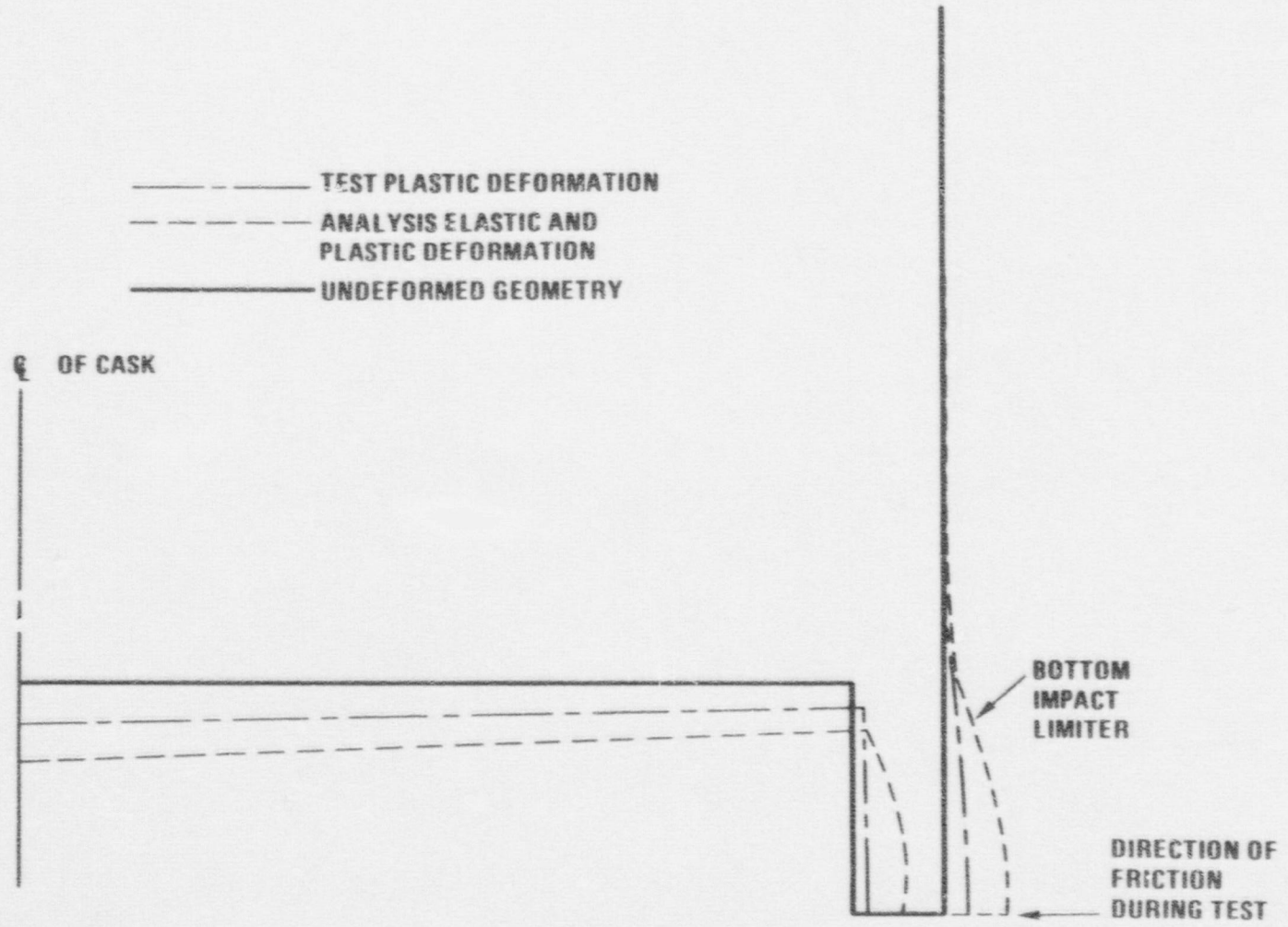
ANALYSIS CONSERVATIVELY PREDICTS DISPLACEMENTS



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CONCLUSIONS

- HALF-SCALE TESTS CONFIRM THAT THE DHLW CASK DESIGN IS CAPABLE OF WITHSTANDING THE REGULATORY DROP ENVIRONMENTS

- THE ANALYTICAL APPROACH USED TO DESIGN THE DHLW CASK IS CONSERVATIVE

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TIEDOWN DESIGN

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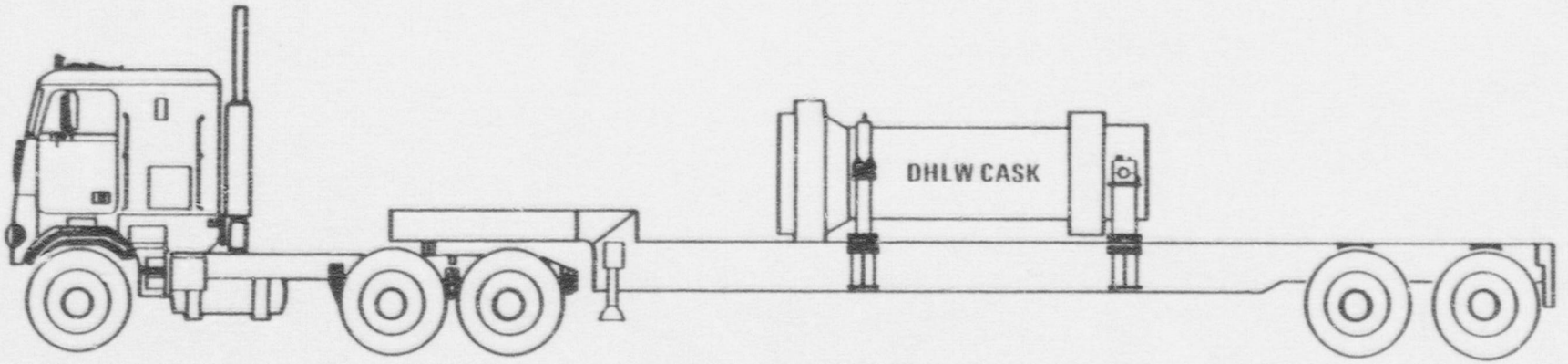
DHLW CASK IS TRANSPORTED ONLY BY TRUCK



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THE TIEDOWN TRUNNIONS ARE DESIGNED BASED ON CONSERVATIVE CRITERIA

- 7 G VERTICAL, 4 G LONGITUDINAL, 4 G TRANSVERSE
- STRESSES ARE BELOW YIELD
- TRUNNION BOLTS PROTECT THE CASK FROM EXCESSIVE LOADS

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THE 7–4–4 G DESIGN ACCELERATIONS ARE CONSERVATIVE FOR TRUCK TRANSPORT

- 7–4–4 G ACCELERATIONS (ANSI N14.23) ARE BASED ON MEASURED TRUCK DATA
- 2–10–5 G ACCELERATIONS (10CFR71) ARE BASED ON RAIL DATA
- THE 7 G VERTICAL ACCELERATION (ANSI N14.23) IS CONSERVATIVE FOR TRUCK TRANSPORT
- THE 10 G LONGITUDINAL ACCELERATION (10CFR71) IS DERIVED FROM TRAIN COUPLING LOADS
- THE 4 G LONGITUDINAL ACCELERATION (ANSI N14.23) IS CONSERVATIVELY DERIVED FROM TRUCK TEST DATA

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SINGLE CONTAINMENT DESIGN

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WASTE FORM CONSISTENT WITH SINGLE CONTAINMENT CASK DESIGN

- BASES
  - CONTENTS IS IN SOLID FORM
  - TESTS SHOW THAT <1 Ci OF PLUTONIUM IN RESPIRABLE FORM (<10 μm AERODYNAMIC EQUIVALENT DIAMETER) IS GENERATED INSIDE CANISTER AFTER 30-FT FREE DROP AND PUNCTURE EVENTS
  - CANISTER HAS NEVER RUPTURED DURING NUMEROUS 30-FT DROP TESTS

DISCUSSION