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Appendix E

Neutron Shield Tank Flexible Hose Evaluation

The neutron shield water jacket on the cask is connected to expansion tanks by means of a flexible hose with Snap-Tite valved quick disconnect couplings. The flexible hose construction consists of a corrugated stainless steel tube which is wrapped with stainless wire braid. (See Material Specification Section - page VI-3 through VI-6) Braiding prevents hose elongation under pressure, dampens vibration and provides mechanical protection for the corrugated stainless steel tube core.

The flexible metal hose is well suited for the service intended. All components of the hose assembly are stainless steel and have a high resistance to deterioration and aging which is normally associated with rubber type hoses. The maximum allowable operating temperature for the flexible metal hose is 1500°F (Anaconda Metal Hose Div. Bulletin CR (3ED). The bursting pressure for the ½" BW21-1H Anaconda Metal Hose is 3000 psig. Using the temperature correction factors and the recommended factor of safety of 4:1 as given in the Anaconda Metal Hose Div. Bulletin EN-1 (3ED) the following safe operating pressure is determined:

Maximum operating temperature - 340°F
System design pressure - 235 psig
Temperature correction factor - 0.83
Rated bursting pressure - 8,000 psig
Rated bursting pressure at temperature - 8000 x 0.83 = 6640 psig

Safe operating pressure (4:1 F.S.):

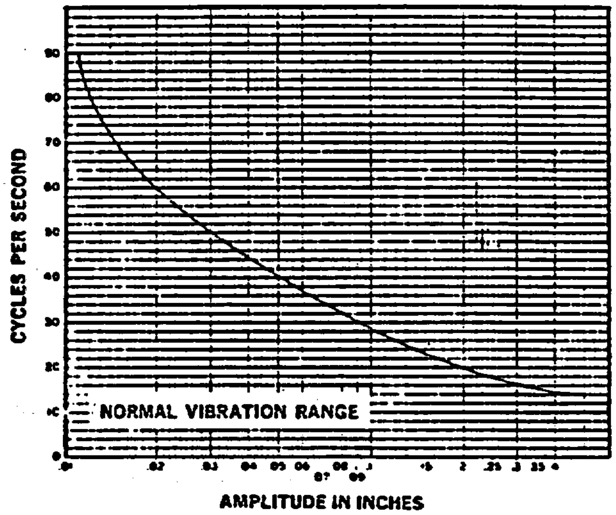
$$\frac{6640}{4} = 1660 \text{ psig}$$

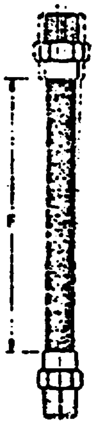
Margin of safety on operating pressure:

$$\frac{1660}{235} - 1 = 6.06$$

The flexible metal hose system is not susceptible to failure as a result of improper hook-up or operator error. The hose is fitted with quick disconnect valved type couplings which reauires the operator to perform a definite operation in order to complete the connection. If the operator does not perform the operations correctly, the coupling halves will not make up and the result is immediately obvious. There would be no leakage of shield water in such an event, since both coupling halves are equipped with a spring loaded plunger arrangment which seals off flow when the coupling is disconnected.

The flexible metal hose assembly is not susceptible to failure due to normal transport and handling conditions. The manufacturer states that the hose assembly will accept normal vibrations encountered in average industrial applications as shown on the graph below.





EN11

For the $\frac{1}{2}$ inch, BW21-1H, Anaconda hose, the manufacturer recommends a minimum length of $5\frac{1}{2}$ inches. The normal vibration range should have no detrimental effect on the life of hose assemblies with length greater than $5\frac{1}{2}$ inches. The hose assembly used on the neutron shield tank system is 19 inches long. Severe shock will decrease the life of the hose assembly. The shock loads under normal conditions of transport are reported to be 3g maximum which is not considered to be a severe shock condition and should have no effect on the hose assembly.

To verify the structural integrity of the flexible metal hose assembly and end fittings, a test was performed on a mock-up of the hose assembly. The mock-up (see sketch on pg. XI-E6) consisted of two $1\frac{1}{2}$ inch diameter rods which were machined to accept the Snap-Tite fittings. The flexible hose was assembled with Snap-Tite nipples on each end. The Snap-Tite fittings on the $1\frac{1}{2}$ inch diameter rods were connected to the Snap-Tite fittings on the flexible hose. The test procedure was as follows:

1. The flexible line assembly shall be pressurized to 235 psig hydrostatic which is the neutron shield tank system design pressure.
2. The pressurized flexible line assembly shall be mounted in a tensile test machine and a gradual load applied to the assembly until there is either a visible indication of leakage (not pressure drop) or the testing machine has reached its limit of travel. The load at which the limiting condition

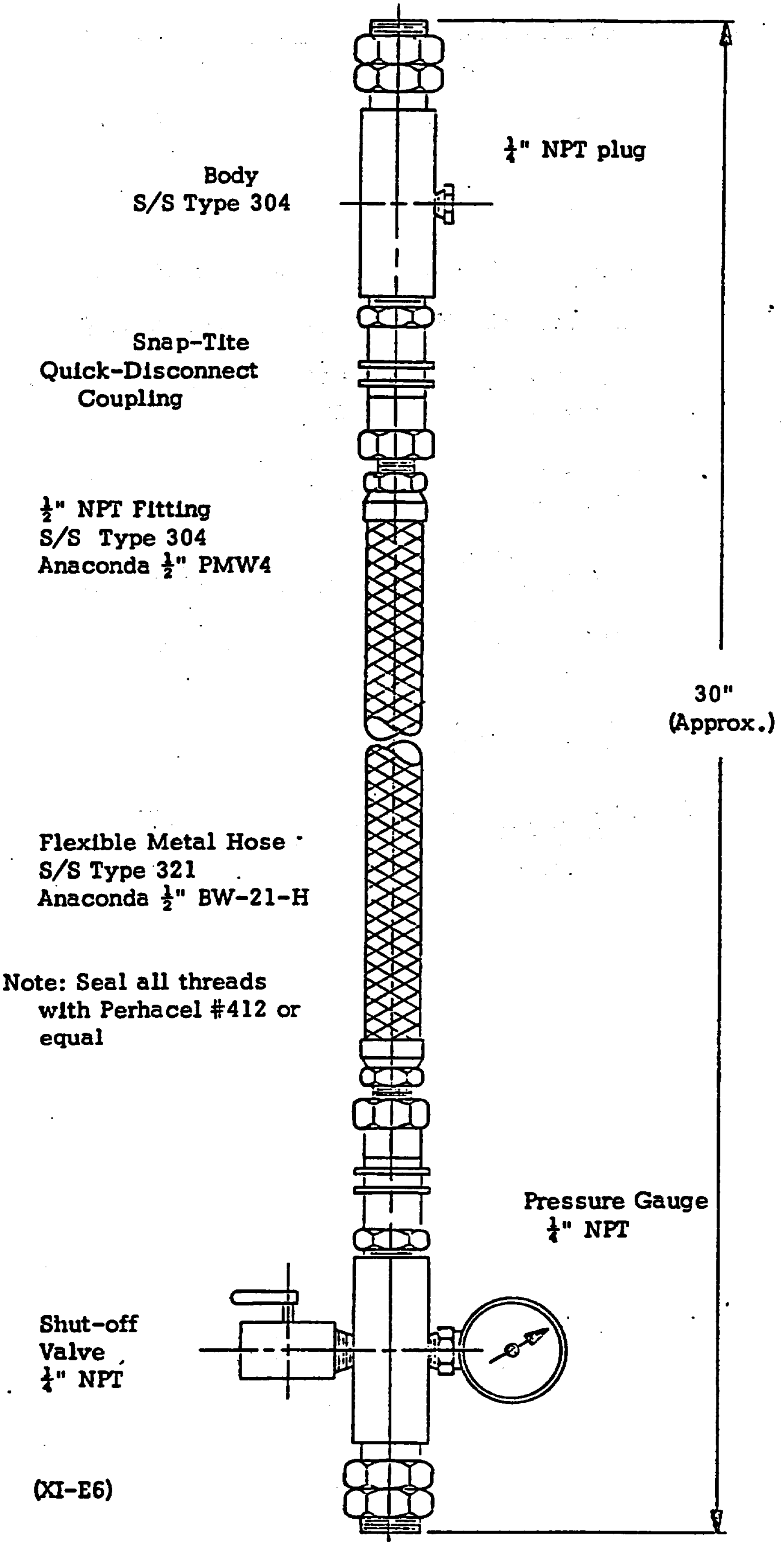
occurs shall be recorded. If failure occurs by leakage, the location of the leak and nature of failure shall be recorded.

Test results:

The pressurized flexible line assembly was mounted in the test machine. A gradual load was applied until the stainless steel wire braid, which covers the corrugated stainless steel tube, failed at one end of the flexible line assembly. At this point, there was no leakage from the flexible line assembly. The force required to break the wire braid outer covering was 4,301 pounds. With the wire braid outer covering broken, the inner corrugated stainless steel tube was free to elongate. The load on the flexible line assembly droped off as a result of the free elongation of the inner corrugated stainless steel tube. As the test machine reached its limit of travel, a load of only 589 pounds could be developed. At this point in the test there still was no leakage from the flexible line assembly, and this assembly had been stretched approximately 10 inches beyond its original length. It was decided to stop the pull test and, with the assembly mounted in the machine, increase the hydrostatic pressure in the flexible line assembly. The pressure was increased in approximately 500 psi increments until the corrugated stainless steel tube ruptured. The tube ruptured at the same location the wire braid failed. The rupture pressure was 1,500 psig. There was no structural damage to the Snap-Tite coupling assemand no evidence of leakage.

Conclusion:

The flexible hose assembly can withstand a great amount of distortion along with over-pressurization without loss of neutron shield water.


¼" NPT plug
Body
S/S Type 304
Snap-Tite
Quick-Disconnect
Coupling
½" NPT Fitting
S/S Type 304
Anaconda ½" PMW4
30"
(Approx.)
Flexible Metal Hose
S/S Type 321
Anaconda ½" BW-21-H
Note: Seal all threads
with Perhacel #412 or
equal
Pressure Gauge
¼" NPT
Shut-off
Valve
¼" NPT

(XI-E6)

APPENDIX F

ANALYSIS OF SHELL BUCKLING IN 81G SIDE DROP

CONTENTS

1. 10/24 CASK AXIAL DIMENSIONS
2. CASK COMPONENT WEIGHTS
3. LOCATION AND MAGNITUDE OF MAXIMUM BENDING MOMENT
4. DISTRIBUTION OF BENDING MOMENT AMONG THE CASK SHELLS
5. COMPUTATION OF MAXIMUM AXIAL COMPRESSIVE STRESS IN THE SHELLS.
6. EVALUATION OF SHELL STABILITY.

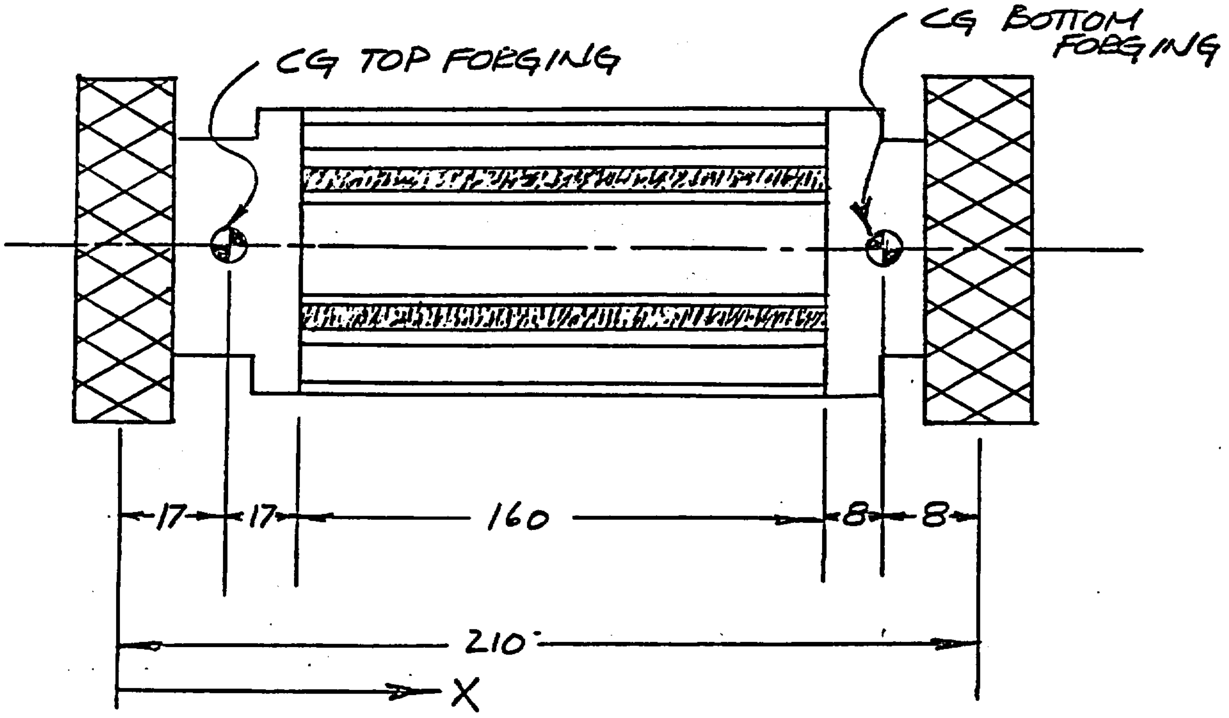
REFERENCES

1. SAFETY ANALYSIS REPORT, NLI 10/24 SPENT-FUEL SHIPPING CASK, FEB. 1976 REVISION.

ANALYSIS FOR SHELL BUCKLING UNDER 81G SIDE DROP

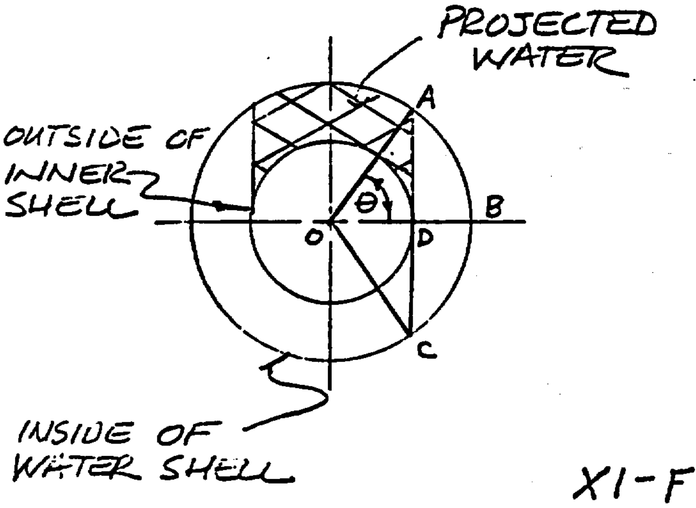
1.0 10/24 CASK AXIAL DIMENSIONS

(REF. 1, p XI-3-59xxx)



2.0 TABLE OF CASK COMPONENT WEIGHTS

2.1 WEIGHT OF PROJECTED WATER ABOVE OUTER SHELL.



$$\theta = \cos^{-1} \frac{\overline{OA}}{\overline{OD}}$$

$$= \cos^{-1} \frac{40.25}{31.25}$$

$$\theta = 39.1°$$

2.1 WEIGHT OF PROJECTED WATER ABOVE OUTER SHELL (CONT.)

AREA OF SECTOR OABC = A_{OABC}

$$A_{OABC} = \pi(40.25)^2\left(\frac{2\cdot 39.1}{360}\right) = 1105.\ IN^2$$

AREA OF TRIANGLE OAC

$$A_{OAC} = 31.25 * 40.25 \sin(39.1°)$$

$$= 793\ IN^2$$

AREA OF SEGMENT ABC

$$A_{ABC} = A_{OABC} - A_{OAC}$$

$$= 312.4\ IN^2$$

AREA OF ANNULUS BETWEEN THE SHELLS (TOTAL WATER AREA)

$$A_W = \pi(40.25^2 - 31.25^2) = 2022\ IN^2$$

AREA OF PROJECTED WATER

$$A_{PW} = \frac{A_W - 2\,A_{ABC}}{2}$$

$$= \frac{2022 - 2 * 312.4}{2}$$

$$\underline{\underline{A_{PW} = 699\ IN^2}}$$

TOTAL WEIGHT PROJECTED WATER

$$W_{PW} = 160 * A_{PW} * \gamma_W$$

$$= 160 * 699 * 0.03611 = 4039\ LB.$$

XI-F3

2.0 TABLE OF CASK COMPONENT WEIGHTS (CONT.)

2.2 FORGING WEIGHTS

CONTENTS	34100. LB.
INNER SHELL	4880.
LEAD	64900.
OUTER SHELL & FINS	20163.
WATER	11676.
WATER SHELL & FINS	16967.
TOTAL	152686.

TOTAL CASK WEIGHT LESS IMPACT ABSORBERS = 195000 LB

FORGING WEIGHT FOR ANALYSIS

$$W_F = 0.5\,(195000 - 152686)$$

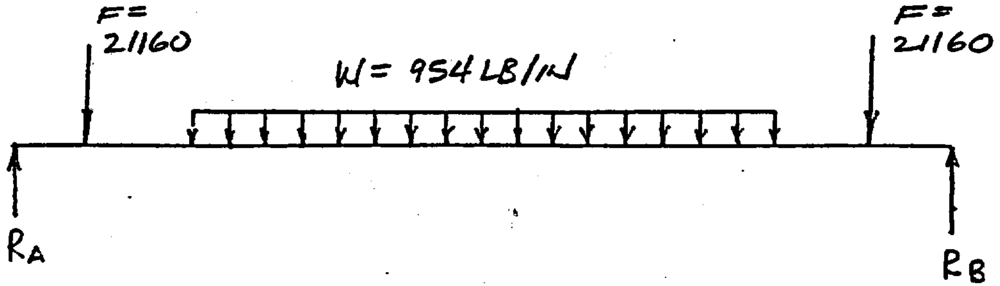
$$\underline{\underline{W_F = 21160\ \text{LB.}}}$$

2.0 TABLE OF CASK COMPONENT WEIGHTS (CONT.)

TABLE 1. CASK COMPONENT WEIGHTS

DESCRIPTION	TOTAL WEIGHT (LB)	WEIGHT PER UNIT AXIAL LENGTH (LB/IN)
CONTENTS	34100	
INNER SHELL	4880	
LEAD	64900	
OUTER SHELL AND FINS	20163	
PROJECTED WATER	4039	
TOTAL OF COMPONENTS ON COMPOSITE	128080.	800.5
WATER ON OUTER SHELL	7637.	
WATER SHELL & FINS	16967.	
TOTAL OF COMPONENTS ON WATER SHELL	24604.	154.0
TOTAL WEIGHTS LESS FORGINGS	152684.	954.0
FORGING (EACH)	21160	
TOTAL WEIGHT OF ANALYZED STRUCTURE	195000.	

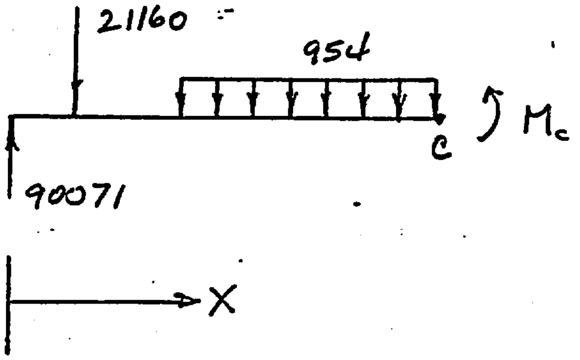
3.0 LOCATION AND MAGNITUDE OF MAXIMUM BENDING MOMENT



$$\Sigma M_A = (17)(21160) + (34+80)(195)(160) + \qquad + M\circlearrowleft$$
$$(21160)(34+8+160) - R_B(210) = 0$$

$R_B = 104929$ LB.

$R_A = 195000 - 104929 = 90071$ LB.



$$\Sigma M_c = M_c - R_A x + F(x-17) + W(x-34)\left(\frac{x-34}{2}\right)$$

$$\frac{dM_c}{dx} = 0 = -R_A + F + Wx - 34W$$

$$= -90071 + 21160 + 954x - 32436$$

$\underline{\underline{x = 106.2 \text{ IN.}}}$ LOCATION OF MAX. MOMENT

TOTAL MOMENT @ $x = 106.2$ IN.

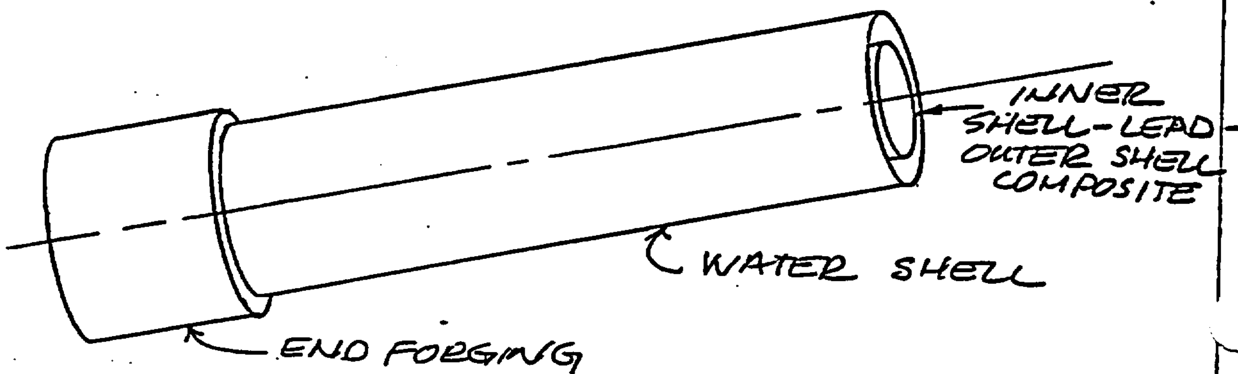
$$0 = M_c - (90071)(106.2) + (21160)(106.2) - (21160)(17)$$
$$+ \left(\frac{954}{2}\right)(106.2)^2 - (34)(954)(106.2) + (578)(954)$$

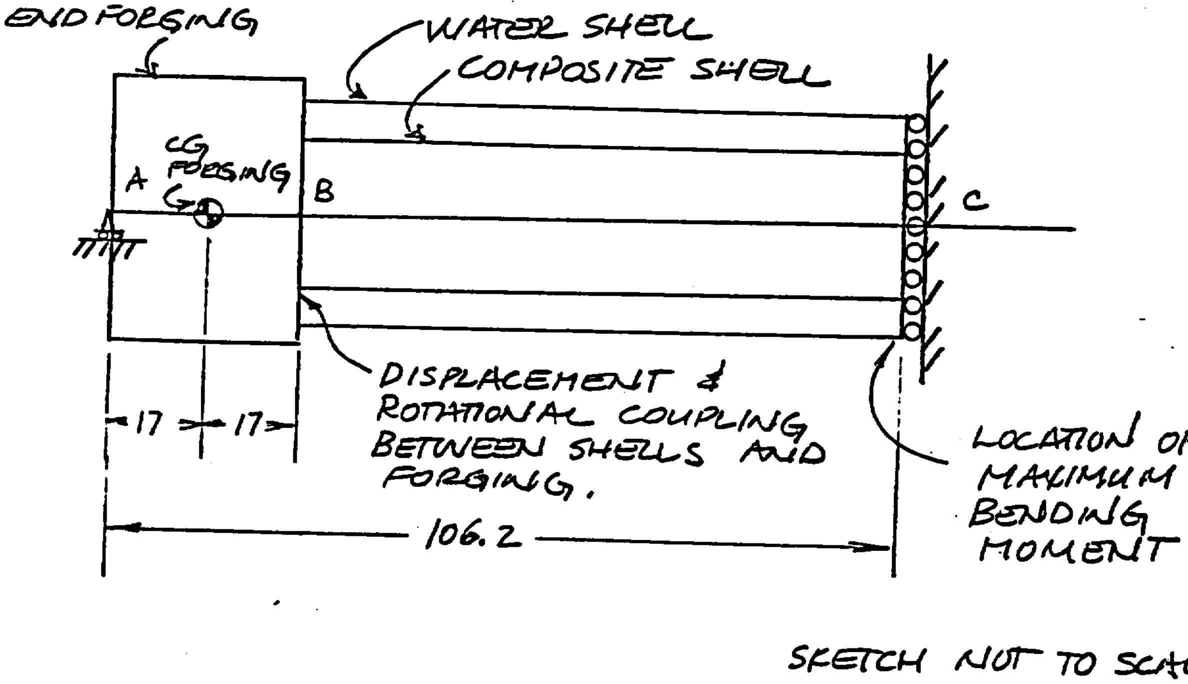
$\underline{\underline{M_c = 5.24\,(10)^6 \text{ IN. LBS.}}}$

X1-F6

4.0 DISTRIBUTION OF BENDING MOMENT AMONG THE CASK SHELLS

TO DETERMINE THE DIVISION OF THE TOTAL BENDING MOMENT TO THE INNER SHELL - LEAD - OUTER SHELL COMPOSITE AND TO THE WATER SHELL, A SMALL ANSYS MODEL WAS DEVELOPED. THE MODEL CONSISTED OF ELASTIC-PLASTIC PIPE ELEMENTS (ANSYS STIF 20). THE CASK WAS SIMULATED BY TWO CONCENTRIC PIPES AS SHOWN IN THE SKETCH BELOW, THE INNER PIPE REPRESENTING THE COMPOSITE AND THE OUTER PIPE REPRESENTING THE WATER SHELL.





SKETCH NOT TO SCALE!

4.0 DISTRIBUTION OF BENDING MOMENT AMONG CASK SHELLS (CONT.)

FROM THE SKETCH OF THE BENDING MODEL, IT IS SEEN THAT THE BOUNDARY CONDITIONS ENFORCED ARE AS FOLLOWS:

1) AT LOCATION A, A PINNED-END WAS ASSUMED (LOCATION A IS AT THE AXIAL CENTER OF THE IMPACT ABSORBER)

2) LOCATION B, THE INTERSECTION OF THE CASK SHELLS WITH THE END FORGING, DISPLACEMENT AND ROTATIONAL COUPLING WAS ENFORCED BETWEEN ALL THREE INTESECTING MEMBERS, i.e., THE FORGING, THE COMPOSITE SHELL, AND THE WATER SHELL.

3) AT THE LOCATION OF THE MAXIMUM BENDING MOMENT, LOCATION C, A ROTATIONAL RESTRAINT WAS ENFORCED. NOTE THAT THIS IS A SLIGHT APPROXIMATION SINCE THE POINT IN THE SHELLS OF ZERO SLOPE AND THE POINT OF MAXIMUM BENDING MOMENT DO NOT COINCIDE EXACTLY. TO BE SURE THAT THIS BOUNDARY CONDITION DID NOT ALTER THE MOMENT IN THE SHELLS, THE TOTAL MOMENT COMPUTED FOR THE SHELLS FROM THE ANSYS MODEL WAS ADJUSTED TO AGREE WITH THE MAXIMUM BENDING MOMENT COMPUTED ABOVE (SEE CORRECTION BELOW).

THE STIFFNESS PARAMETERS OF THE ANSYS ELEMENT USED TO SIMULATE THE COMPOSITE WERE COMPUTED SUCH THAT THE ANSYS ELEMENT HAD THE SAME BENDING CROSS-SECTIONAL INERTIA AS THE COMBINATION OF THE INNER AND OUTER SHELLS;

$$I_{OS} = \frac{\pi}{4}(R_o^4 - R_i^4) = \frac{\pi}{4}(31.25^4 - 29.25^4)$$

$$= 1.74(10)^5 \text{ IN}^4$$

$$I_{IS} \doteq \frac{\pi}{4}(23.25^4 - 22.5^4) = 2.82(10)^4 \text{ IN}^4$$

$$I_{TOTAL} = 1.74(10)^5 + 2.82(10)^4 = 2.023(10)^5 \text{ IN}^4$$

4.0 DISTRIBUTION OF BENDING MOMENT AMONG THE CASK SHELLS (CONT.)

THE WALL THICKNESS OF THE ANSYS COMPOSITE SHELL WAS SELECTED TO YIELD THE TOTAL BENDING INERTIA, I_{TOTAL}. THEREFORE,

$$I_c = \frac{\pi}{4}\left(31.25^4 - R_i^4\right) = 2.023(10)^5$$

$$R_i = 28.9 \text{ IN.}$$

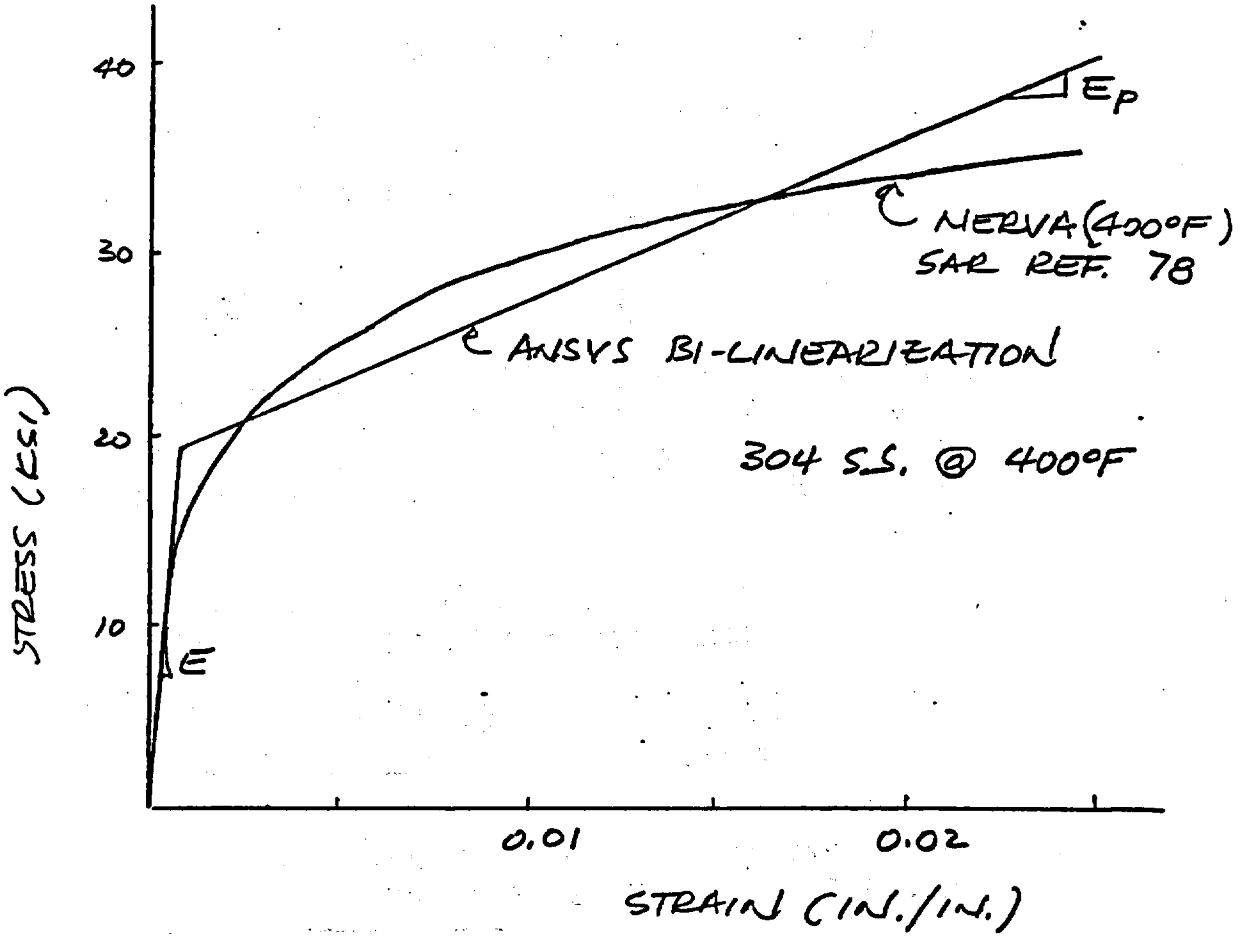
THE WATER SHELL WAS ASSUMED TO BE SIMPLY A 0.75 IN. THICK SHELL WITH O.D. = 41.0 IN, i.e, THE FINS WERE NEGLECTED IN THE SHELL'S STIFFNESS. THIS IS A CONSERVATIVE ASSUMPTION SINCE THE SECOND-ORDER STIFFENING OF THE WATER SHELL BY THE FINS WOULD ENABLE THE SHELL TO SUPPLY MORE RESISTING MOMENT AT POINT B, AND THUS REDUCE THE LOAD ON THE COMPOSITE SHELL,

THE MATERIAL PROPERTIES ASSUMED WERE THAT OF STAINLESS-STEEL AT 400°F. THE ANSYS BI-LINEAR VERSION OF THESE PROPERTIES IS GIVEN IN FIG. 1,

THE LOADING ON THE MODEL CONSISTED OF THE 1G WEIGHTS COMPUTED ABOVE, 800 LB/IN. ON THE COMPOSITE SHELL, 154.0 LB/IN. ON THE WATER SHELL, AND 21160 LB. FOR THE FORGING. THE BENDING MODEL WAS THEN SUBJECTED TO 81G VERTICAL ACCELERATION. ADDITIONAL LOADS IMPOSED CONSISTED OF 235 PSI IN THE WATER CHAMBER AND A 600 PSI SIMULATION OF THE LEAD PRESSURE ON THE COMPOSITE SHELL. FURTHER, A THERMAL STRESS RESULTING FROM THE APPROXIMATE 30°F TEMPERATURE DIFFERENCE BETWEEN THE SHELLS WAS IMPOSED.

4.0 DISTRIBUTION OF BENDING MOMENT AMONG CASK SHELLS (CONT.)

FIGURE 1. STRESS-STRAIN CURVE USED FOR 304 STAINLESS STEEL IN 816 SIDE DROP CALCULATIONS.



ANSYS BI-LINEAR STRESS-STRAIN CURVE FOR SIDE-DROP CALCULATION

T(°F)	σ_y (PSI)	E_p/E
200	18000.	0.0315
300	18000.	0.0321
400	18000.	0.0327
500	18000.	0.0337

4.0 DISTRIBUTION OF BENDING MOMENT AMONG THE CASK SHELLS (CONT.)

THE RESULTS OF THE ANSYS CALCULATION INDICATE THAT THE BENDING MOMENTS ARE DISTRIBUTED AS FOLLOWS;

COMPOSITE; $M_{CS} = 2.67 (10)^8$ IN-LBS.

WATER SHELL; $M_{WS} = 1.55 (10)^8$ IN-LBS.

THE TOTAL MOMENT FROM THIS COMPUTATION IS THEREFORE

$$M_T = 4.22 (10)^8 \text{ IN. LBS.}$$

THIS TOTAL MOMENT IS SLIGHTLY SMALLER THAN THAT COMPUTED BY HAND CALCULATION OF $4.24 (10)^8$ IN. LBS. ADJUSTING THE INDIVIDUAL SHELL MOMENTS, THE FINAL RESULTS ARE;

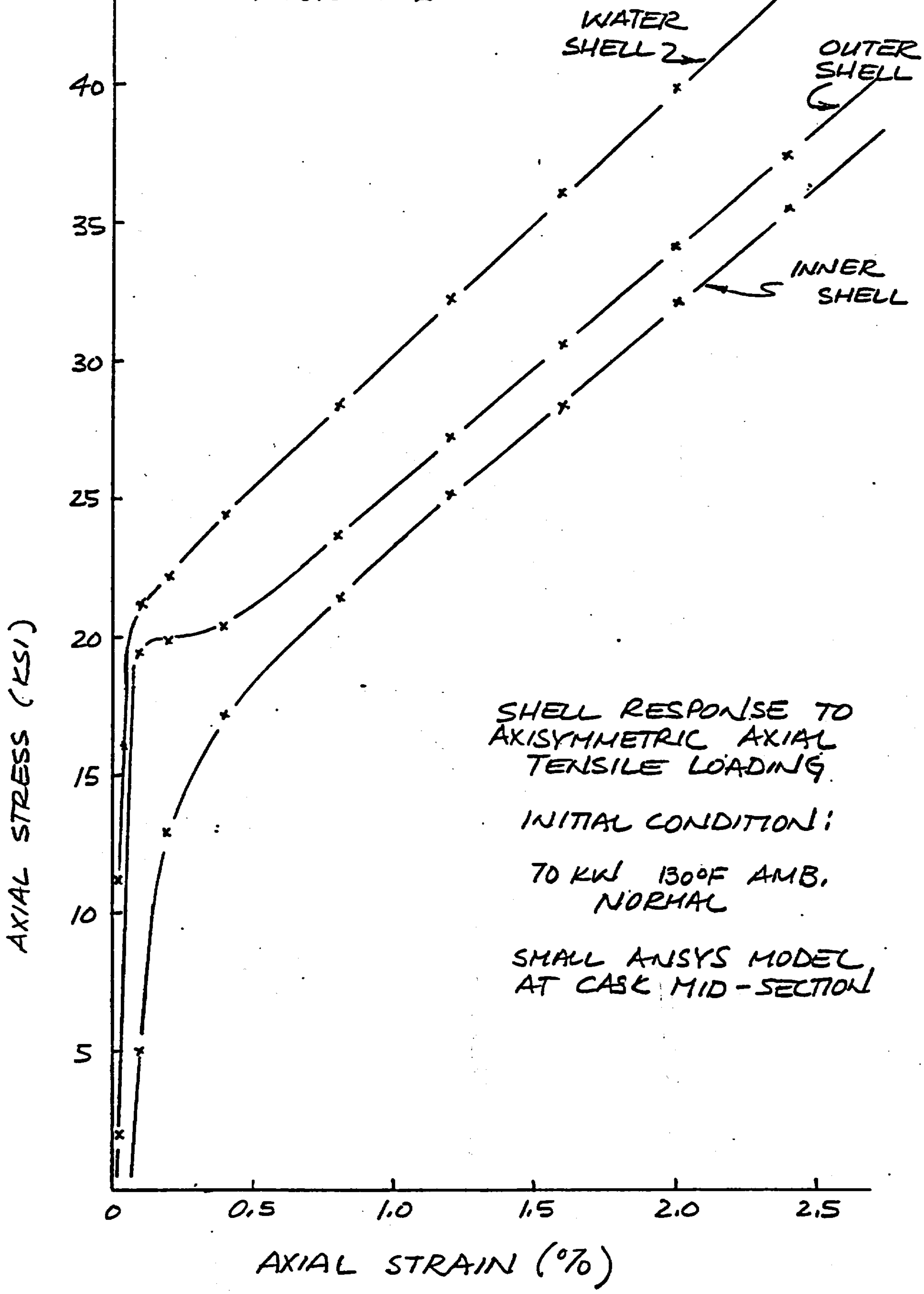
$$\underline{M_{CS} = 2.68 (10)^8 \text{ IN. LBS.}}$$

$$\underline{M_{WS} = 1.56 (10)^8 \text{ IN. LBS.}}$$

5.0 COMPUTATION OF MAXIMUM AXIAL COMPRESSIVE STRESS IN THE INNER AND OUTER SHELL

USING THE SMALL AXISYMMETRIC ANSYS MODEL OF THE CENTER PLANE OF THE CASK (REF. 1, P XI-3-58) THE STRESS-STATE OF THE 70KW 130°F AMB. NORMAL CONDITION WAS FIRST DETERMINED. THEN, IN ADDITION TO THIS LOADING, AXISYMMETRIC AXIAL DISPLACEMENTS WERE IMPOSED IN SMALL INCREMENTS UP TO THE AXIAL STRAIN LEVELS EXPECTED IN THE 81 G SIDE DROP. BOTH TENSILE AND COMPRESSIVE SOLUTIONS WERE EXAMINED. THE STRESS-STRAIN CURVE OF FIG. 1 WAS ALSO USED IN THIS CALCULATION. THE LEAD STRESS-STRAIN CURVES OF REF. 1, FIG. 4.9.6-13 (a) & (b) WERE USED. THE RESULTS OF THESE AXIAL STRAIN CASES ARE PRESENTED IN FIGS. 2 & 3.

FIGURE 2



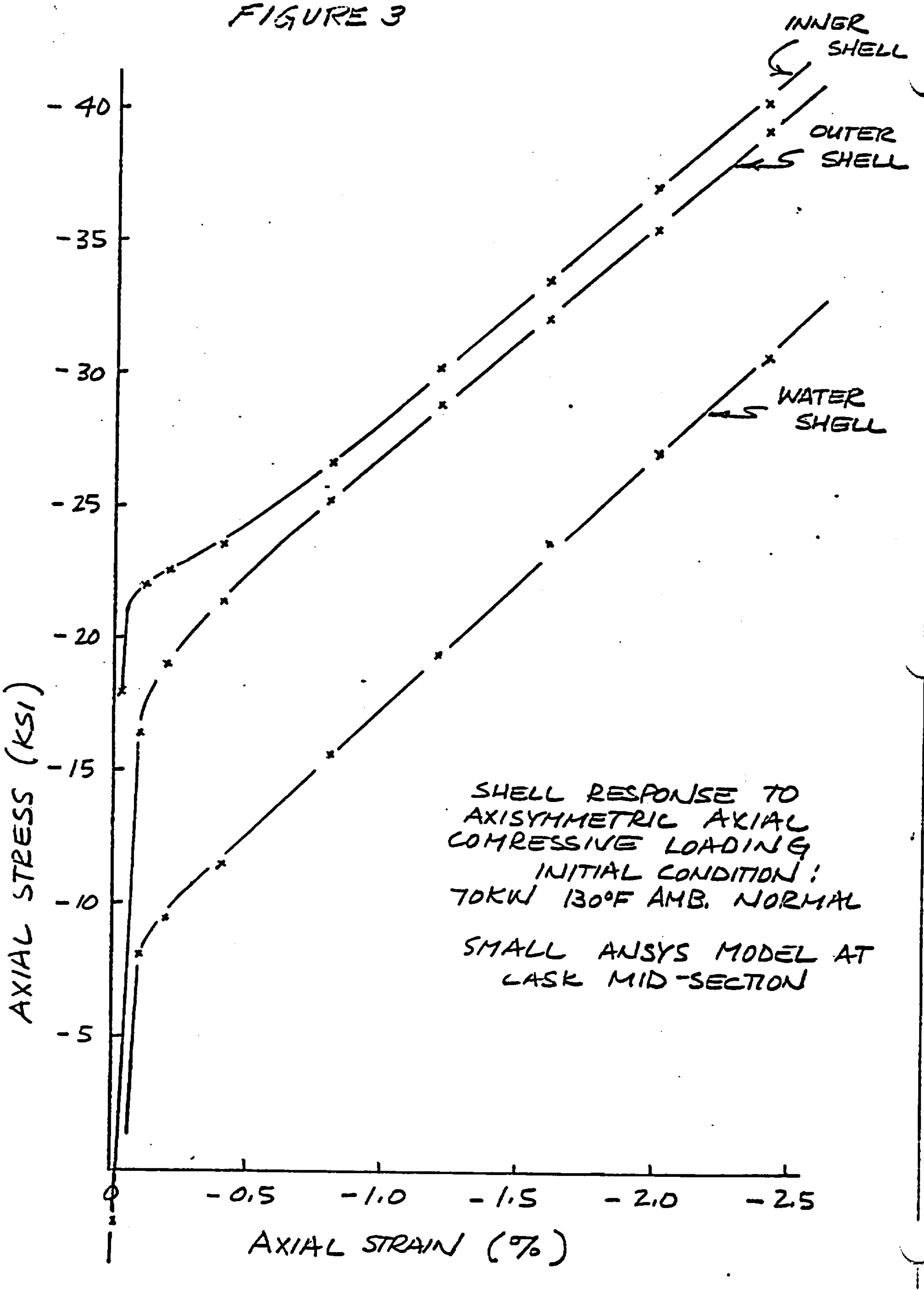
SHELL RESPONSE TO AXISYMMETRIC AXIAL TENSILE LOADING

INITIAL CONDITION:

70 KW 130°F AMB.
NORMAL

SMALL ANSYS MODEL
AT CASK MID-SECTION

FIGURE 3



SHELL RESPONSE TO AXISYMMETRIC AXIAL COMRESSIVE LOADING
INITIAL CONDITION:
70KW 130°F AMB. NORMAL

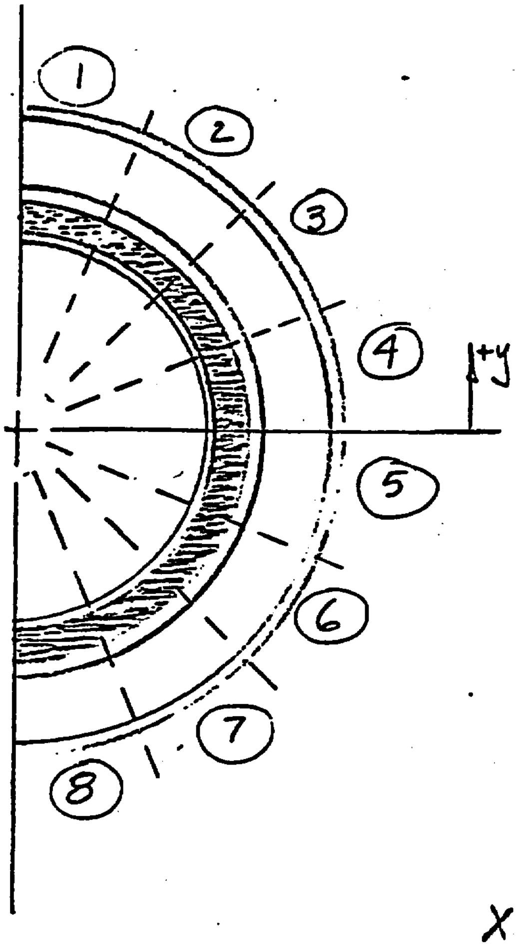
SMALL ANSYS MODEL AT CASK MID-SECTION

5.0 COMPUTATION OF MAXIMUM AXIAL COMPRESSIVE STRESSES IN THE SHELLS (CONT.)

TO DETERMINE THE BENDING STRAINS AT THE CENTER PLANE OF THE CASK, RADII OF CURVATURE WERE ASSUMED FOR THE CASK AXIAL CENTER-LINE. THE STRAINS RESULTING FROM THE ASSUMED RADII OF CURVATURE (A PLANE-SECTION-REMAIN-PLANE ASSUMPTION WAS USED FOR THE COMPOSITE AND SEPARATELY FOR THE WATER SHELL.) WERE USED WITH FIG. 2 & 3 TO DETERMINE THE AXIAL STRESSES. THE AXIAL STRESSES WERE THEN APPROXIMATLY INTEGRATED TO DETERMINE THE RESULTING MOMENT.

THIS APPROXIMATE INTEGRATION WAS COMPLETED BY FIRST DIVIDING A SYMMETRIC HALF OF THE CASK INTO EIGHT EQUAL CIRCUMFERENTIAL SEGMENTS AS SHOWN BELOW. THE STRAINS AND STRESS WERE THEN COMPILED FOR EACH SEGMENT FOR EACH ASSUMED RADIUS OF CURVATURE. THE STEPS OF THE INTEGRATION ARE SUMMARIZED FOR THREE ASSUMED RADII OF CURVATURE IN TABLES 2-4.

THE RESULTS OF THE INTEGRATION WERE NEXT PLOTTED IN FIGS. 4 & 5. THESE FIGURES SHOW THE MOMENT IN THE COMPOSITE AND WATER SHELL VS. CENTER-LINE RADIUS OF CURVATURE.



BENDING MOMENT COMPUTATIONS

$R_c = 1600$ IN.
INITIAL AXIAL STRAIN = −0.000097 IN/IN

SHELL & LOC.	y (IN.)	TOTAL STRAIN IN./IN.	STRESS (KSI)	INCREMENTAL MOMENT (−) IN-LBS
INNER				
1	24.44	−0.01537	−34.2	$5.63\ (10)^6$
2	19.02	−0.01198	−30.2	3.87
3	12.71	−0.00804	−26.8	2.29
4	4.46	−0.00288	−23.0	0.691
5	−4.46	0.00269	14.8	0.445
6	−12.71	0.00785	21.2	1.82
7	−19.02	0.01179	25.1	3.22
8	−24.44	0.01518	27.8	4.58
				$\Sigma\ 2.25(10)^7$
OUTER				
1	29.67	−0.0186	−34.2	$2.41\ (10)^7$
2	25.15	−0.0158	−33.0	1.97
3	16.81	−0.0106	−27.6	1.10
4	5.90	−0.00378	−21.3	0.299
5	−5.90	0.00359	20.2	0.283
6	−16.81	0.0104	25.7	1.03
7	−25.15	0.0156	30.3	1.81
8	−29.67	0.0195	32.8	2.31
				$\Sigma\ 11.21(10)^7$
WATER				
1	39.85	−0.0250	−31.8	$1.52\ (10)^7$
2	33.78	−0.0212	−28.2	1.14
3	22.57	−0.0142	−21.3	0.575
4	7.93	−0.00505	−13.0	0.123
5	−7.93	0.00486	25.3	0.296
6	−22.57	0.0140	34.0	0.918
7	−33.78	0.0210	40.6	1.64
8	−39.85	0.0248	44.8	2.10
				$\Sigma\ 8.31(10)^7$

TOTAL SUM FOR THREE FULL SHELLS

$\bar{M} = 4.35\ (10)^8$ IN-LBS

TABLE 3

BENDING MOMENT COMPUTATIONS

$R_c = 1800$ IN.
INITIAL AXIAL STRAIN = -0.000097 IN/IN

SHELL # LOC.	Y (IN.)	TOTAL STRAIN IN./IN.	STRESS (KSI)	INCREMENTAL MOMENT (-) IN-LBS
INNER				
1	24.44	-0.01367	-30.8	5.07 $(10)^6$
2	19.02	-0.01066	-28.6	3.66
3	12.71	-0.00716	-26.0	2.23
4	4.46	-0.00257	-22.7	0.682
5	-4.46	0.00238	14.2	0.427
6	-12.71	0.00696	20.2	1.73
7	-19.02	0.01047	23.8	3.05
8	-24.44	0.01348	26.2	4.31
				Σ 2.12 $(10)^7$
OUTER				
1	29.67	-0.01658	-32.7	2.31 $(10)^7$
2	25.15	-0.01407	-30.5	1.82
3	16.81	-0.00944	-26.2	1.05
4	5.90	-0.00337	-20.6	0.289
5	-5.90	0.00318	20.2	0.283
6	-16.81	0.00924	24.8	0.990
7	-25.15	0.01388	29.0	1.73
8	-29.67	0.01639	31.0	2.19
				Σ 10.6 $(10)^7$
WATER				
1	39.85	-0.02224	-29.5	1.41 $(10)^7$
2	33.78	-0.01886	-25.8	1.04
3	22.57	-0.01264	-20.0	0.540
4	7.93	-0.00450	-12.2	0.116
5	-7.93	0.00431	24.8	0.235
6	-22.57	0.01244	33.5	0.904
7	-33.78	0.01867	38.5	1.56
8	-39.85	0.02204	41.6	1.98
				Σ 7.79 $(10)^7$

TOTAL SUM FOR THREE FULL SHELLS

$\bar{M} = 4.10(10)^8$ IN-LBS

Rev: TRB 4 MAY 76 | TABLE 4 | JHA-74-1c | 5/76

BENDING MOMENT COMPUTATIONS

$R_c = 2031.5$ IN.
INITIAL AXIAL STRAIN = -0.000097 IN/IN

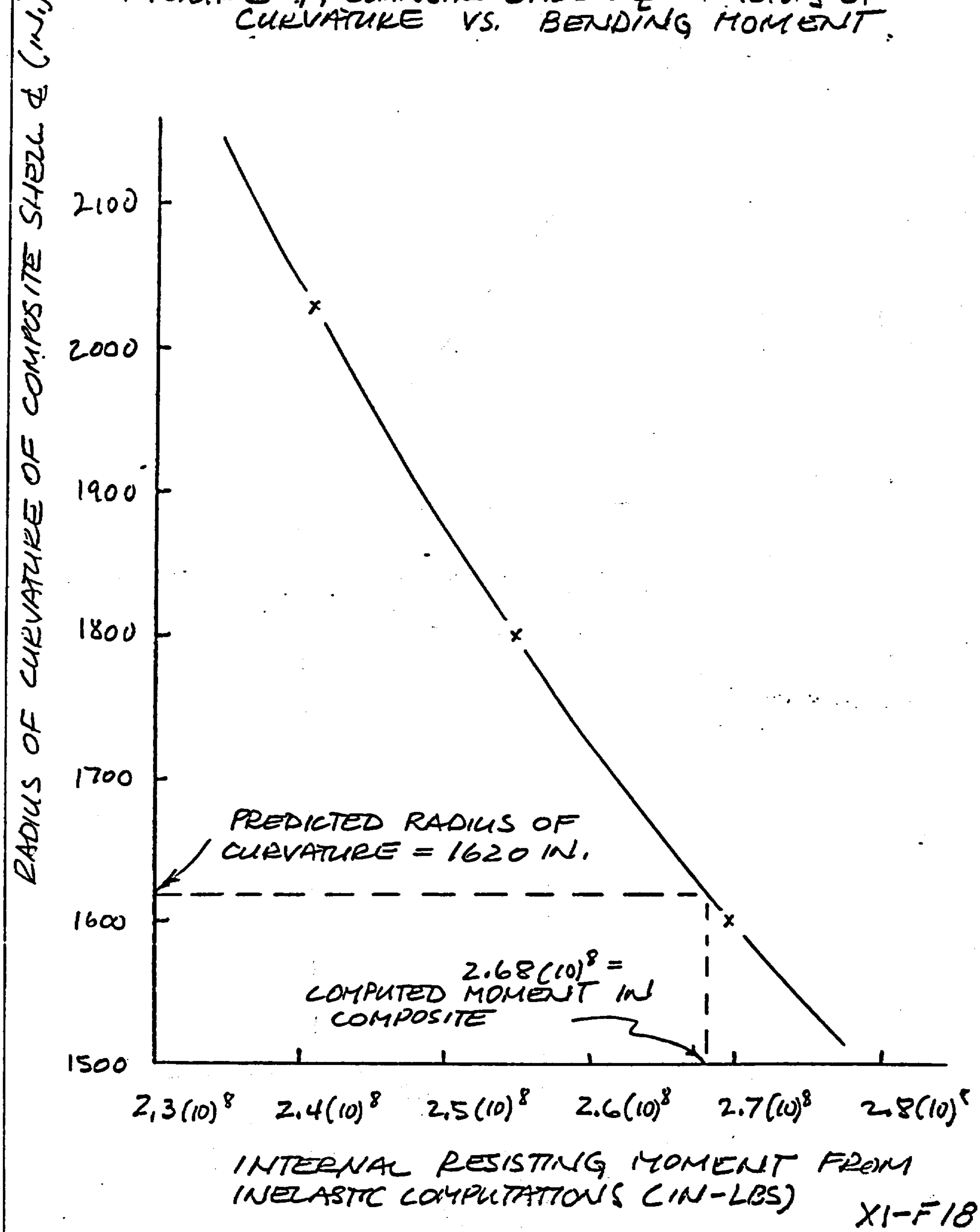
SHELL & LOC.	y (IN.)	TOTAL STRAIN IN/IN	STRESS (KSI)	INCREMENTAL MOMENT (-) IN-LBS
INNER				
1	24.44	-0.01210	-30.2	$4.98(10)^6$
2	19.02	-0.00946	-27.8	3.57
3	12.71	-0.00635	-25.5	2.19
4	4.46	-0.00229	-22.8	0.686
5	-4.46	0.00210	13.6	0.409
6	-12.71	0.00616	19.6	1.68
7	-19.02	0.00927	22.3	2.86
8	-24.44	0.01190	25.0	4.12
				$\Sigma\ 2.05(10)^7$
OUTER				
1	29.67	-0.01470	-31.0	$2.19(10)^7$
2	25.15	-0.01248	-29.0	1.73
3	16.81	-0.00837	-25.8	1.03
4	5.90	-0.00300	-20.4	0.286
5	-5.90	0.00281	20.1	0.282
6	-16.81	0.00818	22.0	0.879
7	-25.15	0.01228	25.2	1.51
8	-29.67	0.01451	29.4	2.07
				$\Sigma\ 9.98(10)^7$
WATER				
1	39.85	-0.01971	-26.8	$1.28(10)^7$
2	33.78	-0.01673	-23.8	0.962
3	22.57	-0.01121	-18.6	0.502
4	7.93	-0.00400	-11.5	0.109
5	-7.93	0.00381	24.5	0.232
6	-22.57	0.01101	31.1	0.840
7	-33.78	0.01653	36.3	1.47
8	-39.85	0.01952	39.3	1.87
				$\Sigma\ 7.27(10)^7$

TOTAL SUM FOR THREE FULL SHELLS

$\bar{M} = 3.86(10)^8$ IN-LBS

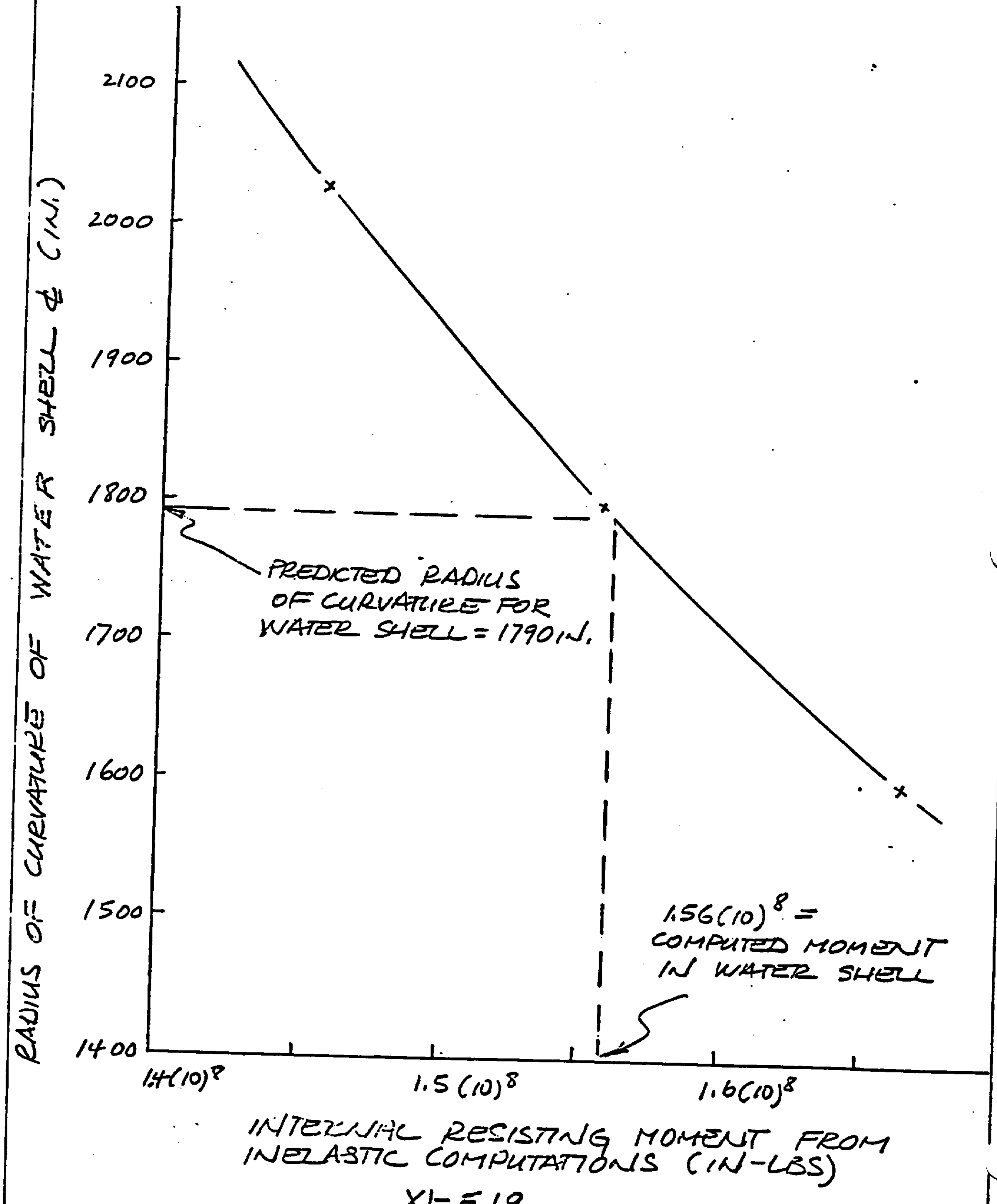
5.0 COMPUTATION OF MAXIMUM AXIAL COMPRESSIVE STRESS IN THE INNER AND OUTER SHELLS. (CONT.)

FIGURE 4, COMPOSITE SHELLS ℄ RADIUS OF CURVATURE VS. BENDING MOMENT.



5.0 COMPUTATION OF MAXIMUM COMPRESSIVE STRESSES IN THE SHELLS. (CONT.)

FIGURE 5. WATER SHELL ℄ RADIUS OF CURVATURE VS. BENDING MOMENT



5.0 COMPUTATION OF MAXIMUM AXIAL COMPRESSIVE STRESS IN THE INNER SHELL AND OUTER SHELL. (CONT.)

FOR THE INNER SHELL - LEAD - OUTER SHELL COMPOSITE, FIG 4 SHOWS THE COMPUTED RADIUS OF CURVATURE TO BE 1620 IN. FROM TABLE 2 THE MAXIMUM COMPRESSIVE STRESSES IN THE SHELLS ARE THEREFORE COMPUTED TO BE APPROXIMATELY:

INNER SHELL, $\sigma_x = -34,200$ PSI
OUTER SHELL, $\sigma_x = -34,200$ PSI

FOR THE WATER SHELL THE RADIUS OF CURVATURE IS SHOWN TO BE 1790 IN. IN FIG, 5. TABLE 3 YIELDS THE MAXIMUM COMPRESSIVE STRESS IN THE WATER SHELL TO BE APPROXIMATELY:

WATER SHELL, $\sigma_x = -29500$ PSI

6.0 EVALUATION OF SHELL STABILITY

THE BUCKING CALCULATION FOR THE AXIALLY LOADED COMPOSITE OF REF. 1, p. XI-4-121mm, WAS REPEATED USING SLIGTLY CORRECTED INPUT VALUES. IN THE COMPUTATION THE DEFORMATION FORMULATION OF REF. 1 APPENDIX C WAS USED. THE INPUT TO BUCKLING COMPUTATION IS SHOWN IN TABLE 5. IN THE COMPUTATION THE AXIAL HALF-WAVE-LENGTH AND THE NUMBER OF CIRCUMFERENTIAL WAVES WAS VARIED TO INSURE THE MINIMUM CRITICAL STRESS WAS FOUND,

THE RESULTS OF THE BUCKLING EVALUATION INDICATE THAT THE CRITICAL AXIAL STRESS IS 39.7 KSI, AND CORRESPONDS TO AN AXISYMMETRIC MODE WITH AXIAL HALF-WAVE-LENGTH OF 9.0 IN,

REFERENCE 1, pp. XI-4-121ii & 121jj INDICATES THE WATER SHELL IS NOT UNSTABLE DUE TO BUCKLING AT A COMPRESSIVE STRESS OF THE COMPUTED VALUE OF $\sigma_x = -29500$ psi. THE INDICATED CRITICAL STRESS FOR AXIAL BUCKLING IS -39200 psi.

6.0 EVALUATION OF SHELL STABILTY

TABLE 5. PARAMETERS OF BUCKLING COMPUTATION

	INNER SHELL	LEAD	OUTER SHELL
HOOP STRESS	-18200	-600.	7250.
AXIAL STRESS	$-p^{(1)}$	-810	$-p^{(1)}$
RADIAL STRESS	-300.	-600.	-420.
TEMPERATURE ASSUMED FOR PROPERTIES	400°F	450°F	400°F
TANGENT SLOPE	EMPIRICAL CURVE	2000 PSI (3)	EMPIRICAL CURVE
SECANT SLOPE	EMPIRICAL CURVE	10000 PSI (3)	EMPIRICAL CURVE

NOTES (1) THE AXIAL LOAD IN THE SHELLS WAS TAKEN AS THE LOADING PARAMETER,

(2) & (3) SEE NOTES REF. 1 pp. XI-4-121 mm & nn.

DUE TO USE OF STATIC PROPERTIES FOR THE LEAD, THE BUCKLING COMPUTATION ABOVE IS VERY CONSERVATIVE, i.e, IF DYNAMIC STIFFENING FOR THE LEAD WAS ASSUMED, THE PREDICTED CRITICAL BUCKLING VALUE WOULD BE INCREASED SIGNIFICANTLY.

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APPENDIX G

BUCKLING UNDER PUNCTURE TEST CONDITIONS

LEAD PRESSURE DUE TO 800 PSI WATER PRESS.

THE SMALL AXISYMMETRIC ANSYS MODEL OF THE CASK SHELLS (SEE SAR P. XI-3-58) WAS USED TO DETERMINE THE STATE OF STRESS AND STRAIN IN THE CASK FOR THE NORMAL CONDITIONS OF TRANSPORT, 70 KW, 130°F AMB WITH 800 PSI IN THE WATER CHAMBER. THIS CASE SIMULATED THE AXISYMMETRIC PART OF THE PIN-PUNCTURE LOADING. THE STRESS-STRAIN CURVES OF SAR, FIG. 3.8.3-11 FOR STAINLESS-STEEL AND SAR, FIG. 4.9.6-13(a)&(b) FOR LEAD WERE USED IN THIS COMPUTATION. THE LEAD PRESSURE RESULTING FROM THIS COMPUTATION WAS 732 PSI. (THIS IS THE SAME COMPUTATION PRESENTED AT THE NLI-NRC MEETING OF 15 APRIL '76.)

TO INCLUDE THE AXIAL STRESSES THA RESULT FROM THE 7.07G LATERAL LOAD OF THE PIN-PUNCTURE, THE METHOD AND DATA FROM THE 81G, 30 FT. SIDE-DROP EVALUATION PRESENTED AT THE NL-NRC 15 APRIL MEETING WAS USED. THE APPROACH WAS TO ASSUME SOME LARGE RADIUS OF CURVATURE FOR THE CASK CENTER-LINE AND THEN TO COMPUTE THE RESULTING INTERNAL MOMENT. THE RADIUS OF CURVATURE ASSUMED WAS 8000 IN. AND THE RESULTING MOMENT WAS $2.68(10)^8$ IN-LBS. TABLE 1 PRESENTS THIS COMPUTATION. THE REQUIRED MOMENT FOR THE 7.07G LOADING IS APPROXIMATLY $3.7(10)^7$ IN-LBS. THEREFORE, THE STRESSES RESULTING FROM THE ASSUMED 800.0 IN. RADIUS ARE CONSERVATIVE. THE AXIAL COMPRESSIVE STRESSES DEVELOPED FROM THIS COMPUTATION ARE:

INNER SHELL $\sigma_x = -23000$ psi

OUTER SHELL $\sigma_x = -21200$ psi

BUCKLING UNDER THE PUNCTURE TEST CONDITIONS (CONT.)

BUCKLING CALCULATION

THE BUCKLING CALCULATION FOR THE CASK SHELLS UNDER 70KW 130°F NORMAL, 800 psi WATER CHAMBER AND > 7.07G AXIAL COMPRESSIVE LOADS WAS COMPLETED USING THE THEORETICAL DEVELOPMENT OF SAR SECTION XI, APPENDIX C. THE ISOTROPIC MODULI DETERMINATION WAS USED FOR THE LEAD IN THIS EVALUATION. THE PARAMETERS OF THE BUCKLING SOLUTION ARE GIVEN BELOW:

	INNER	LEAD	OUTER
HOOP STRESS (PSI)	-P*22.9/0.75	-P(1)	(P-800)*30.25/2.0
AXIAL STRESS	-23000.(2)	-P	-21200.
RADIAL STRESS	-P/2.0	-P	-(P+800.)/2.0
TEMPERATURE	413°F	400°F	350°F
TANGENT SLOPE	EMPIRICAL CURVE(3)	1400 psi(4)	EMPIRICAL CURVE(3)

NOTES:

(1) THE LEAD PRESSURE WAS CONSIDERED THE LOADING PARAMETER.

(2) ANSYS RESULTS FOR SHALL MODEL AND BENDING CALCULATIONS DESCRIBED ABOVE

(3) SEE NOTE 3, SAR P. XI-3-59 a

(4) SEE NOTE 3, SAR P. XI-3-59 a

IN THE BUCKLING SOLUTION, THE NUMBER OF CIRCUMFERENTIAL WAVES AND THE NUMBER OF AXIAL WAVES WAS VARIED TO INSURE THAT A MINIMUM VALUE OF CRITICAL PRESSURE WAS FOUND.

THE CRITICAL PRESSURE WAS FOUND TO BE 810 psi @ AXIAL HALF WAVE LENGTH OF 160 IN. AND 6 CIRCUMFRENTIAL WAVES.

BUCKLING UNDER THE PUNCTURE TEST CONDITIONS (CONT.)

ALTHOUGH THIS EXACT ANALYSIS WAS NOT REPEATED USING THE DEFORMATION MODULI FORMULATION OF THE BUCKLING THEORY, THE RESULTS OF SIMILAR DEFORMATION THEORY CALCULATIONS SHOW THE CRITICAL STRESS IS INCREASED BY A SIGNIFICANT FACTOR OVER THE COMPARABLE ISOTROPIC THEORY CALCULATION.

TABLE 1

BENDING MOMENT COMPUTATION 7.07 g PIN PUNCTURE LOADING

R_c = 8000. IN.

INITIAL AXIAL STRAIN = −0.000097 IN/IN

SHELL & LOC.	Y (IN.)	TOTAL STRAIN IN/IN	STRESS (KSI)	INCREMENTAL MOMENT (−)
INNER				
1	24.44	−0.0032	−23.0	$3.79(10)^6$
2	19.02	−0.0025	−22.7	2.91
3	12.71	−0.0017	−22.3	1.91
4	4.46	−0.0007	−21.5	0.15
5	−4.46	0.0005	~0.	~0.
6	−12.71	0.0015	11.0	0.94
7	−19.02	0.0023	13.5	1.73
8	−24.44	0.0030	15.0	2.47
				$\Sigma\ 1.39(10)^7$
OUTER				
1	29.67	−0.0038	−21.2	$1.54(10)^7$
2	25.15	−0.0032	−20.5	1.27
3	16.81	−0.0022	−19.5	0.81
4	5.90	−0.0008	−13.5	0.20
5	−5.90	0.0006	17.0	0.25
6	−16.81	0.0020	20.0	0.83
7	−25.15	0.0032	20.0	1.23
8	−29.67	0.0036	20.1	1.46
				$\Sigma\ 7.54(10)^7$
WATER				
1	39.85	−0.0051	−12.8	$6.10(10)^6$
2	33.78	−0.0043	−12.0	4.85
3	22.57	−0.0029	−10.7	2.89
4	7.93	−0.0011	−8.5	0.81
5	−7.93	0.0009	20.4	1.93
6	−22.57	0.0027	23.2	6.27
7	−33.78	0.0041	24.8	10.00
8	−39.85	0.0049	25.2	12.02
				$\Sigma\ 4.99(10)^7$

TOTAL FOR THREE FULL SHELLS

$\bar{M} = 2.68(10)^8$ IN-LBS

REQ'D 7.07g MOMENT = $3.67(10)^7$ IN-LBS

PIN-PUNCTURE LOADING - DESIGN CRITERIA

PRIMARY STRESS CRITERIA, Sc 3

FOR THE GENERAL CASK LOADINGS OF THE PIN-PUNCTURE i.e., 7.07G AND 800psi IN THE WATER CHAMBER, THE PRIMARY STRESSES WERE COMPUTED AND COMPARED TO THE 0.7 S_u ALLOWABLE STRESS. THIS CALCULATION IS SUMMARIZED IN TABLES 2(a)&(b). AS INDICATED ON SAR PAGE XI-1-76, THE CRITERIA DOES NOT REQUIRE THE LOCAL EFFECTS OF THE PIN-PUNCTURE TO BE ADDRESSED BY A PRIMARY STRESS CRITERION,

PRIMARY PLUS SECONDARY STRESS RANGE CALCULATION, S

TO SIMULATE THE LOCAL STRESS FROM THE PIN-PUNCTURE AN ADDITIONAL LOAD CASE WAS INTRODUCED WHICH CONSIDERED THE PIN TO EXERT 50000psi (THE PIN MATERIAL'S STRENGTH) AT THE MID-CASK OUTER SURFACE OF THE INNER AND OUTER SHELLS. IN TABLE 3, THE BASE CASE STRESSES ARE LISTED FOR ALL LOADINGS, INCLUDING THE PIN STRESS, CASE 15 AT LOCATIONS 12 AND 14 (SEE SAR FIG. 3.8.4-15 & 16), WHERE THE STRESS APPEARS AS A COMPRESSIVE RADIAL COMPONENT. (NOTE THAT THE OTHER STRESSES APPEARING IN TABLE 3 ARE IDENTICAL TO THOSE OF SAR TABLE 3.8.4-2.)

THE LOADING CASES CONSIDERED IN THE NORMAL OPERATION OF THE CASK AND THE ACCIDENT CONDITIONS ARE LISTED IN TABLE 4. LOAD CASES 26, 30, 34, 35, 36 AND 37 ARE DIFFERENT COMBINATIONS OF THE PIN PUNCTURE ALONG WITH THE DIFFERENT HEAT LOADS AND AMBIENT CONDITIONS.

NOTE, IN THIS TABLE 4, THE 50000psi PIN LOAD IS COMBINED WITH ONLY THE -7.07G AXIAL BENDING LOAD IN CASES 26, 30 & 34. IN CASES 35, 36 & 37, THE +7.07G AXIAL BENDING IS CONSIDERED

PIN - PUNCTURE - DESIGN CRITERIA (CONT.)

WITHOUT THE RADIAL PIN PRESSURE. ALSO, TABLE 4 CONSIDERS ONLY THE -81G, 30 FT. DROP LOADING CASES IN THE RANGE CONSIDERATIONS. ANOTHER RANGE CALCULATION OF RANGE WAS MADE USING THE +81G BENDING LOADING BUT NO LARGER STRESS RANGES WERE FOUND. THE TWO SIGNS OF THE 81G BENDING WERE NOT INCLUDED IN THE SAME RANGE CALCULATION SINCE IF THEY WERE BOTH INCLUDED IT IMPLIES THAT THE CASK IS SUBJECTED TO TWO 30 FT. DROP LOADINGS.

THE RESULTS OF THIS STRESS RANGE CALCULATION ARE GIVEN IN TABLE 5. THE MAXIMUM STRESS RANGE FOR THE OUTSIDE OF THE OUTER SHELL (LOCATION 14) IS 103274 psi, FOR THE OUTSIDE OF THE INNER SHELL (LOCATION 12) 98601 psi. NEITHER OF THESE STRESS RANGES EXCEEDS THE MAXIMUM STRESS RANGE THAT OCCURS AT LOCATION 26 OF 123560 PSI. SINCE ALL POINTS IN THE CASK WERE CONSIDERED IN THE RANGE EVALUATION, THE REPORTED MAXIMUM RANGE CONSIDERS ALL POINTS IN THE CASK, NOT JUST THE POINTS EXCEEDING THE ALTERNATE 1 STRESS ALLOWABLE.

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TABLE 2(a)

ACCIDENT PRIMARY STATIC AND DYNAMIC STRESS EVALUATION

BASE CASE	MULTIPLIER	BASE CASE DESCRIPTION
9	8.00000	100 PSI WATER CHAMBER
10	.16500	100 PSI CAVITY
11	7.07000	1.0 G SIDE DROP

LOCATION	EFFECTIVE STRESS	TEMP.	STRESS ALLOWABLES 0.9SY	0.7SU	0.9SU
1	4544	268	21028	45465	58455
3	3855	248	21395	45990	59130
5	9967	218	21945	46777	60142
7	8606	316	20148	44205	56835
9	7641	303	20336	44546	57274
11	10266	420	18389	41895	53865
13	8801	359	19359	43076	55384
15	38375	323	20019	44021	56599
17	8061	302	20405	44572	57307
19	6545	290	20625	44887	57712
21	6500	292	20588	44835	57645
23	7981	271	20973	45386	58354
25	4070	241	21523	46174	59366
27	9730	218	21945	46777	60142
29	463	260	21175	45675	58725
31	1790	256	21248	45780	58860
33	2057	240	21541	46200	59400

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TABLE 2(b)

ACCIDENT PRIMARY STATIC AND DYNAMIC STRESS EVALUATION

BASE CASE	MULTIPLIER	BASE CASE DESCRIPTION
9	8.00000	100 PSI WATER CHAMBER
10	.16500	100 PSI CAVITY
11	-7.07000	1.0 G SIDE DROP

LOCATION	EFFECTIVE STRESS	TEMP.		STRESS ALLOWABLES	
			0.9SY	0.7SU	0.9SU
1	4572	268	21028	45465	58455
3	1973	248	21395	45990	59130
5	6228	218	21945	46777	60142
7	6433	316	20148	44205	56835
9	5018	303	20386	44546	57274
11	7862	420	18389	41895	53865
13	4992	359	19359	43076	55384
15	40150	323	20019	44021	56599
17	6759	302	20405	44572	57307
19	5909	290	20625	44887	57712
21	6500	292	20588	44835	57645
23	6573	271	20973	45386	58354
25	3047	241	21523	46174	59366
27	6968	218	21945	46777	60142
29	1887	260	21175	45675	58725
31	1790	256	21248	45780	58860
33	2057	240	21541	46200	59400

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TABLE 3

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
1	1	0	0	0	0
1	2	-0	38589	13740	-0
1	3	-0	30352	11074	-0
1	4	-16	21994	-5604	0
1	5	0	21696	8599	0
1	6	-16	17703	-26774	0
1	7	-0	-3621	-1032	-0
1	8	-0	-1086	-47	-0
1	9	-0	-555	-531	-0
1	10	-100	1964	968	-0
1	11	-0	204	-0	-0
1	12	-15	39188	5827	0
1	13	-16	35788	1688	0
1	14	-16	34561	-19753	0
1	15	0	0	0	0
2	1	0	0	0	0
2	2	1510	-20457	-8491	-791
2	3	1276	-17360	-7076	-588
2	4	322	-44706	-29619	-262
2	5	1408	-10115	-4022	-456
2	6	580	-80532	-61123	41
2	7	-174	-2582	-722	68
2	8	-82	-626	98	52
2	9	-109	-69	-343	63
2	10	102	-299	153	-58
2	11	-0	204	-0	-0
2	12	1455	-34616	-21073	-606
2	13	1200	-42980	-26541	-382
2	14	-200	-75403	-58354	291
2	15	0	0	0	0
3	1	0	0	0	0
3	2	2505	-19246	-9884	769
3	3	1303	-14883	-7620	579
3	4	127	3881	-5672	234
3	5	1504	-14795	-12401	474
3	6	-466	16383	-10535	-72
3	7	-520	695	-32	-136
3	8	67	-233	103	26
3	9	50	-138	-340	14
3	10	-90	-114	211	-38

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
3	11	-0	278	-0	-0
3	12	1158	-10397	-9797	730
3	13	-189	-4345	-7474	20
3	14	-1161	18652	-13302	-213
3	15	0	0	0	0
4	1	0	0	0	0
4	2	-0	13690	1722	-0
4	3	-0	10893	1448	-0
4	4	-235	-4556	-2365	0
4	5	0	8535	1138	0
4	6	0	-25280	-15429	0
4	7	0	-11812	-3669	-0
4	8	-0	-932	-102	-0
4	9	-100	72	-263	-0
4	10	-0	418	380	-0
4	11	-0	278	-0	-0
4	12	-14	4542	84	0
4	13	-33	319	902	0
4	14	0	-38661	-23438	0
4	15	0	0	0	0
5	1	0	0	0	0
5	2	-0	-1150	-443	-0
5	3	-0	-919	-377	-0
5	4	-235	36467	10384	0
5	5	0	-884	3012	0
5	6	0	20846	20101	0
5	7	-0	-5297	-716	-0
5	8	-0	-3339	-509	-0
5	9	-100	8831	2572	-0
5	10	-0	-25	61	-0
5	11	-0	274	-0	-0
5	12	-14	10775	-2449	0
5	13	-33	14221	5449	0
5	14	0	35048	18925	0
5	15	0	0	0	0
6	1	0	0	0	0
6	2	-0	-925	-375	-0
6	3	-0	-677	-265	-0
6	4	0	-22338	-7258	0
6	5	0	3684	4382	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
6	6	0	21075	20170	0
6	7	-0	850	1129	-0
6	8	-0	298	583	-0
6	9	-0	-6682	-2082	-0
6	10	-0	160	116	-0
6	11	-0	274	-0	-0
6	12	0	-5549	-1914	0
6	13	0	-5117	-352	0
6	14	0	12092	12038	0
6	15	0	0	0	0
7	1	0	0	0	0
7	2	-0	-875	39789	-0
7	3	-0	-791	29377	-0
7	4	-16	-14465	-10039	0
7	5	0	-358	25802	0
7	6	-16	-28860	-32165	0
7	7	-0	-3722	-964	-0
7	8	-0	-860	-19	-0
7	9	-0	136	-897	-0
7	10	-100	458	957	-0
7	11	-0	273	-0	-0
7	12	-16	-6743	22532	0
7	13	-16	-12241	12143	0
7	14	-16	-26901	-10856	0
7	15	0	0	0	0
8	1	0	0	0	0
8	2	1398	2796	39237	52
8	3	1085	1104	28730	67
8	4	-334	-12975	-8603	-119
8	5	905	1521	25028	950
8	6	-1065	-30301	-30890	31
8	7	-20	-3789	-938	-90
8	8	-2	-884	-27	-8
8	9	-33	2	-909	11
8	10	-64	525	938	-12
8	11	-0	273	-0	-0
8	12	742	-3335	22988	-320
8	13	419	-6467	14093	-335
8	14	-431	-20391	-8025	-228
8	15	0	0	0	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
9	1	0	0	0	0
9	2	1303	-4994	-22178	119
9	3	367	-3916	-16574	102
9	4	-394	-4757	-2986	-216
9	5	896	-7031	-16790	56
9	6	-872	-12172	10037	-10
9	7	10	-4766	-130	-86
9	8	-3	-1016	48	41
9	9	-50	-7	-820	-5
9	10	-42	253	599	-4
9	11	-0	373	-0	-0
9	12	544	-4296	-14561	-276
9	13	171	-4890	-10035	-344
9	14	-367	-15718	-533	-183
9	15	0	0	0	0
10	1	0	0	0	0
10	2	0	-7592	-21440	0
10	3	0	-5390	-15882	0
10	4	-235	8166	7013	0
10	5	0	-3569	-11674	0
10	6	0	6171	20583	0
10	7	0	-4450	-34	0
10	8	0	-1006	48	0
10	9	-100	-91	-798	0
10	10	0	303	573	0
10	11	-0	372	-0	-0
10	12	-14	484	-8641	0
10	13	-33	6573	872	0
10	14	0	842	11006	0
10	15	0	0	0	0
11	1	0	0	0	0
11	2	0	9045	40061	0
11	3	0	6864	29480	0
11	4	-16	-23434	-25920	0
11	5	0	6676	27363	0
11	6	-16	-29632	-42799	0
11	7	0	-2318	-137	0
11	8	0	-2712	-30	0
11	9	0	-75	-1176	0
11	10	-100	396	1098	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
11	11	-0	377	-0	-0
11	12	-16	-4680	17403	0
11	13	-16	-16381	247	0
11	14	-16	-34147	-26639	0
11	15	0	0	0	0
12	1	0	0	0	0
12	2	1209	9042	38783	-3
12	3	894	6860	28540	-2
12	4	-708	-21399	-23149	0
12	5	800	6214	26033	-5
12	6	-1093	-27529	-39393	1
12	7	-3	-2315	-133	32
12	8	-1	-2712	-30	-11
12	9	-38	-75	-1140	0
12	10	-60	399	1059	0
12	11	-0	377	-0	-0
12	12	506	-3338	18159	0
12	13	-10	-14105	2449	0
12	14	-319	-31834	-23587	0
12	15	-50000	-0	-0	-0
13	1	0	0	0	0
13	2	1459	-8223	-23865	-3
13	3	1092	-6240	-17111	-1
13	4	-735	-825	2225	0
13	5	1006	-8840	-17236	-4
13	6	-1134	-7334	14707	4
13	7	3	-2630	-70	-29
13	8	-6	-2685	99	39
13	9	-51	11	-834	0
13	10	-44	281	651	0
13	11	-0	512	-0	-0
13	12	460	-4243	-11136	0
13	13	-110	-2849	-4426	0
13	14	-356	-9741	7796	0
13	15	0	0	0	0
14	1	0	0	0	0
14	2	0	-8247	-21371	0
14	3	0	-6264	-15995	0
14	4	-235	10314	12601	0
14	5	0	-4408	-11834	0

TABLE 3 (CONTI)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
14	6	0	2118	22673	0
14	7	0	-2624	-64	0
14	8	0	-2685	93	0
14	9	-100	11	-786	0
14	10	0	283	609	0
14	11	-0	512	-0	-0
14	12	-14	-4243	-11136	0
14	13	-33	-2849	-4426	0
14	14	0	486	16752	0
14	15	-50000	-0	-0	-0
15	1	0	0	0	0
15	2	0	-1356	0	0
15	3	0	-1042	0	0
15	4	-235	9322	12711	0
15	5	0	1784	0	0
15	6	0	26887	-19	0
15	7	0	-2223	4	0
15	8	0	-2641	-4	0
15	9	-100	1464	5417	0
15	10	0	87	0	0
15	11	-0	506	-0	-0
15	12	-14	3368	748	0
15	13	-33	5861	1509	0
15	14	0	32512	-33	0
15	15	0	0	0	0
16	1	0	0	0	0
16	2	0	-1365	0	0
16	3	0	-1042	0	0
16	4	0	9440	12746	0
16	5	0	1784	0	0
16	6	0	26995	13	0
16	7	0	-2223	3	0
16	8	0	-2641	-3	0
16	9	0	1464	5417	0
16	10	0	87	0	0
16	11	-0	506	-0	-0
16	12	0	3430	767	0
16	13	0	5975	1521	0
16	14	0	32695	22	0
16	15	0	0	0	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
17	1	0	0	0	0
17	2	0	-1219	16977	0
17	3	0	-3401	12926	0
17	4	-16	-4569	-2407	0
17	5	0	5956	15797	0
17	6	-16	-17600	-21849	0
17	7	0	-478	-1278	0
17	8	0	-384	242	0
17	9	0	642	-777	0
17	10	-100	2566	1867	0
17	11	-0	174	-0	-0
17	12	-16	7013	16423	0
17	13	-16	7985	10575	0
17	14	-16	3127	-4322	0
17	15	0	0	0	0
18	1	0	0	0	0
18	2	1582	14413	21759	711
18	3	1521	12774	17922	532
18	4	133	-25168	-8369	-7
18	5	1661	-7061	9033	28
18	6	-930	-40657	-26435	11
18	7	-493	-7138	-3726	-135
18	8	42	-5336	-1193	-7
18	9	-167	-792	-1254	-98
18	10	-157	85	1016	-28
18	11	-0	174	-0	-0
18	12	1504	-32362	1103	-323
18	13	950	-36269	-5975	-296
18	14	-366	-44064	-19572	-350
18	15	0	0	0	0
19	1	0	0	0	0
19	2	0	8960	16132	0
19	3	0	5186	12479	0
19	4	-16	-18589	-3030	0
19	5	0	-4241	10580	0
19	6	-16	-35515	-15895	0
19	7	0	-1099	-1281	0
19	8	0	-3699	-327	0
19	9	0	244	-739	0
19	10	-100	1915	1923	0

TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
19	11	-0	174	-0	-0
19	12	-16	-16914	8842	0
19	13	-16	-15243	5466	0
19	14	-16	-22134	-3520	0
19	15	0	0	0	0
20	1	0	0	0	0
20	2	0	10097	16473	0
20	3	0	8547	13488	0
20	4	0	13204	6508	0
20	5	0	12650	15647	0
20	6	0	17063	-122	0
20	7	0	-7039	-3063	0
20	8	0	3351	1788	0
20	9	0	-742	-1035	0
20	10	0	373	1460	0
20	11	-0	174	-0	-0
20	12	0	22316	20611	0
20	13	0	16663	15038	0
20	14	0	19027	8829	0
20	15	0	0	0	0
21	1	0	0	0	0
21	2	1861	0	15407	0
21	3	-1494	0	12410	0
21	4	9355	0	3430	0
21	5	-19599	0	4874	0
21	6	38415	0	3591	0
21	7	-493	0	-1569	0
21	8	1243	0	761	0
21	9	105	0	-888	0
21	10	-151	0	1095	0
21	11	-0	0	-0	-0
21	12	-13359	0	7879	0
21	13	-9482	0	4452	0
21	14	5446	0	-2847	0
21	15	0	0	0	0
22	1	0	0	0	0
22	2	1716	0	12849	0
22	3	-1395	0	10461	0
22	4	-10837	0	-3174	0
22	5	16581	0	17536	0

TABLE 3 (CONT.)
BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
22	6	-37361	0	-22505	0
22	7	736	0	-1018	0
22	8	-1403	0	-318	0
22	9	104	0	-784	0
22	10	-159	0	1246	0
22	11	-0	0	-0	-0
22	12	9880	0	16647	0
22	13	6377	0	10596	0
22	14	-5370	0	-6189	0
22	15	0	0	0	0
23	1	0	0	0	0
23	2	1377	2609	-10743	-969
23	3	1549	2446	-8148	-532
23	4	-265	-4494	-8938	36
23	5	1105	-4274	-12135	-424
23	6	-748	-18752	-12941	48
23	7	457	2307	99	-124
23	8	-323	-7502	-1817	137
23	9	-89	151	-831	29
23	10	-178	-463	314	69
23	11	-0	237	-0	-0
23	12	344	-4309	-12024	118
23	13	0	-8438	-11510	344
23	14	-1354	-28600	-20067	219
23	15	0	0	0	0
24	1	0	0	0	0
24	2	0	-7242	-13055	0
24	3	0	-5721	-10116	0
24	4	-235	4974	186	0
24	5	0	-4780	-8545	0
24	6	0	10783	3155	0
24	7	0	-1832	-1204	0
24	8	0	-3988	-583	0
24	9	-100	-257	-893	0
24	10	0	625	636	0
24	11	-0	237	-0	-0
24	12	-14	-2172	-6956	0
24	13	-33	3894	-726	0
24	14	0	7020	-1947	0
24	15	0	0	0	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
25	1	0	0	0	0
25	2	0	-13635	-8237	0
25	3	0	-10556	-2418	0
25	4	0	17066	-5032	0
25	5	0	-4631	-5280	0
25	6	0	62964	-19394	0
25	7	0	-2690	-561	0
25	8	0	5797	26	0
25	9	0	43	-356	0
25	10	0	900	130	0
25	11	-0	200	-0	-0
25	12	0	3762	-4011	0
25	13	0	15600	-3073	0
25	14	0	75983	-14153	0
25	15	0	0	0	0
26	1	0	0	0	0
26	2	0	23117	3398	0
26	3	0	8236	2964	0
26	4	-235	-16180	-8120	0
26	5	0	-3500	-1236	0
26	6	0	-69868	-45419	0
26	7	0	3576	1147	0
26	8	0	-17483	-6159	0
26	9	-100	-197	-491	0
26	10	0	-822	-342	0
26	11	-0	200	-0	-0
26	12	-14	-9923	-3114	0
26	13	-33	-20066	-6764	0
26	14	0	-96828	-53277	0
26	15	0	0	0	0
27	1	0	0	0	0
27	2	0	-2953	48	0
27	3	0	-2206	24	0
27	4	-235	42790	10154	0
27	5	0	535	3958	0
27	6	0	49485	16661	0
27	7	0	-2856	-530	0
27	8	0	-4203	-1156	0
27	9	-100	9246	2562	0
27	10	0	291	-11	0

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TABLE 3 (CONT.)

BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	SIGR	STRESS COMPONENTS SIGZ	SIGH	SIGRZ
27	11	-0	197	-0	-0
27	12	-14	12558	3533	0
27	13	-33	20685	5353	0
27	14	0	59703	-10156	0
27	15	0	0	0	0
28	1	0	0	0	0
28	2	0	883	1198	0
28	3	0	615	870	0
28	4	0	-28596	-11261	0
28	5	0	2444	4531	0
28	6	0	-6899	-254	0
28	7	0	433	456	0
28	8	0	-934	-176	0
28	9	0	-7124	-2349	0
28	10	0	-158	-146	0
28	11	-0	197	-0	-0
28	12	0	-7206	-2396	0
28	13	0	-11399	-4273	0
28	14	0	-8003	1692	0
28	15	0	0	0	0
29	1	0	0	0	0
29	2	0	4588	1274	0
29	3	0	3215	892	0
29	4	-16	1136	717	0
29	5	0	1527	1445	0
29	6	-16	-1150	-393	0
29	7	0	-6176	-1801	0
29	8	0	3528	1059	0
29	9	0	-45	-9	0
29	10	-100	6953	2173	0
29	11	-0	106	-0	-0
29	12	-15	3249	1563	0
29	13	-15	2075	1078	0
29	14	-15	1163	670	0
29	15	0	0	0	0
30	1	0	0	0	0
30	2	0	11675	3400	0
30	3	0	8369	2439	0
30	4	0	-6140	-1467	0
30	5	0	5339	2589	0

TABLE 3 (CONT.)
BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
30	6	0	-15233	-4617	0
30	7	0	-1978	-541	0
30	8	0	-3660	-1098	0
30	9	0	-326	-93	0
30	10	-0	-4519	-1263	-0
30	11	-0	106	-0	-0
30	12	0	909	861	0
30	13	0	-1608	-27	0
30	14	0	-4510	-1032	0
30	15	0	0	0	0
31	1	0	0	0	0
31	2	0	10409	3020	0
31	3	-0	-7582	-2202	0
31	4	0	-22684	-5110	0
31	5	0	11024	2209	0
31	6	0	-39304	-8805	0
31	7	0	180	106	0
31	8	0	-5066	-1519	0
31	9	0	-46	-9	0
31	10	0	-1218	-278	0
31	11	-0	0	-0	-0
31	12	0	-10840	4028	0
31	13	0	-18018	-3778	0
31	14	0	-26309	-5339	0
31	15	0	0	0	0
32	1	0	0	0	0
32	2	0	13374	3910	0
32	3	0	9335	2729	0
32	4	0	14996	6194	0
32	5	0	-1886	-1562	0
32	6	0	15863	7745	0
32	7	0	-10838	-3199	0
32	8	0	3512	1054	0
32	9	0	-500	-145	0
32	10	0	3460	1125	0
32	11	-0	0	-0	-0
32	12	0	16010	6000	0
32	13	0	18112	7061	0
32	14	0	21296	8943	0
32	15	0	0	0	0

TABLE 3 (CONT.)
BASE CASE STRESS DATA FOR EACH CASK LOCATION

LOCATION	BASE CASE NUMBER	STRESS COMPONENTS SIGR	SIGZ	SIGH	SIGRZ
33	1	0	0	0	0
33	2	0	5187	1213	0
33	3	0	3300	803	0
33	4	0	19418	6755	0
33	5	0	-6049	-2944	0
33	6	0	30512	12707	0
33	7	0	-6060	-1871	0
33	8	0	3387	1803	0
33	9	0	-320	1	0
33	10	0	2830	932	0
33	11	-0	0	-0	-0
33	12	0	10861	-2523	0
33	13	0	17614	5745	0
33	14	0	26429	-31605	0
33	15	0	0	0	0
34	1	0	0	0	0
34	2	0	18478	5200	0
34	3	0	13534	3873	0
34	4	0	-27295	-7259	0
34	5	0	15606	3552	0
34	6	0	-54181	-12701	0
34	7	0	-4664	-1453	0
34	8	0	-4730	-632	0
34	9	0	-214	33	0
34	10	0	-529	-76	0
34	11	-0	0	-0	-0
34	12	0	-5957	-1396	0
34	13	0	-17798	-4879	0
34	14	0	-31605	-5541	0
34	15	0	0	0	0

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TABLE 4.

```
ACCIDENT STRESS RANGE EVAL. NORM. CYCLE  ALL DROPS AND POST FIRE

       LOAD CASES CONSIDERED IN ACCIDENT STRESS RANGE EVALUATION


LOAD CASE   1  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    1            1.000      0.0 STRESS

LOAD CASE   2  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
    8            -.100     30 G BOTTOM END DROP
   11            3.160     1.0 G SIDE DROP

LOAD CASE   3  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
    8            -.100     30 G BOTTOM END DROP
   11           -3.160     1.0 G SIDE DROP

LOAD CASE   4  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
    8             .100     30 G BOTTOM END DROP
   11            3.160     1.0 G SIDE DROP

LOAD CASE   5  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
    8             .100     30 G BOTTOM END DROP
   11           -3.160     1.0 G SIDE DROP

LOAD CASE   6  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
   11           14.550     1.0 G SIDE DROP

LOAD CASE   7  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    2            1.000     -40.0 F ISOTHERMAL
   11          -14.550     1.0 G SIDE DROP

LOAD CASE   8  FOR RANGE CALCULATIONS
 BASE CASE    MULTIPLIER
    3            1.000     70.0 F ISOTHERMAL
    8            -.100     30 G BOTTOM END DROP
   11            3.160     1.0 G SIDE DROP
```

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TABLE 4 (CONT.)

```
ACCIDENT STRESS RANGE EVAL. NORM. CYCLE  ALL DROPS AND POST FIRE

          LOAD CASES CONSIDERED IN ACCIDENT STRESS RANGE EVALUATION


     LOAD CASE    9  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          3           1.000     70.0 F ISOTHERMAL
          8           -.100     30 G BOTTOM END DROP
         11          -3.160     1.0 G SIDE DROP

     LOAD CASE   10  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          3           1.000     70.0 F ISOTHERMAL
          8            .100     30 G BOTTOM END DROP
         11           3.160     1.0 G SIDE DROP

     LOAD CASE   11  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          3           1.000     70.0 F ISOTHERMAL
          8            .100     30 G BOTTOM END DROP
         11          -3.160     1.0 G SIDE DROP

     LOAD CASE   12  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          3           1.000     70.0 F ISOTHERMAL
         11          14.550     1.0 G SIDE DROP

     LOAD CASE   13  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          3           1.000     70.0 F ISOTHERMAL
         11         -14.550     1.0 G SIDE DROP

     LOAD CASE   14  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          4           1.000     NORMAL  70KW  130F AMBIENT
          8           -.100     30 G BOTTOM END DROP
         11           3.160     1.0 G SIDE DROP

     LOAD CASE   15  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          4           1.000     NORMAL  70KW  130F AMBIENT
          8           -.100     30 G BOTTOM END DROP
         11          -3.160     1.0 G SIDE DROP

     LOAD CASE   16  FOR RANGE CALCULATIONS
      BASE CASE     MULTIPLIER
          4           1.000     NORMAL  70KW  130F AMBIENT
          8            .100     30 G BOTTOM END DROP
         11           3.160     1.0 G SIDE DROP
```

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TABLE 4 (CONT.)

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ACCIDENT STRESS RANGE EVAL. NORM. CYCLE  ALL DROPS AND POST FIRE

       LOAD CASES CONSIDERED IN ACCIDENT STRESS RANGE EVALUATION


   LOAD CASE  17  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
        8             .100    30 G BOTTOM END DROP
       11           -3.160    1.0 G SIDE DROP

   LOAD CASE  18  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
       11           14.550    1.0 G SIDE DROP

   LOAD CASE  19  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
       11          -14.550    1.0 G SIDE DROP

   LOAD CASE  20  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        5            1.000    10 MIN. IN POOL COOL-DOWN

   LOAD CASE  21  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        6            1.000    POST FIRE 70KW  130F AMBIENT
       10             .858    100 PSI CAVITY

   LOAD CASE  22  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
       10             .858    100 PSI CAVITY
       14            1.000    POST FIRE 70KW -40F AMBIENT

   LOAD CASE  23  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
        7            1.000    30 G TOP END DROP

   LOAD CASE  24  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
        8            1.000    30 G BOTTOM END DROP

   LOAD CASE  25  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
       11          -81.000    1.0 G SIDE DROP

   LOAD CASE  26  FOR RANGE CALCULATIONS
    BASE CASE     MULTIPLIER
        4            1.000    NORMAL  70KW  130F AMBIENT
        9            5.800    100 PSI WATER CHAMBER
       11           -7.070    1.0 G SIDE DROP
       15            1.000    PIN PUNCTURE STRESS
```

TABLE 4. (CONT.) 5/76

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ACCIDENT STRESS RANGE EVAL. NORM. CYCLE  ALL DROPS AND POST FIRE

        LOAD CASES CONSIDERED IN ACCIDENT STRESS RANGE EVALUATION


LOAD CASE  27  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     7           1.000     30 G TOP END DROP
    12           1.000     NORMAL 40KW  -40F AMBIENT

LOAD CASE  28  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     8           1.000     30 G BOTTOM END DROP
    12           1.000     NORMAL 40KW  -40F AMBIENT

LOAD CASE  29  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
    11         -81.000     1.0 G SIDE DROP
    12           1.000     NORMAL 40KW  -40F AMBIENT

LOAD CASE  30  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     9           5.800     100 PSI WATER CHAMBER
    11          -7.070     1.0 G SIDE DROP
    12           1.000     NORMAL 40KW  -40F AMBIENT
    15           1.000     PIN PUNCTURE STRESS

LOAD CASE  31  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     7           1.000     30 G TOP END DROP
    13           1.000     NORMAL 70KW  -40F AMBIENT

LOAD CASE  32  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     8           1.000     30 G BOTTOM END DROP
    13           1.000     NORMAL 70KW  -40F AMBIENT

LOAD CASE  33  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
    11         -81.000     1.0 G SIDE DROP
    13           1.000     NORMAL 70KW  -40F AMBIENT

LOAD CASE  34  FOR RANGE CALCULATIONS
 BASE CASE     MULTIPLIER
     9           5.300     100 PSI WATER CHAMBER
    11          -7.070     1.0 G SIDE DROP
    13           1.000     NORMAL 70KW  -40F AMBIENT
    15           1.000     PIN PUNCTURE STRESS
```

TABLE 4. (CONT.)

```
ACCIDENT STRESS RANGE EVAL. NORM. CYCLE  ALL DROPS AND POST FIRE


          LOAD CASES CONSIDERED IN ACCIDENT STRESS RANGE EVALUATION


     LOAD CASE  35  FOR RANGE CALCULATIONS
      BASE CASE    MULTIPLIER
          4          1.000      NORMAL  70KW  130F AMBIENT
          9          5.800      100 PSI WATER CHAMBER
         11          7.070      1.0 G SIDE DROP

     LOAD CASE  36  FOR RANGE CALCULATIONS
      BASE CASE    MULTIPLIER
          9          5.800      100 PSI WATER CHAMBER
         11          7.070      1.0 G SIDE DROP
         12          1.000      NORMAL 40KW  -40F AMBIENT

     LOAD CASE  37  FOR RANGE CALCULATIONS
      BASE CASE    MULTIPLIER
          9          5.800      100 PSI WATER CHAMBER
         11          7.070      1.0 G SIDE DROP
         13          1.000      NORMAL 70KW  -40F AMBIENT
```

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TABLE 5

ACCIDENT STRESS RANGE EVAL. NORM. CYCLE ALL DROPS AND POST FIRE

STRESS RANGE DATA LOAD CASE 26 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWABL STRESS
1	439	-40	29152	67273	70	29152	57377
2	435	-40	46239	67342	70	46239	57446
3	403	-40	34781	67807	70	34781	57912
4	381	-40	33013	68131	70	33013	58235
5	257	-40	97970	69340	70	97970	59444
6	257	-40	84243	69340	70	84243	59444
7	476	-40	55016	66634	70	51023	56739
8	471	-40	51192	66721	70	47424	56825
9	459	-40	32291	66928	70	32291	57032
10	435	-40	35457	67342	70	35457	57446
11	561	-40	72788	65168	70	62207	55273
12	556	-40	77657	65254	70	77657	55359
13	514	-40	42825	65979	70	42825	56083
14	490	-40	103274 ←	66393	70	103274	56497
15	327	-40	62513	68657	70	62513	58762
16	327	-40	62558	68657	70	62558	58762
17	462	-40	28342	66876	70	28342	56980
18	458	-40	45492	66945	70	43897	57049
19	458	-40	29879	66945	70	28752	57049
20	458	-40	21894	66945	70	21894	57049
21	456	-40	36657	66979	70	36657	57084
22	455	-40	27264	66997	70	27264	57101
23	427	-40	24590	67480	70	24590	[illegible]34
24	402	-40	23978	67911	70	23978	58015
25	402	-40	67798	67911	70	67798	58015
26	374	-40	79612	68199	70	79612	58303
27	257	-40	101658	69340	70	100911	59444
28	257	-40	75057	69340	70	74789	59444
29	386	-40	7628	68082	70	7628	58186
30	386	-40	21998	68082	70	18692	58186
31	386	-40	33975	68082	70	33975	58186
32	386	-40	13982	68082	70	13982	58186
33	344	-40	48861	68491	70	48861	58596
34	344	-40	47487	68491	70	44142	58596

TABLE 5 (CONT.)

ACCIDENT STRESS RANGE EVAL. NORM. CYCLE ALL DROPS AND POST FIRE

STRESS RANGE DATA LOAD CASE 21 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWABL STRESS
1	439	-40	45332	67273	70	45332	57377
2	435	-40	81556	67342	70	81556	57446
3	403	-40	50929	67807	70	50929	57912
4	381	-40	42656	68131	70	39859	58235
5	257	-40	69614	69340	70	69614	59444
6	257	-40	84243	69340	70	84243	59444
7	476	-40	71032	66634	70	60620	56739
8	471	-40	66807	66721	70	56613	56825
9	459	-40	45119	66928	70	40592	57032
10	435	-40	42519	67342	70	36961	57446
11	561	-40	81819	65168	70	71238	55273
12	556	-40	98601 ←	65254	70	98601	55359
13	514	-40	45450	65979	70	40679	56083
14	490	-40	55212	66393	70	55212	56497
15	327	-40	71356	68657	70	71356	58762
16	327	-40	71349	68657	70	71349	58762
17	462	-40	37146	66876	70	36826	56980
18	458	-40	54901	66945	70	53315	57049
19	458	-40	45261	66945	70	41487	57049
20	458	-40	28721	66945	70	28721	57049
21	456	-40	58228	66979	70	58228	57084
22	455	-40	54178	66997	70	54178	57101
23	427	-40	23330	67480	70	22630	57584
24	402	-40	32674	67911	70	32674	58015
25	402	-40	94067	67911	70	94067	58015
26	374	-40	96600	68199	70	81719	58303
27	257	-40	55554	69340	70	54807	59444
28	257	-40	64273	69340	70	64273	59444
29	386	-40	12351	68082	70	12351	58186
30	386	-40	32328	68082	70	29022	58186
31	386	-40	51373	68082	70	51373	58186
32	386	-40	20718	68082	70	20718	58186
33	344	-40	44312	68491	70	44312	58596
34	344	-40	73586	68491	70	70241	58596

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TABLE 5 (CONT.)

ACCIDENT STRESS RANGE EVAL. NORM. CYCLE ALL DROPS AND POST FIRE

STRESS RANGE DATA LOAD CASE 22 USED AS REFERENCE

LOC	MAX TEMP	MIN TEMP	STRESS RANGE	ALLOWABLE STRESS	MIN TEMP	STRESS RANGE	ALLOWAB STRES
1	439	-40	55169	67273	70	55169	57377
2	435	-40	75549	67342	70	75549	5744
3	408	-40	54811	67807	70	54811	5791
4	381	-40	56037	68131	70	53240	5823
5	257	-40	55412	69340	70	55412	59444
6	257	-40	75260	69340	70	75260	59444
7	476	-40	49723	66634	70	39311	5673
8	471	-40	44580	66721	70	35717	5682
9	459	-40	38100	66928	70	33572	57032
10	435	-40	32942	67342	70	30736	5744
11	561	-40	65659	65168	70	55078	5527
12	556	-40	83069	65254	70	83069	5535
13	514	-40	40946	65979	70	37569	5608
14	490	-40	56844	66393	70	56844	5649
15	327	-40	76995	68657	70	76995	5876
16	327	-40	77040	68657	70	77040	5876
17	462	-40	31553	66876	70	31553	5698
18	458	-40	58194	66945	70	56604	5704
19	458	-40	31880	66945	70	28106	5704
20	458	-40	21734	66945	70	21734	5704
21	456	-40	32969	66979	70	32969	5708
22	455	-40	32291	66997	70	32291	5710
23	427	-40	31877	67480	70	31877	58
24	402	-40	28911	67911	70	28911	5801
25	402	-40	101845	67911	70	101845	5801
26	374	-40	123560 ←	68199	70	108679	5830
27	257	-40	77050	69340	70	77050	5944
28	257	-40	63169	69340	70	63169	5944
29	386	-40	14664	68082	70	14664	5818
30	386	-40	21605	68082	70	18299	5818
31	386	-40	38378	68082	70	38378	5818
32	386	-40	26151	68082	70	26151	5818
33	344	-40	62757	68491	70	62757	5859
34	344	-40	51010	68491	70	47655	5859

ANSYS SOLUTIONS FOR INPUT TO BUCKLING SOLUTION - NORMAL CONDITIONS AND PIN-PUNCTURE CONDITIONS.

THE SMALL ANSYS MODEL OF THE CASK SHELLS (SEE SAR p. XI-3-58) WAS USED TO DETERMINE THE STATE OF STRESS AND STRAIN IN THE CENTRAL PLANE OF THE CASK FOR THE FOLLOWING TWO CONDITIONS:

CASE A: 70KW 130°F NORMAL CONDITIONS
16.5 PSI IN FUEL CAVITY
140 PSI IN WATER CAVITY

CASE B: 70KW 130°F NORMAL CONDITIONS
16.5 PSI IN FUEL CAVITY
800 PSI IN WATER CAVITY

FOR THE SOLUTIONS THE STRESS-STRAIN CURVES OF SAR FIG. 3.8.3-11 FOR STAINLESS STEEL AND SAR FIG. 4.9.6-13(a) & (b) FOR LEAD WERE USED.

TABLES 6 & 7 PRESENT THE RESULTS OF THESE SOLUTIONS. THESE TABLES SHOW THE COMPONENT STRESSES, ELASTIC STRAINS AND PLASTIC STRAINS FOR EACH ELEMENT OF THE MODEL. THE MODEL GEOMETRY IS SKETCHED BELOW.

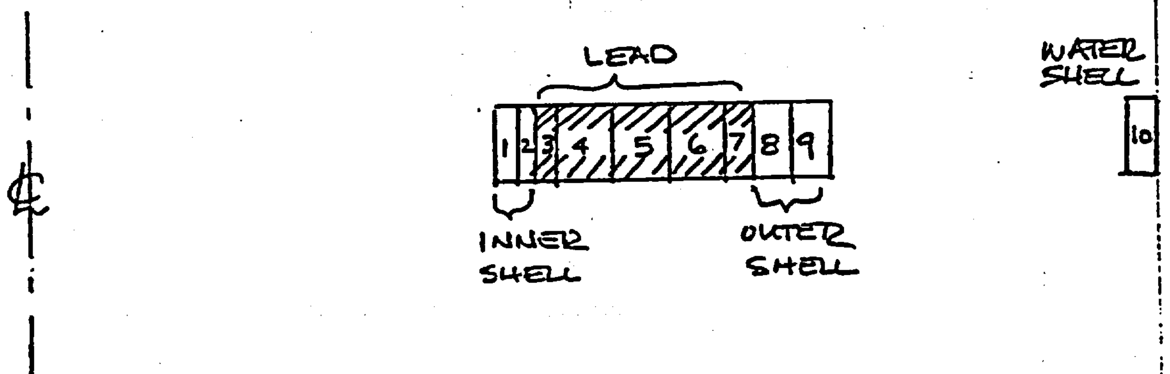

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TABLE 6

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STRESSES, ELASTIC & PLASTIC STRAINS FOR SOLUTION A
(70KW, 130°F NORMAL, 16.5 PSI FUEL CAVITY, 140PSI WATER CAVITY)

ELEM. NO.	σ_R (RADIAL)	σ_x (AXIAL)	σ_θ (HOOP)	ϵ_R^E $\times(10)^6$	ϵ_x^E $\times(10)^6$	ϵ_θ^E $\times(10)^6$	ϵ_R^P $\times(10)^6$	ϵ_x^P $\times(10)^6$	ϵ_θ^P $\times(10)^6$
1	-235	-16930	-18174.	387.9	-429.8	-490.8	385.4	-195.5	-191.9
2	-530	-17235	-18181	380.4	-438.0	-484.3	360.5	-185.4	-175.1
3	-598	-733	-762	25.0	-81.9	-105.3	1904.0	-978.6	-925.4
4	-606	-756	-782	30.1	-87.2	-107.4	1367.9	-764.4	-603.5
5	-623	-795	-810	36.4	-96.6	-108.5	719.5	-481.9	-237.5
6	-638	-872	-811	45.8	-133.1	-86.2	131.4	-175.6	44.2
7	-641	-758	-641	-21.1	-109.3	-20.8	-179.8	10.0	178.8
8	-555	-622	4669	-66.0	-69.2	187.3	0.0	0.0	0.0
9	-304	4680	9726	-172.1	68.9	313.0	0.0	0.0	0.0
10	-71	9681	7510	-193.7	276.0	171.4	0.0	0.0	0.0

STRESS, ELASTIC & PLASTIC STRAINS FOR SOLUTION B
(70 KW, 130°F NORMAL, 16.5 FUEL CAVITY, 800 PSI WATER)

ELEM. NO.	σ_R (RADIAL)	σ_X (AXIAL)	σ_θ (HOOP)	ϵ_R^E $\times(10)^6$	ϵ_X^E $\times(10)^6$	ϵ_θ^E $\times(10)^6$	ϵ_R^P $\times(10)^6$	ϵ_X^P $\times(10)^6$	ϵ_θ^P $\times(10)^6$
1	-409	-17646	-21941	432.2	-412.3	-622.7	774.4	-282.6	-491.8
2	-761	-17937	-21962	422.4	-419.1	-616.2	737.0	-275.9	-461.1
3	-732	-940	-990	54.1	-110.6	-150.0	2299.1	-1021.5	-1277.6
4	-745	-971	-1016	60.0	-117.1	-152.6	1725.1	-806.1	-919.0
5	-768	-1019	-1056	67.2	-127.1	-155.4	1033.0	-523.0	-510.0
6	-790	-1074	-1087	74.4	-142.3	-152.7	411.9	-237.9	-174.0
7	-795	-1133	-1047	75.3	-180.3	-115.3	-10.2	0.0	9.8
8	-843	-5065	-3457	63.9	-140.8	-62.8	0.0	0.0	0.0
9	-844	225	1830	-54.3	-2.6	75.0	0.0	0.0	0.0
10	-400	20275	39514	-559.2	280.0	1207.1	-2214.4	-75.9	2290.4

TABLE 7

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Section XII

SECTION XII

COOLING SYSTEM DESIGN

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SECTION XII

COOLING SYSTEM DESIGN

INTRODUCTION

This section discusses the operation and performance of a redundant auxiliary cooling system. Subsequent events in the package design resulted in a lower decay heat load limit. Consequently the package temperatures became less important to the facility receiving spent fuel and the need for auxiliary cooling becomes optional.

The following section has not been revised and/or expanded to cover the optional arrangements since package integrity is not dependent on auxiliary cooling.

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SECTION XII
COOLING SYSTEM DESIGN

1.0 Design Basis

The NLI 10/24 rail cask is designed to dissipate decay heat under normal conditions of transport without any dependence on auxiliary cooling. Under these conditions, highest average fuel temperature would run on the order of 833 °F, and the cask body average temperature would be on the order of 350°F since decay heat is transferred through the cask body. While this presents no problem from the standpoint of meeting 10 CFR 71 requirements, it may prolong the cask cooldown time at the fuel reprocessing plant. For this reason the fuel shipment is cooled mechanically during transport to remove decay heat at the cask cavity wall. This results in very low cask operating temperatures and a highest average fuel temperature on the order of 600°F.

The rail car mounted cooling system developed for use with the NLI 10/24 cask is designed to meet the following general criteria:

- Loss of any single active or passive component does not result in loss of auxiliary cooling.
- System components and supports are designed to meet the rail shock and vibration environment.
- Lowest possible cask operating temperatures are achieved without sacrificing simplicity of design.

2.0 General System Description

Heat is transferred from the cask to an external heat exchanger by an intermediate cooling water stream and thence rejected to the atmosphere. Water is forced through channels provided on the outside of the fuel cask's inner shell where the decay heat is transferred to it by conduction and convection. A forced-draft, air-cooled exchanger removes the heat from the cooling water and the water is returned to the cask in a closed circuit. Ambient extreme conditions from 130°F to -40°F were considered for the design.

Equipment supports and mounts are designed for all normal forces and accelerations reported for rail transport service.

The fuel cask's design provides for two (2) separate, independent coolant flow paths. The heat transfer surface of each path is sized for the total decay heat removal. The external coolant system components will be assembled in modules. Two (2) identical modules provide 100% redundancy. Each module contains a heat exchanger, forced circulation pump, diesel engine driven generator, and a fuel system sized for 14 days continuous operation. A general arrangement of system components and piping is shown on Drawing 70654F.

3.0 Process Description

Flow sheet 70640F shows the main coolant loops and the auxiliary diesel generator systems.

The main coolant flow is through the fuel cask coolant channels, air-cooled heat exchanger, expansion tank, and circulation pump. Normally the pump forces water through the loop, which results in a temperature increase at the fuel cask. The exchanger is sized to reject the heat under this mode of operation to an extreme ambient temperature of 130°F in still air. Since the ambient will only be at 130°F a small fraction of the total operating time there is a potential saving in power if the exchanger can be arranged for fan free operation at lower ambients and when the train's forward motion induces large air flows. The temperature of the coolant at the exchanger exit is sensed and used to activate a switch which shuts off the exchanger fan in the exchanger fan plenum on dropping temperature. On rising temperature the fan is started.

Low coolant flow or high coolant temperature at the exit of the cask signals a system failure, and automatically starts the spare coolant system. Since each system is sized for 100% duty, there is no loss of cooling capacity for this condition. In addition to two (2) redundant coolant loops there is a back up for double failure. The air-cooled exchangers are each sized to dissipate 1/2 the design heat load at the extreme ambient in their natural draft mode of operation acting as steam condensers. The equipment is located so that a natural-current thermosyphon will start circulating in each of the loops when the coolant temperature reaches 250°F.

The diesel generators are each provided with storage batteries for self starting. Individual fuel tanks are provided, each with capacity for 14 days continuous operation at twice the calculated average fuel consumption. Electric heaters in the fuel system and in the engine crankcases will assist winter starting at -40°F.

3.1 Forced Circulation Mode (power on)

Either air-cooled heat exchanger is designed to remove 120 kw from the cask. This is almost twice the cask rated heat load and allows for possible future upgrading of cask decay heat. A flow of 82 gpm is circulated through the system. The cooling fluid is heated in the cooling channels located on the outside of the inner shell. The fluid is then circulated back to the heat exchanger where it is cooled by air forced across the finned tubes by a fan.

The twenty (20) cask coolant channels are half rounds of 1.0" dia, schedule 40 stainless steel pipe. Ten (10) channels are for one system and ten (10) for the back up system.

3.2 Natural Circulation Mode (power off)

Two (2) air-cooled heat exchangers will be used at the same time as condensers when there is no power to drive the fans. Each flow loop produces a steam-water flow rate of 866 lb/hr of which 212 lb/hr is vapor at 250°F. Coolant flow is by natural circulation due to the density differences between cask and heat exchanger regions.

4.0 Description of Operation

4.1 Initial Start Up

After a new cask is set in place, flexible hoses are made up to the appropriate connections. Pure water and chemical additive are added through the fill nozzle at the expansion tank. The nozzle, which is the system high point and also serves as a vent, is left open. Coolant System "A" is started in its manual mode of operation. Circulation through the loop will scavange trapped air in the system and heating of the water will drive off dissolved gas. The expansion tank is designed to promote deaeration. System "B" is filled and the circulation pump turned on briefly to scavenge trapped air in the system.

Flow meters F-101 & 102 are installed for checking of the system prior to shipment of the railcar and are not intended for normal operation. (The flow meter bypass must be opened before car shipment since the meters will restrict natural circulation operation on loss of power).

4.2 Normal Operation

Normally the fuel cask cooling system operation is fully automatic and no operator attendance is required. In case of equipment failure the spare system is started without any operator action.

A battery operated panel which denotes any cause of failure is provided for observation at the rail terminal.

4.3 Emergency Operation

In the event of stoppage of both coolant systems due to failure of pumps or generators the change over to the thermosyphon mode of cooling takes place without any manual adjustments. On pump failure, but not electric power failure, the exchanger fans will continue to operate.

As the temperature rises, excess pressure will build up which will be relieved by pressure relief valve PSV 160 and 161. When enough fluid has been blown off to allow the heat exchanger to act as a steam condenser a thermosphyon will start. At this time heat from the fuel cask will be removed as latent heat in steam at 29.8 psia and 250°F.

In designing equipment several provisions had to be made to facilitate this emergency mode of operation. The expansion tank had to be designed and placed so that during the normal mode of operation it is the system high point to facilitate filling and venting. During the emergency mode of operation, after the system inventory is reduced by pressure relief, it must allow operation of the air-cooled condenser without flooding. Pipe lines are arranged to drain from the condenser to the cask without pocketing to preclude surging. The pump will act as a pipeline fitting during emergency and is selected for low pressure drop when idle.

4.4 Extreme Ambient Temperature Operation

As the ambient temperature falls the coolant system will automatically adjust to low temperature operation. The diesel engines crankcases and the diesel fuel tanks are provided with thermostatically operated electric heaters. The electric heaters are imersion type NEMA rated explosion proof.

At 40°F ambient the standby coolant loop starts so that the cask's decay heat can be used to protect the standby loop from freezing.

The system has been designed to operate with glycol solution as well as water to allow return trips of the empty casks under freezing conditions.

Based on the recommendations of Union Carbide Corporation, Terrytown Technical Center, UCAR Thermofluid 17 will be the antifreeze solution used. The mix shall be

54% by weight of UCAR Thermofluid 17 and 46% by weight water. UCAR Thermofluid 17 is an inhibited ethylene glycol based antifreeze. The inhibitors used in this solution are proprietary to Union Carbide.

Union Carbide has performed corrosion tests on a large number of metals with uninhibited ethylene glycol. These tests show that corrosion effects on stainless steel are negligible as long as the ethylene glycol does not degrade thermally or oxidatively to form acidic materials. The purpose of the inhibitors is to prevent thermal and oxidative degradation of the ethylene glycol. Satisfactory performance can be maintained in the fluid by keeping its pH in the prescribed range (8 to 10). A lower pH is indicative of fluid degradation and acidic build-up. If a cooling system fails during transportation, the pH of the fluid will be checked to assure it is still in the prescribed range of 8 to 10. If it is not , the cooling system will be drained, flushed and refilled. Also, during normal cooling system maintenance, the pH will be checked.

The maximum flow rate in the cooling system is 82 gpm. This is not sufficient to cause any errosion of the metal surfaces.

Section XIII

DELETED

QA/QC shall be in accordance with Nuclear Assurance Corporation's Quality Assurance Manual as approved by the NRC. Quality Assurance Program Approval for Radioactive Material Packages Number 0018, Revision 3.

QUALITY ASSURANCE PLAN SUMMARY

SECTION XIII

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

FEB 12 1991

SGTB:LLG
71-0018

Nuclear Assurance Corporation
ATTN: Mr. George N. Dixon, Jr.
Corporate Manager Quality Assurance
6251 Crooked Creek Road
Norcross, GA 30092

Dear Mr. Dixon:

Enclosed is Quality Assurance (QA) Program Approval for Radioactive Material Packages No. 0018, Revision No. 3.

Please note the conditions in the approval.

Sincerely,

Charles MacDonald

Charles E. MacDonald, Chief
Transportation Branch
Division of Safeguards
and Transportation, NMSS

Enclosure:
As stated

NRC FORM 311
(9-87)

U. S. NUCLEAR REGULATORY COMMISSION

QUALITY ASSURANCE PROGRAM APPROVAL
FOR RADIOACTIVE MATERIAL PACKAGES

1. APPROVAL NUMBER
0018

REVISION NUMBER
3

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, and Title 10, Code of Federal Regulations, Chapter 1, Part 71, and in reliance on statements and representations heretofore made in Item 5 by the person named in Item 2, the Quality Assurance Program identified in Item 5 is hereby approved. This approval is issued to satisfy the requirements of Section 71.101 of 10 CFR Part 71. This approval is subject to all applicable rules, regulations, and orders of the Nuclear Regulatory Commission now or hereafter in effect and to any conditions specified below.

2. NAME
Nuclear Assurance Corporation

STREET ADDRESS
6251 Crooked Creek Road

CITY
Norcross

STATE
GA

ZIP CODE
30092

3. EXPIRATION DATE
February 28, 1996

4. DOCKET NUMBER
71-0018

5. QUALITY ASSURANCE PROGRAM APPLICATION DATE(S)
January 24, 1991

6. CONDITIONS

Activities conducted under applicable criteria of Subpart H of 10 CFR Part 71 to be executed with regard to transportation packages.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles MacDonald
Charles E. MacDonald

CHIEF, TRANSPORTATION BRANCH
DIVISION OF SAFEGUARDS AND TRANSPORTATION
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS

FEB 12 1991
DATE

Section XIV

SECTION XIV

FUNCTIONAL TESTING

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SECTION XIV

FUNCTIONAL TESTING

Table of Contents

1.0 Assembly of All Components to Cask

2.0 Trunnion Load Test

3.0 Test for Shielding Integrity

4.0 Leak Tests

5.0 Assembly of cask to rail car

6.0 Thermal Tests

7.0 Disassembly

8.0 Inspection of Lead to Steel Bond

1.0 Assembly

1.1 Assemble fuel basket into cask cavity. Assure that basket does not bind and dimensionally check that basket is fully seated.

1.2 Assemble spacer plug into cask cavity.

1.3 Lower inner closure head over guide pins and onto cask body. flange. Use lift yoke for this operation. Assure that there is no interference between closure head and spacer plug and that closure head has been seated firmly on cask. Install closure head bolts (Remove guide pins).

1.4 Assemble outer head, install outer head bolts.

2.0 Load Test

2.1 Engage two lift trunnions with cask lift yoke. Using load test fixtures in conjunction with lift yoke apply 400,000 lbs. load.

2.2 Upon completion of load test disengage lift yoke and engage opposite two trunnions and repeat test described in 2.1 above.

2.3 Remove lift yoke after second load test and liquid penetrant test four trunnions and their connection to cask for cracks. Visually check for galling, scaring and any signs of deformation of the trunnions and lift yoke.

3.0 Shielding Integrity

3.1 The cask shielding integrity shall be tested using the gamma scan and/or gamma probe method using a Co_{60} source and scintillation equipment. The test will encompass, nominally, 100% of all accessible surfaces of the cylindrical shield.

3.2 Acceptance Criteria

Acceptance will be based on a 12" square mock up of the shield wall whose thickness will be equivalent to the minimum design thickness less 5%.

Any of the following conditions will be cause for rejection.

1. Loss of shielding greater than 5% of the design thickness.
2. Loss of shielding up to 5% of the design thickness over an area greater than 6 square inches.
3. The total of all such areas (Criteria #2) shall not exceed 25% of the total area inspected.

NOTE: The above testing will be accomplished prior to the installation of the neutron shield jacket.

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Functional Testing

4.0 Leak Tests

4.1 Cask Closure Head Seals

The purpose of this tests is to assure the sealing integrity of the closure head seals only, as all the joints in the cask will have been previously inspected using helium and a mass spectrometer and to the same acceptance standards listed herein.

4.1.1 Inner Closure Head

Remove the quick disconnect from the drain line valve and install a calibrated pressure gage. Using the inlet valve, pressurize the cask cavity to 5 psig using clean dry helium. Using a sniffer probe connected to a mass spectrometer scan the joint between the inner head diameter.

and the cask wall, moving at a rate not to exceed 15 inches per minute. A leak rate greater than 1×10^{-6} STP cc/sec. will be cause for rejection.

4.1.2 Outer Closure Head Seal

Both closure head and seals are to be in place during this test. Using the closure head cavity drain line pressurize the cask cavity between the inner and outer head to 5 psig using clean dry helium. Using a sniffer probe connected to a mass spectrometer, scan the joint between the outer head diameter and the cask wall, moving at a rate not to exceed 15 inches per minute. A leak rate greater than 1×10^{-6} STP cc/sec. will be cause for rejection.

4.2 Water Jacket

4.2.1 Remove relief valve and replace with a calibrated pressure gage. Connect pump and supply of distilled water to the quick disconnect valved coupling on the water jacket. Open the vent line at the top end of water jacket. Fill the water jacket with distilled water until overflow occurs through vent line. Close vent line and pressurize water jacket to 300 psig. Close water supply valve. Monitor pressure gage for 30 minutes. Followed by a visual inspection of all joints. Any drop in test pressure or leaks will be cause for rejection.

4.3 Water Jacket Expansion Tank

4.3.1 Remove relief valve and replace with calibrated pressure gage and vent valve assembly. Connect pump and supply of distilled water to inlet on expansion tank. Fill expansion tank with distilled water until overflow occurs through vent valve. Close vent valve and pressurize expansion tank to 300 psig. Close water supply valve. Monitor pressure gage for 30 minutes. Followed by a visual inspection of all joints. Any drop in test pressure or leaks will be cause for rejection.

4.4 Containment Vessel Valves

The containment valves are made up of three components; base plate, valved quick disconnect fitting and a cap which completely encloses the quick disconnect fitting and is bolted the base plate. The primary containment seals are those seals which seal the base plate to the cask flange and the cap to the base plate. The base plate and cap seals shall be subjected to the following leak tests.

Functional Testing

The base plate shall be bolted to the cask flange and a helium leak test performed at this level of assembly. After the base plate has been tested and accepted the cap shall be bolted in place and the cap seal subjected to a helium leak test. A leak rate greater than 1 x 10^{-6} STP cc/sec will be cause for rejection. Acceptance criteria applies to both components and is a test of the metal "O" ring seals used in both components.

4.5 Water Jacket and Expansion Tank Relief Valves

The relief valves; (1) Water Jacket, (1) Expansion Tank; shall be bench tested to verify cracking and reseating pressures. Allowable variation is ± 5% of 220 psig nominal cracking pressure.

4.6 Cask Cavity Hydrostatic Pressure Test

Full cask cavity with distilled water. Pressurize cask cavity thru cavity drain valve to 350 psig. and hold pressure for 30 minutes. There shall be no evidence of leakage or pressure drop during the test period.

4.7 Impact Limiter Housing

Both front and rear impact limiter housings will be tested for leak tightness. Each limiter housing will be purged and filled with dry helium at 10 psig. All weld joints will be bubble tested and shall exhibit no evidence of leakage.

5.0 Assembly of Cask to Rail Car

5.1 Using lifting yoke, position cask over turning saddle on rail car. Lower cask engaging bearing blocks on turning saddle with trunnions on bottom end of cask. Continue downward allowing the cask to rotate to a horizontal position and seating on the hydraulic jack at the top end of the cask. Attach top end impact limiter and lower the cask using the hydraulic jack to bring the impact limiter into contact with the support saddle. Install tie-down link pin at top end of cask. Raise bottom end of cask using the hydraulic jack to disengage the turning saddle. Remove the turning saddle and install the bottom impact limiter. Lower bottom end of cask using the hydraulic jack to engage the

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support saddle. Install tie-down link pin.

Assure the following :

5.1.1 Free engagement of trunnions in bearing blocks.

5.1.2 Operation of hydraulic jacks.

5.1.3 Engagement of top and bottom end of cask in support saddle

5.1.4 Fit of tie-down link pins.

5.1.5 Clearances between the cask and the lift yoke when cask is lowered into horizontal position.

5.1.6 Fit of top and bottom impact limiters.

5.1.7 The cask clears the sides of the personnel barrier as it is being lowered to the horizontal position.

5.2 Bring the roof sections of the personnel barrier into their closed position. Assure that there is no interference between the cask and the personnel barrier roof.

6.0 Thermal Test

The thermal test is outlined in Section XV. If the rail system is equipped With auxiliary cooling the functional test of the cooling system will be carried out as part of the thermal test procedure.

7.0 Disassembly

Upon completion of all the tests, the cask shall be removed from the Rail Car, disassembled, cleaned, reassembled, and returned to the Rail Car.

The following inspections shall be made during these operations :

7.1 Ease of disassembly.

7.2 Check all fasteners and threaded holes for galling, undue wear, burred threads and stripped threads.

7.3 Scoring or marking of any of the components indicating interference with other components.

7.4 Distortion or damage of any of the load carrying surfaces.

If any of the conditions listed in 7.1 through 7.4 do exist, corrective action shall be taken to eliminate the contributory factors.

8.0 Inspection of Lead to Steel Bond

8.1 Ultrasonic inspection methods (pulse echo type or equivalent) shall be used as a means of determining the continuity or lack of continuity at the lead to steel interface. Inspection will be performed over 100% of the accessible areas which require lead to steel bonding.

8.2 Acceptance Criteria

The total area of unbond for those surfaces requiring lead to steel bond shall not exceed 25% of all areas accessible for testing. No single area of unbond shall exceed 3 square feet and shall be separated from other such areas of unbond by a minimum distance of 12 inches.

NOTE: The above testing will be accomplished prior to the installation of the neutron shield jacket.

9.0 Prototype Rail Car Test

The prototype car will be fitted with the cask support and tie-down arrangement as described in this safety analysis report. A set of neutron shield expansion tanks, connecting lines and supports will also be fitted to the prototype car for testing. A simulated cask structure of approximately the same dimensions as the actual cask will be positioned on the car in the same manner as the actual cask. The mass and location of center of gravity of the simulated cask structure will be the same as the actual cask.

The prototype car loaded as described above shall be subjected to a series of static and impact tests as defined by the Association of American Railroads, "Specification for Design, Fabrication and Construction of Freight Cars."

AAR requires a visual inspection of the prototype car be made after each static test and after each impact test. Any permanent damage, to any part of the car, found before or after all tests are completed will be sufficient cause for disapproval of the design. Damage will be considered permanent when the car requires repair in order to return the car to running condition.

The arrangement which supports and ties the cask to the rail car shall be visually inspected. The support and tie down arrangement of the neutron shield expansion tanks and associated piping shall also be visually inspected. Any sign of structural damage such as deformation, elongation of pin holes, or cracked welds will be cause for disapproval of the design.

Section XV

SECTION XV

THERMAL ACCEPTANCE TEST PROCEDURE

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SECTION XV

THERMAL TEST PROCEDURE

Thermal tests will be performed in accordance with detailed thermal test procedure to verify the thermal performance of the shipping cask. The thermal tests will also be used to establish operational parameters relative to preparing a loaded cask for shipment and unloading the cask at the reprocessing plant. Both fuel basket types, i.e., PWR and BWR, will be thermally tested. A cask will only be tested once with the basket type available at time of test. This section describes the thermal test used to verify cask performance and the temperatures used in the thermal stress analysis.

As established in Section VIII, "Thermal Analysis," the thermal response of the cask to PWR and BWR loadings are approximately equal. Therefore, the heat source for the thermal test shall be equivalent to the calculated decay heat source for the ten (10) PWR cask loading of 70kw. The heat source shall be provided by electrical heaters designed and located to simulate the active region of a fuel assembly. The heaters will be positioned such that the 144 inch active length falls within the limits of the neutron shield water jacket. A mockup of the cask closure heads shall be provided which will thermally simulate the top end of the cask. There will be additional penetrations in the closure head mockups to provide for heater leads and thermocouple wire installation.

The thermal tests are to be performed within an area which will be protected against drafts and large temperature changes. The cask shall be completely assembled on the rail car, i.e., the fuel basket, either PWR or BWR, installed in the cask cavity, closure head mockup with heater and thermocouple leads in place. The assembled cask will be positioned horizontally on the rail car to simulate the shipping attitude. The cooling system will be inoperative and drained for this test.

The assembled shipping cask will be instrumented so that temperatures and pressures of the various elements of the system can be monitored and at established time intervals all data will be recorded. To obtain the necessary temperature data, thermocouples will be installed inside the PWR fuel basket cavities, on the outer surface of the outer shell on the outside surface of the water jacket shell and on the ends of the cask.

The thermocouple locations and heater locations in the basket are shown in Figures 1 and 2. The following thermocouple will also be attached to the cask. (See Figure 3)

1. Seven sets of three thermocouples will be mounted circumferentially on the cask surface and on the outer surface of the outer shell on a plane equidistant from the ends of the heater active zone. As viewed from the end of the cask, one set would be mounted in the 0° and then every 30° to the 180° position.
2. A thermocouple at each end of the cask at the center of the top and bottom head.

3. One thermocouple positioned inside the cask cavity on the test head adjacent to the metal seal ring.
4. One thermocouple on the personnel barrier directly over the cask.

Thermocouples will be used to monitor ambient air temperatures on the inside and outside of the personnel barrier. A pressure gage will be mounted on the closure head to indicate cavity pressure. Once the cask and instrumentation are assembled and installed on the rail car, the heaters will be connected to a power source. 70kw will be supplied to the heaters and temperatures and pressures will be measured every half hour until equilibrium is reached. Thermal equilibrium is considered to have been achieved if the cask temperatures fail to rise more than 2°F over a two hour period. As confirmation the test will be conducted for an additional hour using the same criteria.

Thermal Test Acceptance Procedure

The acceptance of the NL 10/24 cask from a heat dissipation standpoint will be determined as follows:

1. The cask will be tested at 70 kw using the procedures outlined in this section.
2. The TRUMP thermal models outlined in Section VIII, Appendices D and E*, will be run at ambient conditions of the test and without solar heat load.
3. Acceptance of the cask will require the following comparison of the test and calculations:
   - (a) The measured temperatures shall not exceed the corresponding calculated values of the 2-D thermal model used in Appendix E of Section VIII.
   - (b) The average of the measured circumferential temperature differences between the inner shell and the outer shell shall not exceed the calculated ΔT value of the 2-D model used in Section VIII Appendix E for that axial position in the cask.
   - (c) The change in temperature difference around the circumference of the cask at any axial measurement position in the cask shall not exceed that calculated from the circumferential model used in Section VIII Appendix E.

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* The temperature profiles resulting from the two different thermal models have been used in the structural analysis. The structural analysis shows the design criteria are met using temperatures resulting from both thermal models.

4. If the temperatures are consistantly higher than those calculated in Item 2, the heat load of the cask will be lowered and new temperature measurements will be made. These measured temperatures will be used in the application of the criteria of Item 3 to determine the acceptable thermal rating of the cask.

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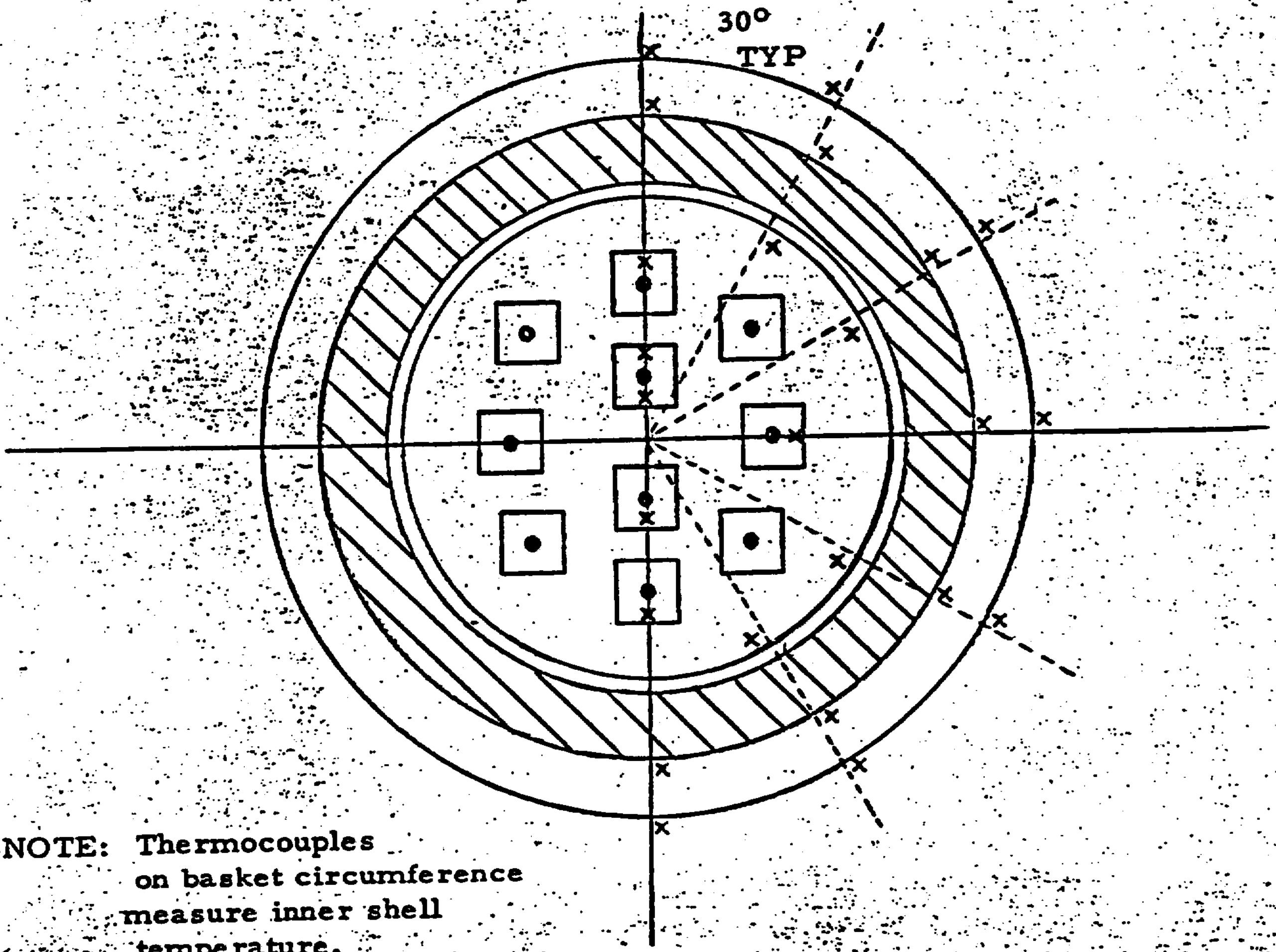
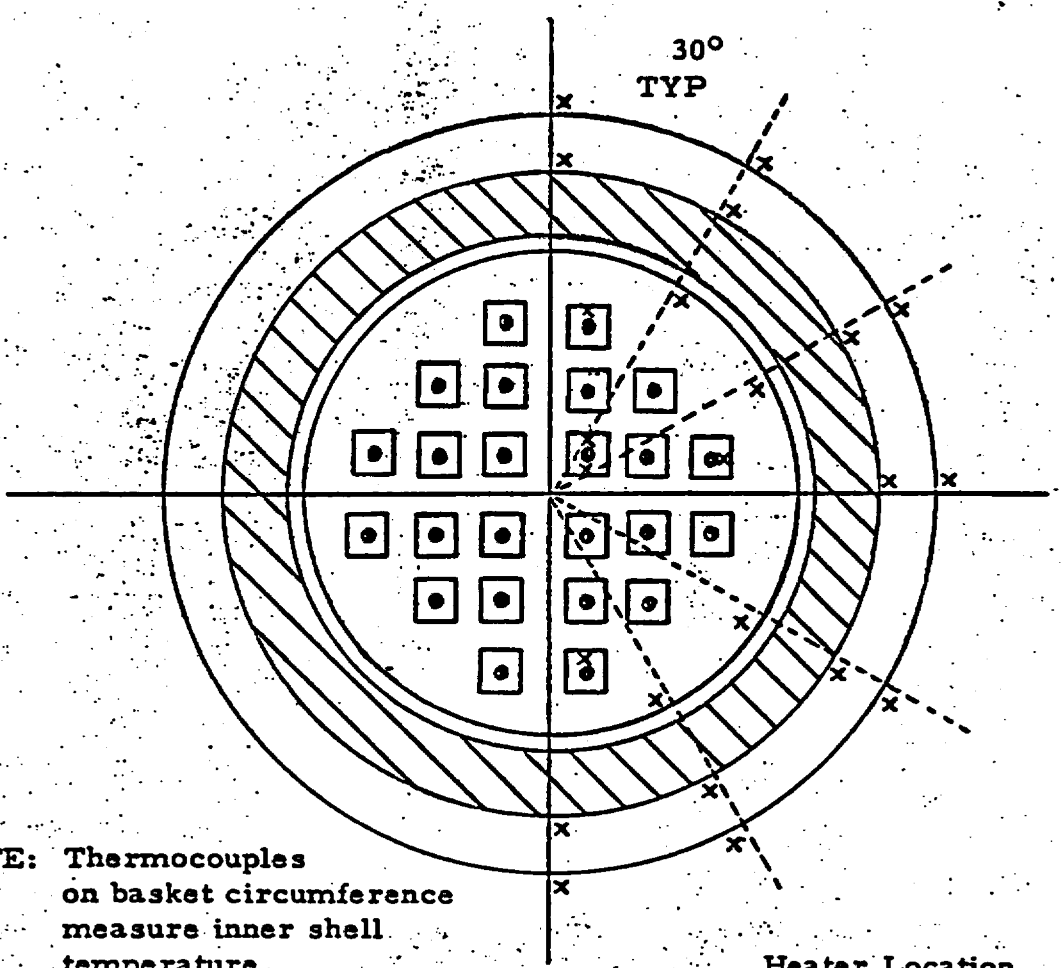


NOTE: Thermocouples on basket circumference measure inner shell temperature.

● Heater Location
x Test Thermocouples

Figure 1 - Section AA PWR Basket



NOTE: Thermocouples
on basket circumference
measure inner shell
temperature

Heater Location

Test Thermocouples

Figure 2 - Section A-A BWR Basket

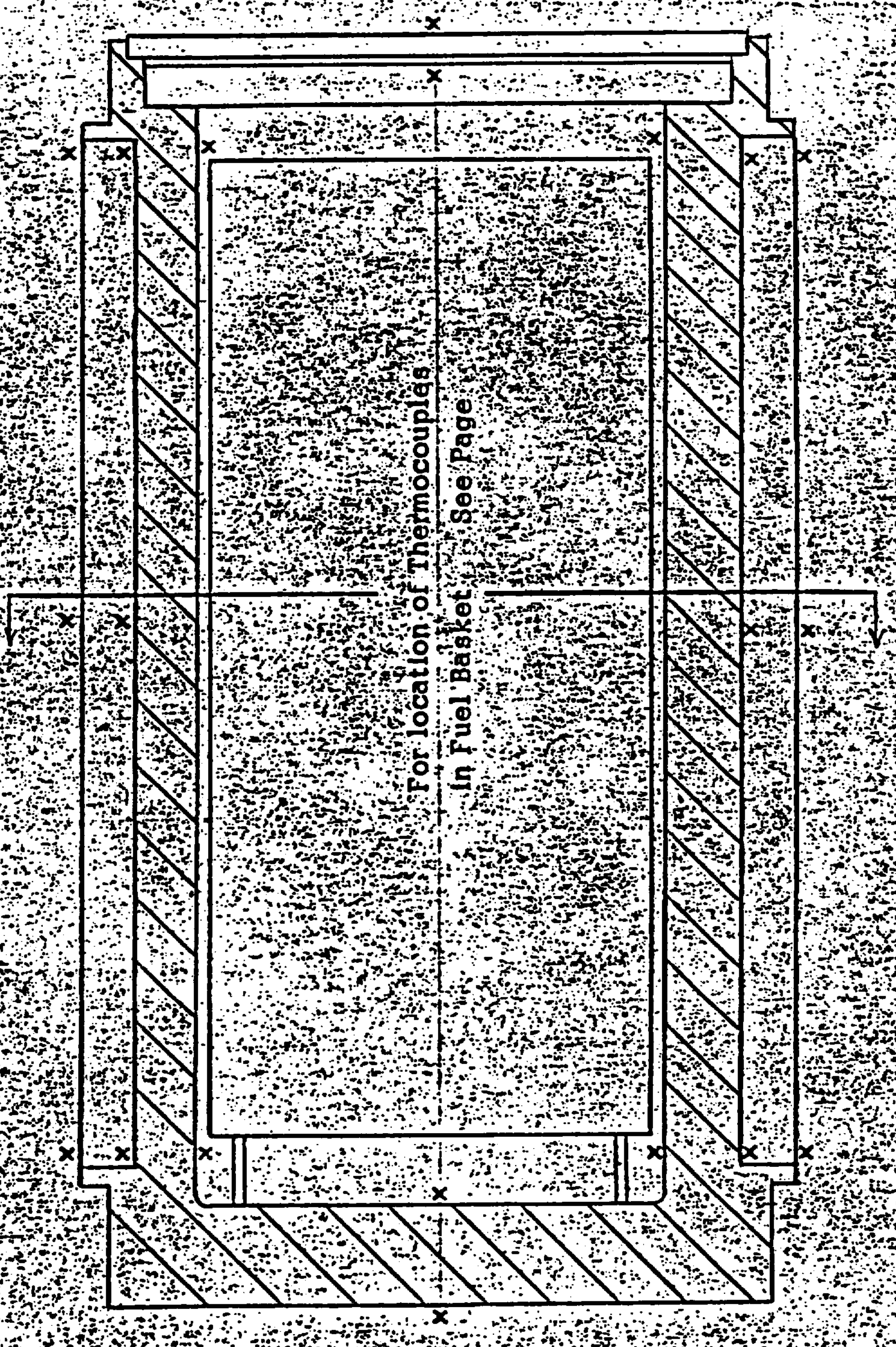


FIGURE 3 - Cask Body Thermocouple Locations

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Section XVI

SECTION XVI

OPERATING PROCEDURES

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SECTION XVI

OPERATING PROCEDURES

INTRODUCTION

It is recognized that each nuclear station would have its own preferred sequence of operations for handling,loading, and preparing the spent fuel cask for shipment. This procedure is intended to be flexible, general one, identifying the operations to be performed.

Prior to delivery of the cask to the nuclear power station, the cask will be subjected to a series of pre-operational checks to assure all valves, instrumentation, seals and auxiliary equipment are functioning correctly; and that the required cask internals have been properly installed. Complete operating procedures and instruction manuals will be furnished.

OPERATING PROCEDURES

A. Preparation of Cask for Loading at Reactor Site

1. Health Physics survey railcar and personnel barrier.
2. Visually inspect railcar and equipment for signs of damage. Note any discrepancy on shipping document.
3. Open personnel barrier.
4. Health Physics survey cask and adjacent surfaces of car.

NOTE "A"

If the neutron shield tank is connected to expansion tank, then Step 5 must be performed.

5. Disconnect water jacket expansion line from water jacket.
6. Position car for removal of cask. Set hand brakes and block wheels against movement in either direction.
7. Inspect cask and tie-downs for signs of damage. Complete receiving inspection portion of shipping document.
8. Release lifting yoke from its tie-down on railcar.

NOTE "B"

When the cask is shipped in an "Unloaded" condition, auxiliary cooling system does not operate, nor is it connected to the cask, Therefore, no connection between cask and cooling system need be broken at this time.

9. Remove rear ("B" End of car) tie-down pin and raise rear end (bottom of Cask). Remove impact limiter then move turning fixture into position and lower cask turning trunnions into the turning fixture bearing blocks, by retracting the rear jack.

10. Remove front ("A" End of car) tie-down pin and raise front end of cask. Remove front (top of cask) impact limiter.

11. Attach lift yoke to the lifting trunnions and raise cask to vertical position. Lift cask from car and set down in designated work area. Remove lifting yoke.

12. Remove outer closure head bolts. Remove 3 threaded plugs from top of closure head and replace with 3 threaded eyebolts.

13. Using shackles, attach lifting slings to 3 eyebolts on outer closure head. Remove outer closure head and set it on supports which are suitable for radiological control and maintaining the cleanliness of closure head. Carefully inspect outer head gasket. If seal shows any damage replace it. Be certain gasket is properly installed and seated. Note any damage or repairs in shipping document.

14. Remove nuts from inner closure head studs. Using shackles, attach lifting slings to 3 eyebolts on inner closure head. Remove inner closure head and set down on a clean surface for radiological control and maintaining the cleanliness of the closure head. Carefully inspect inner closure head gasket. If seal shows any damage, replace it. Be certain that replacement gasket is properly installed and seated. Note any damage or repairs on shipping document.

15. Remove containment vessel valve caps. Remove closure head cavity drain valve cover which is located at top side of cask.

Operating Procedures

16. Remove fuel assembly spacer plug and set down on supports which are suitable for radiological control and maintaining of cleanliness of spacer plug.

17. Survey cask internals. Visually inspect cask cavity for foreign material, damage, etc. Note any discrepancy or repairs on shipping document.

18. Check specific gravity (by hydrometer) of fluid in neutron shield tank. The specific gravity must fall within the limits shown on the graph on page XVI-17. If the specific gravity is outside the required limits, add water or anti-freeze as necessary to adjust specific gravity.
    If fluid level is low, add antifreeze mixture in the proper concentration to fill the neutron shield tank.

19. Fill cask cavity with demineralized water up to level of inner closure head flange.

20. Engage cask lifting yoke with cask trunnions and pick up cask.

21. Position cask vver spent fuel storage pool and slowly lower cask to bottom of pool. Wet cask surface using demineralized water prior to placing cask in storage pool.

22. Disengage lifting yoke from cask and remove yoke from spent fuel storage pool.

B. Loading Fuel Into Cask at Reactor Site

1. Read identification number on top of fuel assembly. Record identification number on shipping document.

2. Pick up fuel assembly, using refueling grapple on refueling bridge.

3. Position refueling bridge over cask. Center fuel assembly over cask cavity. Carefully lower fuel assembly into cask. Release

grapple from fuel assembly and raise to full up position. Confirm that fuel assembly is fully seated in cask. Move refueling bridge clear of cask. Record location of fuel assembly in fuel basket.

4. Repeat steps (1) through (3) above until cask is fully loaded.

C. Removal of Cask From Reactor Site Spent Fuel Pool and Preparation for Shipment

1. Install fuel assembly spacer plug into cask.
2. Attach three-legged sling to cask lifting yoke. Move over cask inner closure head. Attach three-legged sling to lifting eyes on outer surface of inner closure head using shackles.
3. Position inner closure head over cask and slowly lower onto cask flange. Guide pins of varying heights are located in the cask flange to provide initial and final alignment. Visually confirm that closure head is seated.
4. Lower cask handling yoke to slacken closure head cables which, in turn, locates yoke relative to cask trunnions. Engage cask trunnions and begin lifting.
5. Raise cask until closure head cavity drain valve is above water. Install all inner closure head nuts hand tight.
6. Hose cask down with demineralized water. Monitor radiation dose rate as cask emerges from pool. When all cask surfaces have been hosed, immediately move cask out of Fuel Pool to Decontamination Area. Set cask down. Remove lifting yoke and closure head lifting cables.
7. Connect hose from demineralized water supply to quick disconnect fitting on cavity fill line. Connect hose to quick disconnect fitting on cavity drain line with free end placed in pool water or contaminated drain. Open demineralized water supply valve and commence

flushing the cask cavity.

8. Connect demineralized water supply to auxiliary cooling inlet at top of cask. Attach hose to auxiliary cooling outlet at top of cask. Discharge end of hose to be directed to suitable drain. Open demineralized water supply valve and continue to circulate water to drain.

9. Tighten all inner closure head nuts to specified torque.

10. Close demineralized water supply valve to cask cavity. Disconnect hose from demineralized water supply. Connect T-fitting with pressure gage and isolation valve to quick disconnect fitting on cavity fill line.

11. Connect helium bottle (with pressure regulated to 10 psig) to quick disconnect on isolation valve assembly. Open fill valve and isolation valve. Open helium supply valve for a few minutes to allow helium to push out a quantity of water from the cavity.

12. Pressurize cavity to 10 psig minimum. Remove drain hose from cavity drain line. Remove helium hose from cavity fill line. Flood closure head cavity until seal and all valves are completely covered. Hold for 10 minutes and watch for bubbles indicating leaks at closure head seal. If bubbles indicate leaks follow special instructions for correction. If not, drain closure head cavity, re-connect drain and helium supply lines.

13. Open helium supply valve. Allow helium flow to force out remaining cavity water until there is no further discharge from the cavity drain line. As water is flowing from cavity measure temperature of effluent. If water temperature is below 80°F, stop flow and wait for heat in fuel to raise water temperature to 80°F. Then apply helium pressure

and expel water until bubbles from discharge hose indicate that all water has been forced from cask. Close cavity fill and drain valves. Close helium supply valve. Remove helium supply line.

14. Pressure test seals in cavity fill and drain line valve base plates by pressurizing annulus between the double seal to 5 psig. Hold pressure for 10 minutes. If there is no drop in pressure seals are satisfactory.

15. Crack cavity drain valve and bleed off excess pressure, vent to plant off gas system. Connect vacuum gauge to this valve and open it wide. Connect vacuum pump to cavity fill valve with line having vacuum gauge attached. Start pump and open valve. Evacuate cavity until pressure falls below 1" of Hg (.5 psi) on both gauges and remains there for 15 minutes. Valve off pump and hold static vacuum for 15 min. If pressure increase is negligible, close both valves. Reconnect helium line, open fill valve and recharge cavity with helium to just above atmospheric pressure. Close fill valve and disconnect helium line.

16. Decontamination procedures are to be carried out while the above operations are taking place.

17. Install valve caps on drain and fill valves. Pressure test seals in valve caps by pressurizing annulus between the double seal to 5 psig. Hold pressure for 10 minutes. If there is no drop in pressure seals are satisfactory.

18. Attach three-legged sling to eyebolts on outer closure head. Position outer closure head on cask.

Operating Procedures

19. Remove eyebolts from outer closure head and insert threaded metal plugs. Torque closure head bolts to specified foot-pounds.

20. Connect vacuum pump to closure head cavity drain valve. Connect exhaust side of vacuum pump to contaminated off gas system. Open the closure head cavity drain valve. Start vacuum pump and pump closure head cavity to 1.0 inch of mercury. Hold for 15 minutes. Operation must continue until supervisor determines that the vacuum gauge reads 1.0 inch of mercury. The supervisor shall verify that the operation has been performed correctly and will sign off the appropriate check list accordingly. Stop and disconnect vacuum pump. Allow pressure in closure head cavity to return to atmospheric. Close closure head cavity drain valve.

21. Connect pressure gage and isolation valve assembly to cavity drain valve. Connect compressed air supply line to isolation valve. Open isolation valve, open cavity drain valve.

22. Open compressed air supply and pressurize closure head cavity to 10 psig. Close air supply valve. Hold pressure for 10 minutes. If there is no drop in pressure, the outer closure head seal is satisfactory. Record results on shipping document.

23. Open isolation valve to relieve pressure in cavity. Remove pressure gage and isolation valve assembly.

24. Health Physics survey cask for surface contamination and radiation dose rates. If values are higher than those specified in shipping document, continue decontamination. Record final values on shipping document.

25. Install valve cover on the closure head cavity drain valve pocket.

Operating Procedures

26. Attach lifting yoke to cask trunnions. Lift and move cask to railcar location and position cask over turning fixture bearing blocks.

27. Lower cask to railcar. Engage bearing blocks on turning fixture with trunnions on bottom end of cask. Lower cask to horizontal position, moving crane as required to keep crane cables vertical. Disengage cask lifitng yoke from cask trunnions and set aside.

28. Elevate bottom end of cask using car mounted jacks. Disengage bearing blocks on turning fixture and move turning fixture to storage position.

29. Install bottom impact structure. Lower cask using jacks until impact structure seats in saddles. Install hold down pin.

30. Install top impact structure. Lower cask using jack until impact structure seats in saddles. Install hold down pin.

31. Connect cask water jacket to expansion tank by connecting flexible metal hose from expansion tank to quick disconnect fitting on water jacket.

32. Connect flexible pipe from auxiliary cooling unit to quick disconnects near top of cask. Open isolation valves. Start pump on auxiliary cooling unit No. 1. Check level in system expansion tank and fill low level mark with demineralized water, if required. Start fans on auxiliary cooling unit No. 1.

33. Repeat Step 32 for auxiliary cooling unit No. 2 when shipping configuration includes optional redundant system. Perform operational checks per check list to assure all components are functioning properly. Turn unit No. 2 off.

34. Close personnel barrier.

35. Paste shipping placards to outside of personnel barrier as required by 49 CFR 173.399.

36. Perform final Health Physics survey of railcar system.
37. Return all decontaminated service equipment to storage.
38. Station Supervisor review shipping document for completeness and accuracy. Sign off as ready for shipment.

D. Preparation of Cask for Unloading at Fuel Reprocessing Site

1. Health Physics survey railcar and personnel barrier.
2. Inspect railcar and personnel barrier for damage. Note any discrepancy on shipping document.
3. Position railcar for removal of cask. Set handbrakes and block wheels against car mvoement in either direction.
4. Open personnel barrier.
5. Health Physics smear test cask for surface contamination and adjacent surfaces of the railcar. Complete receiving portion of shipping document.
6. Disconnect water jacket expansion line from water jacket.
7. Inspect cask and tie downs for damage. Complete cask/railcar inspection portion of shipping document.
8. Remove rear ("B" End of Car) tie-down pin and raise rear end (bottom of cask). Remove impact limiter then move turning fixture into position and lower cask to engage turning trunnions in turning fixture bearing blocks by retracting the rear jacks.
9. Remove front ("A" End of car) tie-down pin and raise front end of cask. Remove front (top of cask) impact limiter.
10. Shutdown auxiliary cooling units No. 1 and No. 2. Remove inlet and outlet flexible pipes.
11. Attach lift yoke to the lifting trunnions and raise cask to vertical position. Lift cask from car and set down in designated work area. Remove lifting yoke.

Operating Procedures

12. Wash down cask surfaces, as required, prior to entry into fuel pool.
13. Remove cover plate from cavity drain valve.
14. Connect pressure gauge and isolation valve assembly to closure head cavity drain valve. Observe and record pressure. Attach compressed air line to isolation valve. Pressurize closure head cavity to 10 psi above observed pressure. Hold pressure for 10 minutes and watch for pressure drop. Record observations.
15. Remove all outer closure head bolts.
16. Remove three (3) threaded inserts from top of outer closure head and replace with (3) eyebolts. Using slings and shackles, connect closure head eyebolts and cask lifting yoke. Remove outer closure head and set outer closure head on stand in Decontamination Area for radiological control and maintaining cleanliness of closure head. Carefully inspect gasket seal in underside of closure head. If gasket shows any damage, replace.
17. Connect cooldown inlet line (hot water supply line) to quick disconnect fitting on drain valve. Connect cooldown outlet line to fill valve. Open fill valve and vent cask thru cooldown system to plant off gas system. Equalize cask pressure to cooldown system feed pressure thru cask fill line.

<u>CAUTION</u>

The hot gases exiting from the fill valve could be highly radioactive. The exhaust gases must therefore be contained and disposed of accordingly.

Operating Procedures

> Any system for cooling down the package shall be provided with a pressure relief device set so that the maximum pressure in the containment vessel does not exceed the maximum allowable operating pressure of the containment vessel.

18. Open suction drain valve and begin cooldown procedure.

<u>CAUTION</u>

> Coolant flow rates must be controlled to avoid thermal shock to the cask internals.

19. Continue cooldown procedure until cask cavity is completely filled with water.
20. Remove all but four closure head bolts, leaving cooldown system lines still connected and operating.
21. Using lifting yoke with slings attached, engage the cask lift trunnions and connect slings to lifting eyes on inner closure head.
22. Remove cooldown lines. Attach a hose to inner closure head fill valve with free end placed in spent fuel pool. Close inner closure head drain valve. (This approach is taken in the event of steam build-up in cavity prior to insertion in pool.)
23. Position cask over spent fuel storage pool and lower cask until top of inner closure head is about one foot under water. Remove remaining four (4) closure head bolts. Wet cask surfaces with demineralized water prior to placing cask in storage pool.

Remove hose from fill valve. Open both cavity fill and drain valves. Above operations are performed using long handled tools.

24. Slowly lower cask to rest on bottom of spent fuel storage pool. Disengage lifting yoke and slowly raise lifting yoke until inner closure head is raised clear of cask.

25. Set inner closure head on stand in Decontamination Area for radiological control and for maintaining cleanliness. Carefully inspect gasket on underside of closure head. If gasket shows any damage, replace it. Be certain that replacement gasket is properly installed and seated.

26. Remove fuel assembly spacer plug and set on supports suitable for radiological control.

E. Unloading Fuel from Cask at Reprocessing Site

1. Read identification number on top surface of fuel assembly. Record identification number on receiving document.
2. Pick up fuel assembly using fuel grapple.
3. Set fuel assembly in pool storage rack. Release grapple from fuel assembly.
4. Repeat steps (1) through (3) above until all fuel has been removed from cask.

F. Preparation for Returning Unloaded Cask to Reactor Site

1. Install fuel assembly spacer plug into cask.
2. Attach three-legged sling to cask lifting yoke. Position cask lifting yoke over cask inner closure head. Attach three-legged sling to lifting eyes on outer surface of inner closure head, using shackles.

Operating Procedures

3. Position inner closure head over the cask and slowly lower onto cask flange. Guide pins of varying heights are located in cask flange to provide initial and final alignment. Visually confirm that closure head is seated.

4. Lower cask handling yoke to slacken the closure head cables which, in turn, locates yoke legs relative to cask trunnions. Engage cask trunnions and commence cask lift.

5. Raise cask until cavity drain valve is above water. Install at least four inner closure head bolts. After pool water has drained from the closure head cavity, close the cavity drain valve.

6. Commence hosing cask down with demineralized water. When all surfaces have been hosed, move cask to Decontamination Area and set down. Continue cask decontamination.

7. Connect hose from demineralized water supply to quick disconnect fitting on cavity fill valve. Connect a hose to cavity drain valve with free end of hose placed in contaminated drain. Open demineralized water supply valve. Open fill valve and drain valve and proceed to flush cavity for two (2) complete flushes. Close cavity fill valve and drain valve. Disconnect demineralized water supply line.

8. Install remaining inner closure bolts and torque to specified foot-pounds. Connect a hose to drain valve with free end of hose placed in contaminated drain. Connnect T-fitting with pressure gage and isolation valve assembly to quick disconnect on cavity fill valve.

Operating Procedures

9. Connect compressed air (regulated to 10 psig) to quick disconnect on isolation valve. Open drain valve and open compressed air supply and remove water from cavity. Remove hoses as well as pressure gage and isolation valve assembly. Install drain and fill line valve caps.

10. Attach three-legged lift sling to eye bolts on outer closure head. Lift outer closure head and position outer closure head on cask flange. Visually confirm that outer closure head is seated. Remove closure head lift cables.

11. Remove eye bolts from outer closure head and insert threaded metal plugs. Torque closure head bolts to specified foot-pounds.

12. Check concentration of anti-freeze in neutron water jacket. See instruction. A.23.

13. Health Physics survey entire cask for surface contamination. If values are higher than those specified in shipping document, continue decontamination. Record final values on shipping document.

14. Install valve cover on cavity drain valve cavity.

15. Attach the lifting yoke to cask. Move cask to railcar location and position cask over turning fixture bearing blocks.

16. Lower cask to railcar. Engage bearing blocks on turning fixture with trunnions on bottom end of cask. Lower cask to horizontal position, moving lifting yoke as required to keep crane cables vertical. Disengage cask lifting yoke from cask trunnions and set aside.

17. Elevate bottom end of cask using car mounted jacks. Disengage bearing blocks on turning fixture and move turning fixture to storage position.

Operating Procedures

18. Install bottom impact structure. Lower cask using jacks until impact structure seats in saddles. Install hold down pin.

19. Install top impact structure. Lower cask using jack until impact structure seats in saddles. Install hold down pin.

20. Health Physics survey cask for surface contamination to assure compliance with DOT Regulations 173.393 (a). Record final values on shipping document.

NOTE "A"

> When cask is shipped in an "Unloaded" condition, auxiliary cooling system does not operate nor is it connected to the cask. Therefore, no connections between cask and cooling system need be made at this time.

21. Connect water jacket and expansion tank, by connecting flexible metal hose from expansion tank to quick disconnect fitting on vent valve. Check expansion tank valves open. Be sure drain cock is closed.

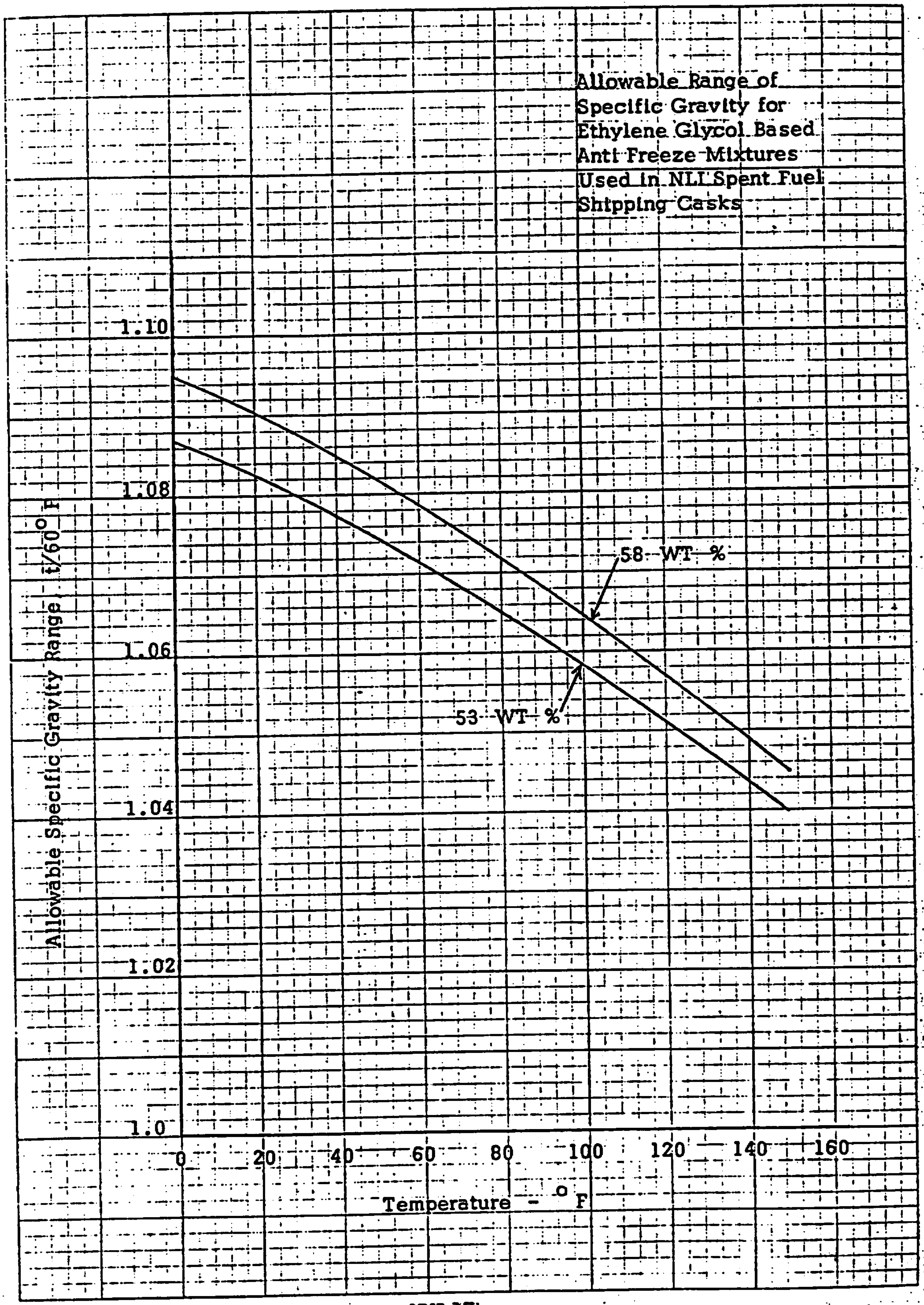
NOTE "B"

> The neutron shield tank need only be connected to the expansion tank when severe temperature changes are expected in transit.

22. Close personnel barrier.

23. Paste "EMPTY" shipping placards to outside of personnel barrier as required by 49 CFR 173.399.

24. Transportation supervisor review shipping document for completeness and accuracy. Sign off as ready for shipment.



Allowable Range of Specific Gravity for Ethylene Glycol Based Anti Freeze Mixtures Used in NLI Spent Fuel Shipping Casks

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Section XVII

SECTION XVII

MAINTENANCE PROGRAM

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SECTION XVII

MAINTENANCE PROGRAM

Prior to the delivery of the shipping cask to the reactor site the cask will go through a set of preoperational checks to assure that all valves, instrumentation and seals are functioning properly and the required set of cask internals have been correctly installed. A checklist will be developed which will list each individual item to be checked and subassemblies or components of the item which require specific maintenance checks. The checklist will include the method of maintenance check to be used, hydrostatic test, air test, NDT, calibration or visual examination and the acceptance criteria for each. Space will be provided on the maintenance checklist form to enter the shipping cask identification number, supervisor's name, date and location. Each checkpoint will require sign-off by the individual making the check and date completed.

The maintenance checklist will also include auxiliary equipment such as the auxiliary cooling systems, lifting rig, personnel shield, expansion tank, and rail car. Maintenance of all running gear will be carried out in accordance with manufacturer's recommended procedures and schedules. Care and maintenance of the diesel generator set, fan and fan motor, pump and pump motor will follow the manufacturer's recommendation for this type of service.

Periodic maintenance and testing of seals, containment vessel valves, and relief valves on the package shall be as follows :

Cask Component	Period	Test/Action
Containment Vessel Valve Assembly		
Base Plate Seals	Each Shipment	*Gas pressure test to 5 psig
	Annually	**Helium Leak Check
Valve Cap Seals	Each Shipment	*Gas pressure test to 5 psig
	Annually	**Helium Leak Check
Inner Closure Head Seal	Each Shipment	Gas Bubble Test - 10 psig
	Annually	***Helium Leak Check
	Annually	Hydrostatic Test to 121 psig
Drain Line Gasket	Quarterly	Replacement
Outer Closure Head Seal	Each Shipment	Gas pressure test to 10 psig
	Annually	Helium Leak Check
Neutron Shield Jacket and Expansion Tank System	Annually	Hydrostatic Test to 300 psig
Neutron Shield Jacket Relief Valve	Annually	Verify cracking and reseating pressures. Allowable variation is ± 5% of nominal cracking pressure
Expansion Tank Relief Valve	Annually	Verify cracking and reseating pressures Allowable variation is ± 5% of nominal cracking pressure.
Impact limiters	Anually	Gas Bubble Test - 10 psig

*See Section XVI, Part C, Step 14 and 17
**See Section XIV, 4.4
***See Section XIV, 4.1.1

The replacement of valves, pressure gages, fittings, seals, and threaded fasteners is considered normal maintenance and would not require engineering approval. Engineering approval is required prior to making any repairs of damaged areas or areas that need refurbishing due to normal wear and tear. All such repairs will be fully documented.

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Section XVIII

SECTION XVIII

ENGINEERING DRAWINGS

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SECTION XVIII

ENGINEERING DRAWINGS

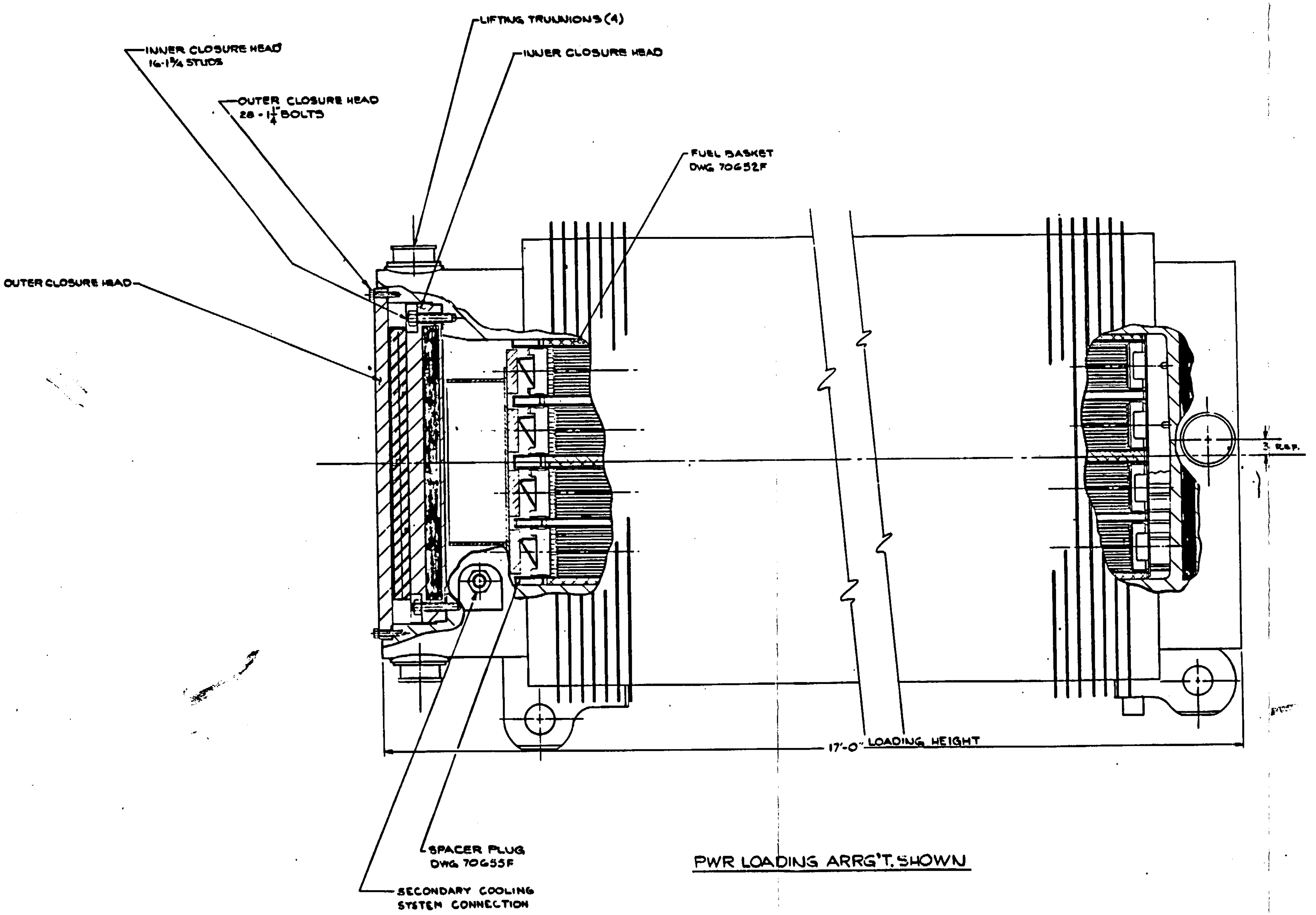
70650F	Sheet 1	Rev. 4	General Arrangement 10/24 Rail Cask
70651F	Sheet 1	Rev. 4	10/24 Rail Cask Details
	Sheet 2	Rev. 5	10/24 Rail Cask Details
	Sheet 3	Rev. 5	10/24 Rail Cask Details
	Sheet 4	Rev. 5	10/24 Rail Cask Details
	Sheet 5	Rev. 3	10/24 Rail Cask Details
	Sheet 6		DELETED
	Sheet 7	Rev. 2	10/24 Rail Cask Details
70652F	Sheet 1	Rev. 7	PWR Fuel Basket 10/24 Rail Cask
	Sheet 2	Rev. 5	PWR Fuel Basket 10/24 Rail Cask
70653F	Sheet 1	Rev. 7	BWR Fuel Basket 10/24 Rail Cask
	Sheet 2	Rev. 5	BWR Fuel Basket 10/24 Rail Cask
70654F	Sheet 1	Rev. 5	NLI 10/24 Cask & Rail Car General Arrangement
	Sheet 2	Rev. 2	Piping Plans & Details Railroad Cask-Cooling System
	Sheet 3		DELETED
70655F	Sheet 1	Rev. 5	PWR Spacer Plug 10/24 Rail Cask
70656F	Sheet 1	Rev. 4	BWR Spacer Plug 10/24 Rail Cask

Engineering Drawings

70640F	Sheet 1		DELETED
70665F	Sheet 1	Rev. 4	Neutron Shield Expansion Tanks 10/24 Rail Cask
70666F	Sheet 1	Rev. 5	10/24 Rail Cask Impact Structure Assembly & Details
	Sheet 2	Rev. 4	10/24 Rail Cask Front Impact Structure Ring Details
	Sheet 3	Rev. 3	10/24 Rail Cask Rear Impact Structure Ring Detail
	Sheet 4		DELETED
70667F	Sheet 1	Rev. 5	10/24 Rail Cask Support Structure Details
	Sheet 2	Rev. 5	10/24 Rail Cask Front Support and Tie Down Details
	Sheet 3	Rev. 5	10/24 Rail Cask Rear Support and Tie Down Details
	Sheet 4		DELETED
70708F	Sheet 1	Rev. 2	10/24 Rail Cask Alternate Construction
70899F	Sheet 1	Rev. 1	Cask, Car Tie-down Arrangement 10/24 Rail Cask
OC-459-1*		Rev. E	General Arrangement - 150 Ton Cask Transfer Car

*Ortner Freight Car Drawing

70650F
SHEET 1 OF 1



PWR LOADING ARRG'T SHOWN

REVISIONS

ZONE	REV	DESCRIPTION		
	1	REV. SPACER PLUG, INNER & OUTER HEAD BOLTING. ADDED RING TO BOTTOM OF CASK	EWB 8-9-74 [illegible]	
	2	REVISED BOTTOM RING IN ZONE F-3, REVISED OUTER CLOSURE HEAD BOLTS, REVISED FUEL BASKET SPACER PLUG. N.D. 1-21-75 INNER CLOSURE HEAD 16-1¾ STUDS WERE 20-1½ BOLTS [illegible]	[illegible] 1-30-75	
	3	ADDED TIE DOWN LUGS & REAR TRUNION. JJC 6-26-75 REVISED PWR BASKET	NR 6-27-75	
	4	REVISED PICTURE OF INNER [illegible] HEAD SEALS & SPACER P[illegible], DELETED LEAD NEUTRON SHIELDING LOCATED AT TOP & BOTTOM OF WATER JACKET.	[illegible] 6/30/78	

SI APERTURE CARD

Also Available On Aperture Card

9111220254-01

ITEM	QTY	NAME	MATL	SPEC	DWG Nº	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN TAT	5/3/73
CHK'D [illegible]	5/7/73
ENG [illegible]	5/7/73
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

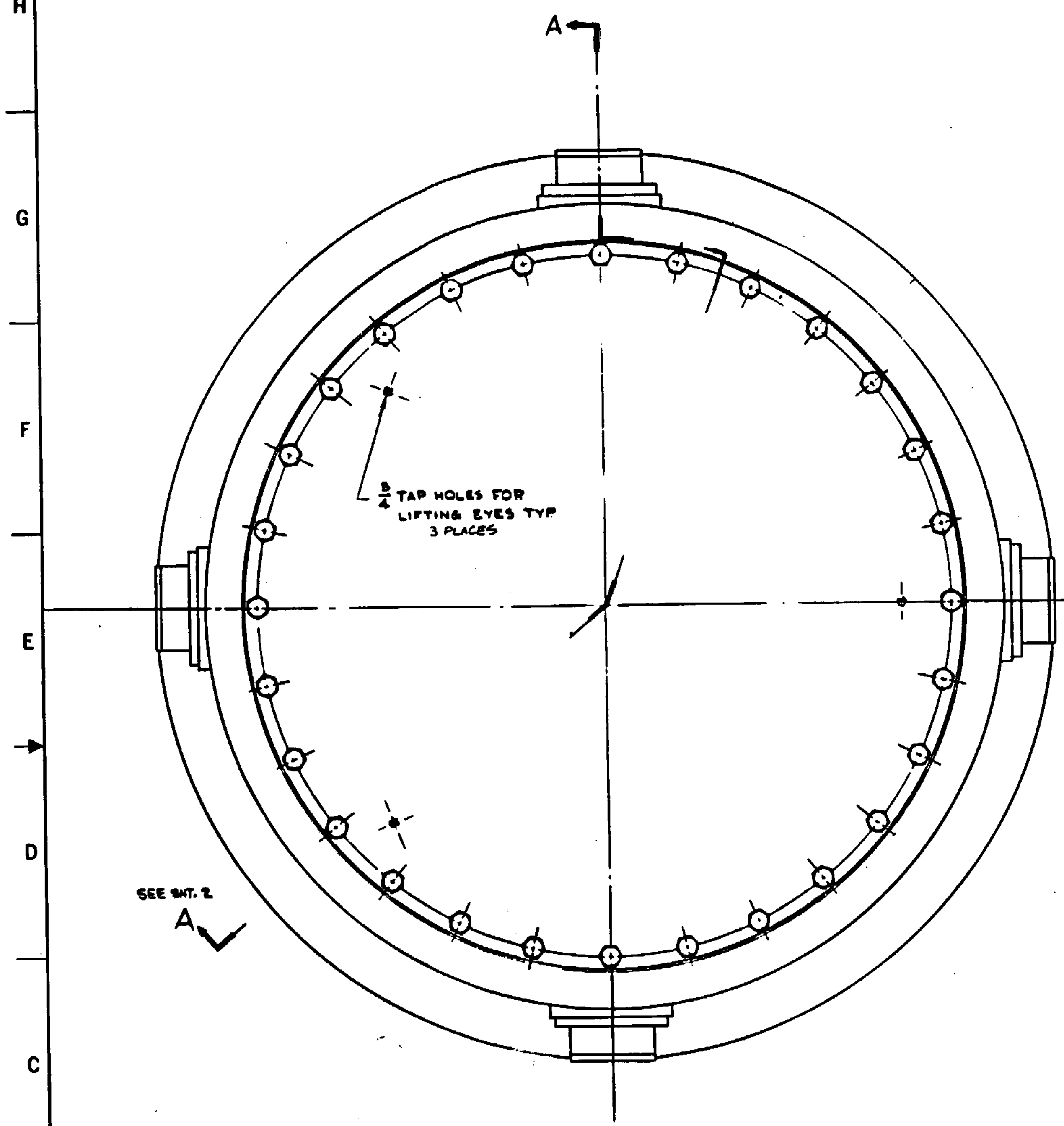
GENERAL ARRANGEMENT
10/24 RAILCASK

CODE IDENT	PROD Nº	SIZE	DRAWING Nº	REV
29932	A-5325	F	70650F	4

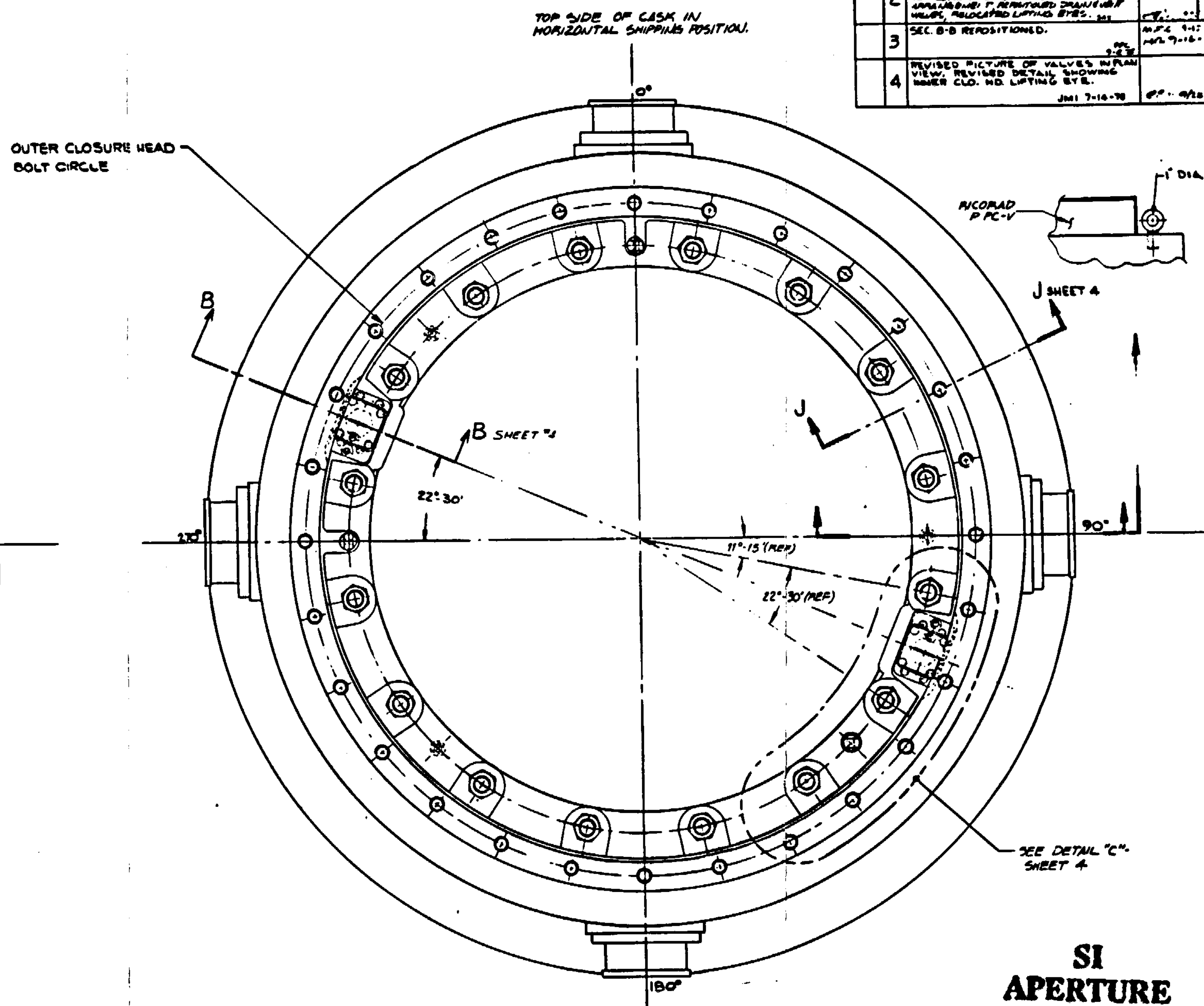
WT
SCALE
SHEET 1 OF 1

70651F
SHEET 1 OF 7

REVISIONS				
ZONE	REV	DESCRIPTION		
	1	REVISED BOLTING ARRANGEMENT & VALVES ADDED BOLTING ARRANGEMENT TO PLAN VIEW. BICORAD P PC-V WAS UNIROYAL DD NEW		
	2	(PLAN VIEW) - DELETED 6 BORE JACK BLT, REPOSITIONED LIFTING EYE HOLES; (PL. VIEW O.F. CL. HD. REM.) - REVISED BOLTING ARRANGEMENT & REPOSITIONED DRAIN & VENT VALVES, RELOCATED LIFTING EYES.		
	3	SEC. B-B REPOSITIONED. 9-8-75	MFC 9-17-75 HRL 9-16-75	
	4	REVISED PICTURE OF VALVES IN PLAN VIEW. REVISED DETAIL SHOWING INNER CLO. HD. LIFTING EYE. JMI 7-14-78	9/28/78	



PLAN VIEW



FLAN VIEW
OUTER CLOSURE HEAD
REMOVED

SI APERTURE CARD

Also Available On Aperture Card

9111220254-02

ITEM	QTY	NAME	MAT'L	SPEC	DWG Nº	DESCRIPTION
LIST OF MATERIAL						

	DATE
DRAWN D.H.B.	4/18/73
CHKD.	5/31/73
ENG	5/31/73
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
DETAILS

CODE IDENT	PROD Nº	SIZE	DRAWING Nº	REV.
29932	A-5325	F	70651F	4
WT	SCALE 3/16		SHEET 1 OF 7	

FIGURE WITHHELD UNDER 10 CFR 2.390

ITEM	QTY	NAME	MAT'L	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN D H B	[illegible]
CHKD. J W K	[illegible]
ENG J C S	[illegible]
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	A-5325	F	70651F	5

WT
SCALE 3/16
SHEET 2 OF 7

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-04

[illegible]

ITEM	QTY	NAME	MATL	SPEC	D'WG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN TAT	[illegible]
CHKD [illegible]	[illegible]
ENG [illegible]	[illegible]
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	A-5325	F	70651F	5

WT | SCALE 1/4 | SHEET 3 OF 7

FIGURE WITHHELD UNDER 10 CFR 2.390

SECTION J-J
SHOWN WITH CLOSURE
HEADS REMOVED

-05

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN T&T	
CHKD	
ENG	
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
34033	A-5525	F	70651F	5

WT
SCALE AS NOTED
SHEET 4 OF 7

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-06

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN J.J.C.	[illegible]
CHKD [illegible]	[illegible]
ENG [illegible]	[illegible]
QC	
PROD	

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
DETAILS

CODE IDENT	[illegible] NO	SIZE	DRAWING NO	REV
39932	E-5526	F	70-651F	3

WT ~ SCALE ~ SHEET 5 OF 7

FIGURE WITHHELD UNDER 10 CFR 2.390

SECTION E-E

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN HTW	[illegible]
CHKD. JFS	[illegible]
ENG [illegible]	[illegible]
Q.C.	
PROD	

N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	A-5525	F	70651F	2

9111220254-07

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-05

NATIONAL LEAD COMPANY
NUCLEAR DIVISION

PWR FUEL BASKET
10/24 RAILCASK

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-09

NL INDUSTRIES
NUCLEAR DIVISION

PWR FUEL BASKET
10/24 RAIL CASK

A-5525

FIGURE WITHHELD UNDER 10 CFR 2.390

E BASKET WITH SUPPORTS (O.A.L.)

9111220254-10

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

DRAWN TAT
CHECK
ENG
Q.C.
PROD

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

BWR FUEL BASKET
10/24 RAILCASK

CODE IDENT	PROJ NO	SIZE	DRAWING NO	REV
209312	A-5325	F	70653F	7

SCALE 3/16 SHEET 1 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390

Aperture

9111220254-11

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN BY	
CHKD. JPK	
ENG.	
Q.C.	
PROD	

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

BWR FUEL BASKET

10/24 RAIL CASK

CONT IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	A-6325	F	70453 F	S

WT
SCALE ~
SHEET 2 OF

FIGURE WITHHELD UNDER 10 CFR 2.390

(

9111220254-12

[illegible]

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN TW	1-29-[illegible]
CHKD. [illegible]	1-24-[illegible]
ENG [illegible]	1-30-[illegible]
Q.C.	
PROD	

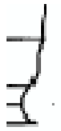
N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

NLI 10/24 CASK & RAILCAR
GENERAL ARRANGEMENT

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	A5325	F	70C54 F	5

WT ——— SCALE ——— SHEET 1 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390



SECTION A-A

9111220254-13

LIST OF MATERIAL

N L INDUSTRIES
NUCLEAR DIVISION

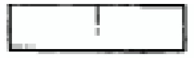
DRAWN J.P.L.

PIPING PLANS & DETAILS
RAILROAD CASK-COOLING SYSTEM

CODE IDENT	PROJ. NO.	SIZE	DRAWING NO.	REV
20933	A-5525	F	10634 F	2

SHEET 2 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390



1

SECTION A-A

9111220254-14

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

DRAWN
CHKD
ENG
Q.C.
PROD
DATE

N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

PWR SPACER PLUG
10/24 RAIL CASK

CODE IDENT	BRASS NR	SIZE	DRAWING NO	REV
29932	5325	F	70653F	5

WT
SCALE ~
SHEET 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

C

C

ITEM QTY NAME MAT'L SPEC DWG NO DESCRIPTION

LIST OF MATERIAL

DATE

DRAWN
CHKD.
ENG
Q.C.
PROD

N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

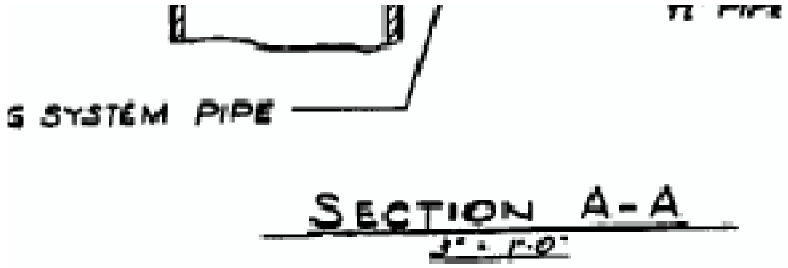
B WR SPACER PLUG

10/24 RAIL CASK

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	E-5528	F	70656F	4

WT SCALE [illegible] SHEET 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390



ITEM	QTY	NAME	MATL	SPEC	DWG Nº	DESCRIPTION
LIST OF MATERIAL						

DRAWN EWB
CHKD. M.F.E.
ENG W.C.C.
Q.C.
PROD

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

NEUTRON SHIELD
EXPANSION TANK
10/24 RAIL CAR

CODE IDENT	PROG NO.	SIZE	DRAWING Nº	REV
29932	A 5575	F	70065 F	4

WT
SCALE —
SHEET 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-17

[illegible]

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN FFC	[illegible]
CHKD HPC	[illegible]
ENG AMC	[illegible]
Q.E.	
PROD	

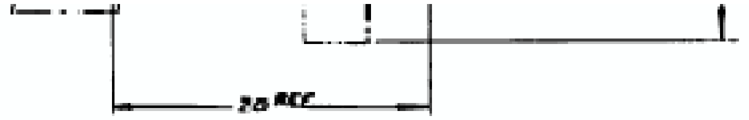
N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
IMPACT STRUCTURE
ASSEMBLY & DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	E-5325	F	70666F	5

WT
SCALE ~
SHEET 1 OF 3

FIGURE WITHHELD UNDER 10 CFR 2.390



SECTION B-B

9111220254-/8

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN SAS	
CHKD	
ENG	
Q.C.	
PROD	

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

FRONT IMPACT STRUCTURE
RING DETAILS
10/24 RAIL CASK

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	E-5325	F	70666 F	4

WT ~ SCALE ~ SHEET 2 OF 3

FIGURE WITHHELD UNDER 10 CFR 2.390

WISE SPECIFIED ALL
LIQUID PENETRANT

WISE SPECIFIED ALL
BE STAINLESS STEEL

ARE HIGH STRENGTH
SOC. HD. CAP SCREWS

B

VIEW FROM REAR OF CASK

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN M.L.S.	[illegible]
CHKD. M. FIE	[illegible]
ENG MAB	[illegible]
Q.C.	
PROD	

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
REAR IMPACT STRUCTURE
RING DETAILS

CODE IDENT	PROJ NO	SIZE	DRAWING NO	REV
29932	E-5526	F	70664F	3

WT ~ SCALE ~ SHEET 3 OF 3

9111220254-/9

FIGURE WITHHELD UNDER 10 CFR 2.390

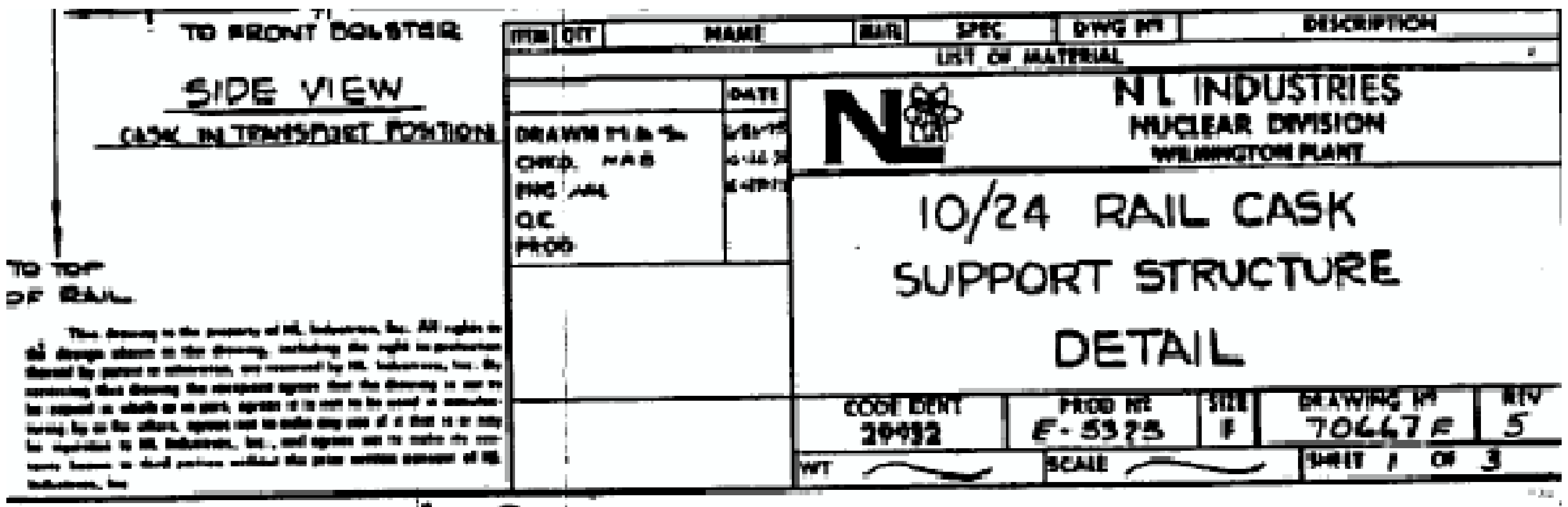


FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-21

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

		DATE
DRAWN	M.A.S	[illegible]
CHKD.	M.F.C.	[illegible]
ENG.	[illegible]	[illegible]
Q.C.		
PROD		

10/24 RAIL CASK
FRONT SUPPORT & TIE DOWN
DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	E-5325	F	70667F	5

WT | SCALE | SHEET 1 OF 2

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-22

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

DRAWN
CHKD.
ENG.
Q.C.
PROD.

DATE

NL INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
REAR SUPPORT & TIE DOWN
DETAILS

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
29932	E-5325	F	70667F	[illegible]

WT ~ SCALE ~ SHEET 3 OF [illegible]

FIGURE WITHHELD UNDER 10 CFR 2.390

9111220254-23

ITEM	QTY	NAME	MATL	SPEC	DWG NO	DESCRIPTION

LIST OF MATERIAL

		DATE
DRAWN	C.A.S.	[illegible]
CHKD.	JFK	[illegible]
ENG.		[illegible]
Q.C.		
PROD		

N L INDUSTRIES
NUCLEAR DIVISION
WILMINGTON PLANT

10/24 RAIL CASK
ALTERNATE CONSTRUCTION

CODE IDENT	PROD NO	SIZE	DRAWING NO	REV
30032	A-5325	F	70708F	2

WT ~ SCALE NONE SHEET 1 OF 1

FIGURE WITHHELD UNDER 10 CFR 2.390

ITEM	QTY	NAME	MAT'L	SPEC	DWG Nº	DESCRIPTION

LIST OF MATERIAL

	DATE
DRAWN R.C.	9-4-75
CHK'D. D.L.C.	9-13-75
ENG E.P.V.	9-4-??
Q.C.	
PROD	

NATIONAL LEAD COMPANY
NUCLEAR DIVISION
WILMINGTON PLANT

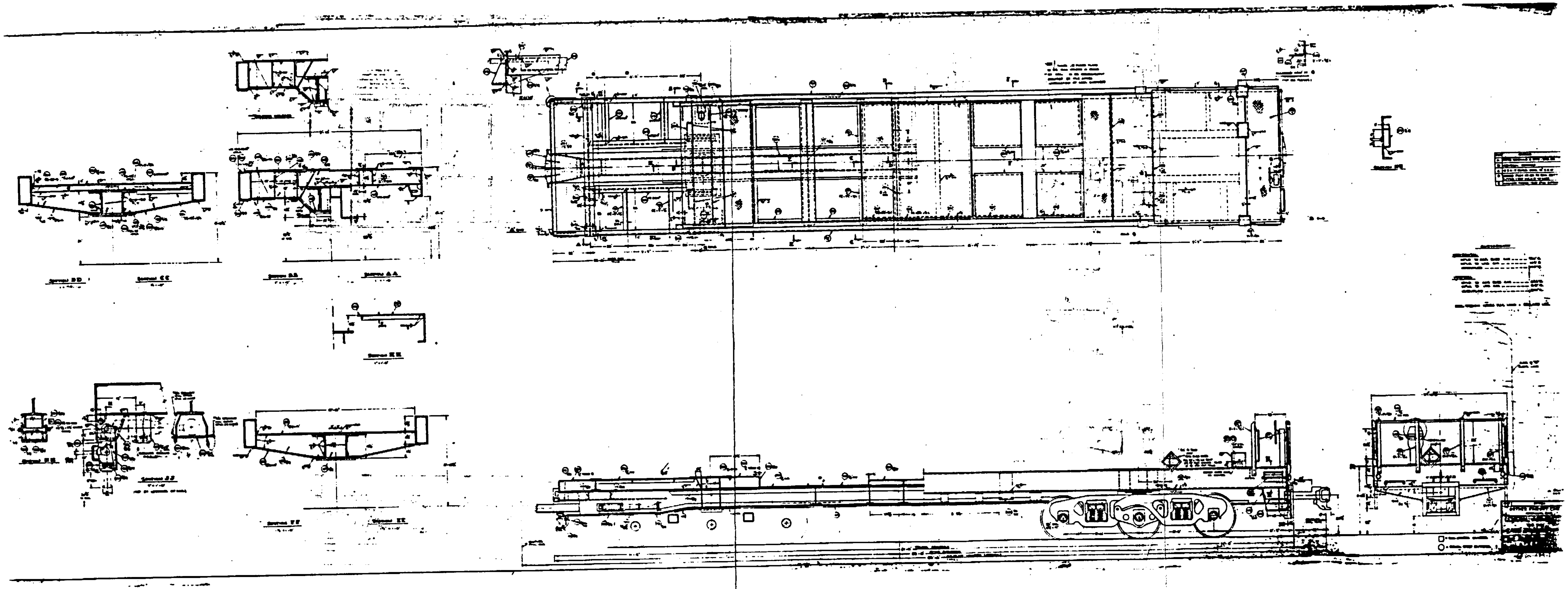
CASK, CAR TIE DOWN
ARRANGEMENT 10/24 RAILCASK

CODE IDENT	PROD Nº	SIZE	DRAWING Nº	REV
29932	A 5325	F	70899F	1

WT ~~~ SCALE ~~~ SHEET 1 OF 1

**SI
APERTURE
CARD**

**Also Available On
Aperture Card**



9111220254-25