PDR
71-9097

NUCLEAR
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U.S. Nuclear Regulatory Commission
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June 21, 1979

Mr. Charles E. MacDonald, Chief
Transportation Branch
Division of Fuel Cycle and Material Safety
U.S. Nuclear Regulatory Commission
Washington, DC 20555

REFERENCE: Docket Number 71-9097

SUBJECT: Certificate of Compliance for CNSI Cask 14-195L

Dear Mr. MacDonald:

In response to your letter of December 11, 1978, we are providing detailed answers to the noted questions. Should additional information or clarification be required, please do not hesitate calling.

Sincerely yours,

NUCLEAR PACKAGING, INC.

Larry J. Hansen

Larry J. Hansen

LJH/dmm

Enclosure

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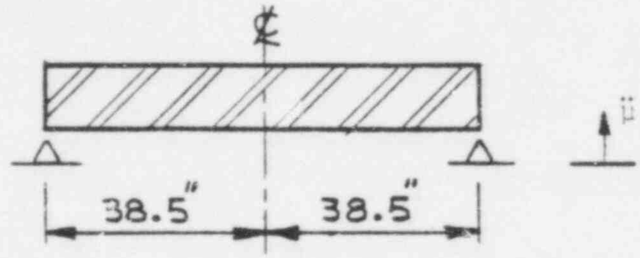
Chem-Nuclear Systems, Inc.
Model No. CNSI-14-195L
Docket No. 71-9097

Question No. 1

The analysis presented in the July 31, 1978 transmittal assumes a Rigid Body Cask Method. For this approach a lid response acceleration was found to be:

$\ddot{x}$ = 109.8 g's (Ref. page 7j, July 31, 1978)

A second and totally different approach can be taken to calculate the response amplitude of the lid. Both methods calculate an estimate of foundation acceleration $\ddot{\mu}$ for the lid.



Given the foundation acceleration, $\ddot{\mu}$, the acceleration response amplitude, $\ddot{x}$, of the lid is found as:

$$\ddot{x} = 2\ddot{\mu} \sin (\pi\tau/T)$$

where:

T = period of lid, sec

= 1/f = 1/70.49

τ = duration of foundation acceleration pulse, $\ddot{\mu}$

$= \frac{1}{\ddot{\mu}} \frac{2h}{g}$, see derivation in July 31, 1978 transmittal

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The first approach to calculate $\ddot{u}$, assumed a rigid body cask. The second method shown below assumes an elastic cask.

Elastic Cask Method

As a moving elastic body (rod) impacts a rigid boundary, an elastic stress wave is developed. This stress wave propagates from the impacted end to the opposite end (where the lid is located) where it is reflected back down the rod. The lid foundation acceleration, $\ddot{u}$, will be computed from the magnitude of this stress wave. The magnitude of the stress wave is:

$$\sigma = \frac{Ev}{c}$$

where:

E = modulus of elasticity

$v = \sqrt{2gh}$, impact velocity

$= \sqrt{2(386.4)(12)} = 96.3$ in/sec

$c = \sqrt{\frac{E}{\rho}}$, sonic velocity of material

The corresponding force is:

$F = \sigma A$; where: A = Area

For the cask sidewalls:

Component	Material	E psi	ρ $(\frac{lbs\text{-}sec^2}{in^4})$	σ (psi)	Area (in^2)	Force (lbs)
Outer Shell	Steel	28.5×10^6	.284/386.4	13938	191.44	2.668×10^6
Inner Shell	Steel	"	"	13938	30.23	0.421×10^6
Shield	Lead	2×10^6	.410/386.4	4436	402.66	1.786×10^6

TOTAL: 4.875×10^6

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The elastic stress wave force, 4.875×10^6 lbs, is applied to the foundation of the lid. This is equivalent to a foundation acceleration of:

$$\ddot{\mu} = \frac{W}{F} = 4100 \text{ g's}$$

Where:

$$W = \text{weight of lid}$$
$$= \frac{\pi}{4}(38.5^2)\left[(1.25)(.284)+(1.625)(.410)\right]$$
$$= 1188.89 \text{ lbs.}$$
$$F = 4.875\times10^6 \text{ lbs.}$$

The associated response acceleration of the lid is found as follows:

The pulse duration is:

$$\tau = \frac{1}{\ddot{\mu}}\sqrt{\frac{2h}{g}} = \frac{1}{4100}\sqrt{\frac{2(1)}{32.2}} = 60.79\times10^{-6} \text{ sec.}$$

The lid response acceleration is:

$$\ddot{x} = 2\ddot{\mu}\sin(\pi\tau/T)$$
$$= 2(4100)\sin\left[\pi(60.79\times10^{-6})(70.49)\right] = \underline{\underline{110.4 \text{ g's}}}$$

This is very close to the prediction for the rigid body case. The reason can be seen by examining the above two equations.

$$\ddot{x} = 2\ddot{\mu}\sin\left[\frac{1}{\ddot{\mu}}\cdot\frac{\pi}{T}\sqrt{\frac{2h}{g}}\right]$$

Let: $\sin x \approx x - \frac{x^3}{6}$ (the first two terms of the sine expansion)

$$a = \frac{\pi}{T}\sqrt{\frac{2h}{g}} = 55.19$$

Then:

$$\ddot{x} = \left[2\ddot{\mu}\left(\frac{a}{\ddot{\mu}}\right) - \frac{1}{6}\left(\frac{a}{\ddot{\mu}}\right)^3\right]$$
$$= 2\left[a - \frac{1}{6}\cdot\frac{a^3}{\ddot{\mu}^2}\right]$$
$$= 110.4 - \frac{28018.32}{\ddot{\mu}^2}$$

It can be seen that the maximum response acceleration of the lid cannot exceed 110.4 g's. As the foundation acceleration decreases, so does the response acceleration. To explore this, let us calculate the foundation acceleration that reduces the response acceleration by 5%:

$$\frac{28018.32}{\ddot{\mu}^2} = (.05)(110.4)$$

$$\ddot{\mu} = \left[\frac{28018.32}{(.05)(110.4)}\right]^{\frac{1}{2}} = 71.24 \text{ g's}$$

This is well below the foundation acceleration value predicted by the rigid body method.

This comparison demonstrates why both the rigid body and elastic body methods give nearly identical results.

Question No. 2

Both the primary and secondary lid of the cask have been structuraly revised. Please note changes shown in Dwg. 1-295-100, Rev. H.

Should the cask impact onto the primary lid end of the cask, loads would be reacted across a number of contact points.

From the drawing it can be seen that a heavy 7/8 inch thick steel plate has been added to the secondary lid to bring its surface up to and flush with the outer cask rim. Therefore, the secondary lid will react inertial and payload impact forces in direct compression.

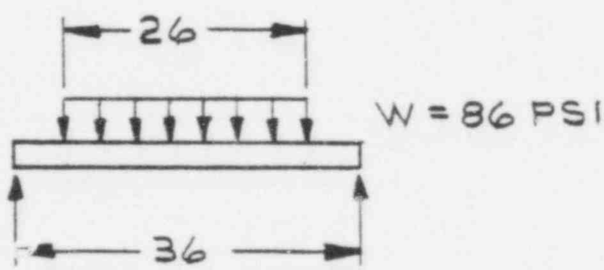
Loads across the primary lid will be reacted at the outer rim by the 12 spacer block (i.e., Item 15). In addition, eight heavy gauge square tubes have been added to the lid to form radial spokes. These tubes are also flush with the top surface of the cask and will provide uniform support. Therefore, impact forces will be reacted in direct compression across the primary lid and spacers, thus resulting in little or no bending stresses.

Question No. 3

As noted above, the secondary lid has been modified to include an additional 7/8 inch thick plate to the outside surface. This plate does not completely cover the central portion of the lid and is, therefore, conservatively neglected from the following analysis.

Loads across the secondary lid could result from inertial forces of the lid and payload. This load for the total primary lid was calculated to 400337 lbs. or 86 psi.

Therefore:



From Roark, 4th Edition, Case 2, the maximum stress is given as:

$$S = (W/4\pi m)(6/t^2)\left[m+(m+1)\log a/r-(m-1)r^2/4a^2\right]$$

Where:

$$W = (86\ \text{psi})(26^2)\pi/4 = 45{,}600\ \text{lb.}$$

$$m = 3$$

$$r = 13$$

$$a = 18$$

$$S = (45660/4\pi 3)(6/t^2)\left[3+4\log 18/13 - 2(13)^2/4(18)^2\right]$$

$$= 1211.6(6/t^2)(4.04)$$

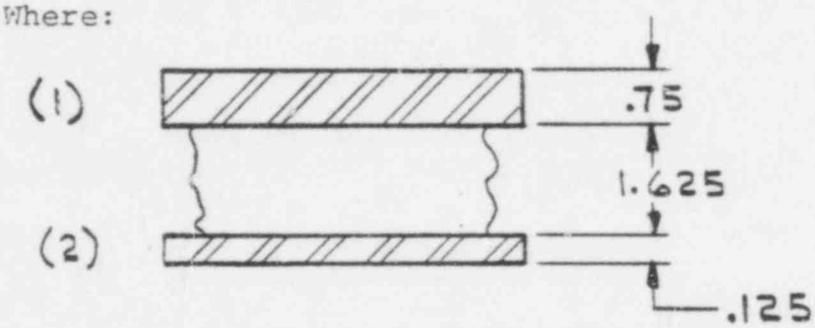
$$= 4896(6/t^2)$$

Since:

$$S = Mc/I = M(6/t^2)$$

$$S = 4896\ c/I$$

Where:



	A	Y	AY	I_o
1	.75	2.125	1.593	.0351
2	.125	.062	.008	
	.875		1.601	

$$\bar{y} = 1.601/.875 = 1.83\ \text{in.}$$

$$I_T = I_o + \Sigma AD^2 = .491\ \text{in}^4$$

$$c = \bar{y} = 1.83$$

$$S = (4896)(1.83)/(.491)$$

$$S = 18247\ \text{psi}$$

Margin of Safety (Secondary Lid Bending)

$$M.S. = F_{Ty}/S-1$$

$$= (36000\ psi)/(18247\ psi)-1$$

$$= \underline{\underline{+.97}}$$

Stresses calculated on page 6 of 8 of previous submittal provide stresses for the inner edge of the primary lid.

Secondary lid bolt loads are:

$$P_b = (86\ psi)(26^2)(\pi/4)/18\ bolts$$

$$= 2536\ lbs/bolt$$

By inspection, this is well below the capcity of a standard 3/4" diameter bolt. Bolt pads are secured to the primary lid by a 3/8 in. weld.

$$f_w = P_b/A_w\ \zeta$$

Where:

$$A_w = (1.5)(\pi)(.375)(\sin 45^o) = 1.25\ in^2$$

$$\zeta = 50\%\ \text{weld efficiency}$$

$$f_w = (2536\ lbs)/(1.25\ in^2)(.50)$$

$$= 4058\ psi$$

Margin of Safety (Boss Attachment)

$$M.S. = F_{ty}/f_w-1$$

$$= 36000\ psi/4058\ -1$$

$$= \underline{\underline{+7.8}}$$

Therefore, it can be concluded that stresses in the secondary lid and inner edge of the primary lid are well within the acceptance criteria.