NuPac Services

A Pacific Nuclear Company

NUPAC SERVICES
A Pacific Nuclear Company

Columbia, SC 29212

SAFETY ANALYSIS REPORT

FOR

NUPAC 50 SERIES CASKS

TO

10 CFR 71 TYPE "A" PACKAGING REQUIREMENTS

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APPLICATION FOR
TYPE A
AUTHORIZING
SHIPMENT OF NUCLEAR MATERIAL
IN THE
NUPAC 50 PACKAGING

1.0 GENERAL INFORMATION

1.1 Introduction

The NuPac 50 packaging has been developed as a safe means of transporting Type "A" quantities of radioactive materials or greater than Type "A" quantities meeting the definition of Low Specific Activity material. Fissile material is limited to those exempt quantities licensed under 10CFR71.7. Authorization is sought for shipment by cargo vessel, motor vehicle and rail.

1.2 Package Description

1.2.1 Packaging

1.2.1.1 General Description

The Nupac 50 packaging is a reusable series of four individual shipping packages designed to protect radioactive material from normal conditions of transport. The four packages are identical except for the thickness of the shield; specifically, the four are identified with the following nomenclature:

Version	Shield Thickness
NuPac 50-1.5L	1.5"
NuPac 50-2.5L	2.5"
NuPac 50-3.0L	3.0"
NuPac 50-4.0L	4.0"

The NuPac 50 casks are top loading shields designed specifically for the safe transport of Type "A" levels of radioactive materials. The shields can accommodate a full capacity 50 cu. ft. liner, or miscellaneous form cargo such as wooden crates, etc.

1.2.1.2 Materials of Construction, Dimensions & Fabricating Methods

General Arrangement drawings of the NuPac 50 packaging are included in Appendix 1.10.1. They show the overall dimensions as well as the material.

The cask body consists of 3/8 inch external and internal steel shells separated by a lead shield between these two shells. The top and bottom ends of the cylindrical cask are constructed of a pair of stacked steel plates. Reference dimensions of the cylindrical lead shield and steel ends are:

	Thicknesses (in)	
Version	Lead Shield[1]	Steel Ends[2]
50-1.5L	1-1/4	2-1/4
50-2.5L	2-1/4	4
50-3.0L	2-3/4	4-1/2
40-4.0L	3-3/4	6

Notes:

(1) Does not include the 3/8" internal and external steel shells.

(2) Comprised of two stepped plates.

The top serves as a removable cask lid and is secured to the cylindrical cask body by eight high strength 1 inch ratchet binders. A 29 1/2 inch secondary cask lid is located in the center of the primary lid and is secured to the primary lid by eight 3/4 inch studs. Lifting lug and tiedowns are a structural part of the package.

1.2.1.3 Containment Vessel

The NuPac 50 cask serves as the containment vessel and its mechanical configuration is described in the foregoing paragraph.

A neoprene gasket is employed in the primary and secondary lid interfaces. The secondary lid also uses a redundant neoprene seal.

Waste products will be contained in 55 gallon drums or with heavy gauge disposable steel liners.

1.2.1.4 Neutron Absorbers

There are no materials used as neutron absorbers or moderators in the NuPac 50 packaging.

1.2.1.5 Package Weight

The gross, net and payload weights of the NuPac 50 packaging are:

	50-1.5L	50-2.5L	50-3.0L	50-4.0L
Lids				
Primary	895	1695	1920	2780
Secondary	515	920	1015	13[illegible]
Cask Body				
Steel Shells	1840	1875	1910	1950
End	1280	2365	2715	3775
Lead	4305	8160	10160	14490
Lugs/Binders	130	130	130	130
Net Cask Wt:	8965	15125	17850	24615
Payload Wt:	4200	4200	4200	4200
Gross Wt:	13165	19325	22050	28815
(Use for Analysis):	13300	19400	22200	29000

1.2.1.6 Receptacles

There are no internal or external structures supporting or protecting receptacles.

1.2.1.7 Drain Port

The cask is provided with a 3/8 inch NPT pipe plug and drain systems. Its use is for removal of entrapped liquids, i.e., rain, decontamination fluids, etc.

1.2.1.8 Tiedowns

Tiedowns are a structural part of the package. From the attached general arrangement drawing it can be seen that four reinforced tiedown locations are provided. Refer to Section 2.5.2 for a detailed analysis of their structural integrity.

1.2.1.9 Lifting Devices

Lifting devices are a structural part of the package. From the general arrangement drawing it can be seen that three reinforced lifting locations are provided. Refer to Section 2.5.1 for a detailed analysis of their structural integrity.

1.2.1.10 Pressure Relief System

There are no pressure relief valves.

1.2.1.11 Heat Dissipation

There are no special devices used for the transfer or dissipation of heat. The package maximum design capacity is 400 watts. However, this value may be exceeded if it can be demonstrated that actual equilibrium temperatures with the higher heat load are still within allowable limits.

1.2.1.12 Coolants

There are no coolants involved.

1.2.1.13 Protrusions

There are no outer or inner protrusions, except for the lifting and tiedown lugs described above.

1.2.1.14 Shielding

The contents will be limited such that the radiological shielding provided will assure compliance with DOT and IAEA regulatory requirements. Should a lead slump occur, as the result of a flat end drop, the deeply stepped lid will provide full shielding protection.

1.2.2 Operational Features

Refer to the General Arrangement drawing of the packaging, in Appendix 2.10.1. There are no complex operational requirements connected with the NuPac 50 packaging and none that have any transport significance.

1.2.3 Contents of Packaging

This application is for transporting the following radioactive materials as defined in U.S.A.and I.A.E.A. regulations:

a) Type "A" quantities in normal or special form;
b) Fissile quantities are those limited to the amounts as generally licensed under 10 CFR 71.7;
c) L.S.A. materials greater than Type "A" quantities;
d) The chemical and physical form of the package contents will be in all forms, other than liquids. This will include ion exchange resins in a dewatered or solidified state, typical PWR and BWR solidified radioactive waste and miscellaneous radiative solid waste materials such as pipe, wood, metal scrap, etc. All solidified resins will be contained within a steel disposable liner. These liners will isolate the contents from the cask. Resin liners used for any solidification process that could create a significant chemical, galvanic or other reaction, will be lined with an inert protective coating.

2.0 STRUCTURAL EVALUATION

This section identifies and describes the principal structural engineering design of the packaging, components, and systems important to safety in compliance with the performance requirements of 10 CFR 71.

2.1 Structural Design

2.1.1 Discussion

The principal structural member of the NuPac 50 package is the primary containment vessel or transport shield, as described in Section 1.2.1 The above components are identified on the drawing as noted in Appendix 2.10.1. A detailed discussion of the structural design and performance of these components will be provided below.

2.1.2 Design Criteria

The shield top and bottom are constructed of two steel plates laminated together. Cylindrical side walls have an external skin and an internal skin of 3/8 inch thick plate. These two plates encase a variable thickness of lead. Pertinent dimensions of the four versions of the NuPac 50 package are as follows:

	Thicknesses (in)		
	Steel	Cylindrical Walls	
Version	Ends	Lead	Total
50-1.5L	2-1/4	1-1/4	2
50-2.5L	4	2-1/4	3
50-3.0L	4-1/2	2-3/4	3-1/2
50-4.0L	6	3-3/4	4-1/2

2.2 Weights and Center of Gravity

The weight of the four cask versions payload are summarized in Section 1.2.1.5. The center of gravity for the assembled package is located at the approximate geometric center of gravity.

2.3 Mechanical Properties of Materials

The NuPac 50 packaging uses an outer and inner shell fabricated of ASTM A516 Gr. 70. Material properties of the steel are as follows:

F_{tu} = 70,000 psi

F_{ty} = 38,000 psi

F_{su} = 42,000 psi

F_{sy} = 22,800 psi

Lead shielding will possess those properties referenced in ORNL-NSIC-68, Table 2.6, Page 84.

Lid studs are fabricated of AISI Type 303 or 304 stainless steel per ASTM A582 or A276 respectively. Properties used for analysis are as follows:

Bar Properties

F_{tu} = 85,000 psi

F_{ty} = 35,000 psi

Tiedown lugs are fabricated of U.S. Steel T-1 material possessing the following properties per ASTM A514:

2" Plate

F_{tu} = 115,000 psi

F_{ty} = 110,000 psi

F_{sy} = .6 F_{ty} = 65,000 psi

2.4 General Standards for all Packages

This section demonstrates that the general standards for all packages are met.

2.4.1 Positive Closure

As described in Section 1.2.1, the positive closure system consists of a primary lid secured by eight high strength 1 inch ratchet binders and a secondary lid affixed with eight 3/4 inch diameter studs. In addition, each package will be sealed with an approved tamper indicating seal and suitable locks to prevent inadvertent and undetected opening.

2.4.2 Chemical and Galvanic Reactions

The shield is constructed from heavy structural steel plates. All exterior surfaces are primed and painted with high quality epoxy. There will be no galvanic, chemical or other reaction in air, nitrogen or water atmosphere.

2.5 Lifting and Tiedown Standards for all Packages

2.5.1 Lifting Devices

There are four lifting lugs for the package; three lifting lugs for the lid assembly (primary and secondary lids) and a single lifting lug for the secondary lid. Each set of lifting lugs is separately evaluated versus the requirements of 10 CFR 71, Section 71.31(c).

2.5.1.1 Package Lifting Lugs

For conservatism, the package is assumed to be lifted by only two of the four identical lifting lugs. The maximum package weight is 29,000 lbs. The lug load is calculated as:

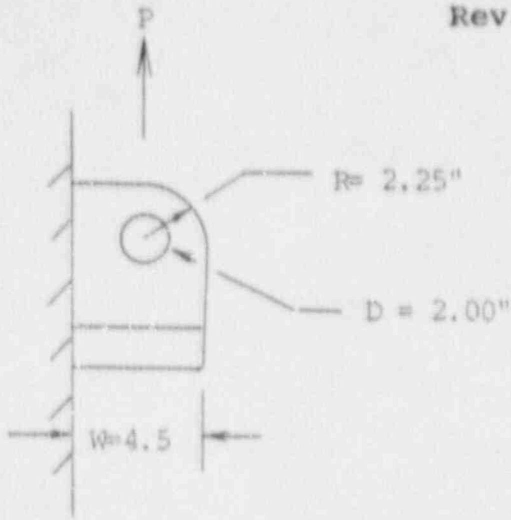
$P_L = Wa_g/N$; where W = Package Weight

a_g = Load Factor

N = Number of Lugs

$P_L = (29000)(3)/2 = 43,500$ lbs.

From the drawing:



Using Reference No. 1 - Figure 4.4.1-3:

$W/D = 4.5/2 = 2.25$ & $R/D = 2.25/2.0 = 1.125$

$K = 1.01$

Ultimate lug capability is given by:

$P_{ult} = K\ D\ T\ F_{tu}$ Where:

$K = 1.01$

$D = 2.0$ in

$t = 1.0$ in

$F_{tu} = 70,000$ psi (A516 Gr 70)

$P_{ult} = (1.01)(2.0)\ (1.0)\ (70000)$

$= 141,400$ lbs. (ultimate)

From Reference No. 1 - Figure 4.4.1-2, the yield correction factor is given to be Y = 1.1 or:

$P_{yld} = P_{ult}\ Y\ F_{ty}/F_{tu}$

$= (141,400)\ (1.1)\ (38000)/(70000)$

$= 84436$ lbs. (yield)

Margin of Safety:

$$M.S. = P_{yld}/P_L - 1$$
$$= 84436/43500 - 1$$
$$= +0.94$$

The yield capacity of the lug to shell weld may be estimated as:

$P_\lambda = F_{sy}A_w$; Where: $F_{sy} = 22,800$ psi

$A_w = L_w \cdot t_w$, weld area

$L_w = 2(8.5+1) = 19$ in.

$t_w = (3/8)\sqrt{2} = 0.530$ (V weld)

$P_\lambda = (22800)(19)(.53) = 229,596$ lbs.

The lug to shell weld margin of safety is:

$$M.S. = 229596/42750 - 1 = +4.37$$

The ultimate capacity of the outer shell may be estimated as:

$P_{su} = F_{su}A_s$; $F_{su} = 42000$ psi

$A_s = (3/8)(8.5)(2) = 6.38$ in^2

$P_{su} = (42000)(6.38) = 267960$ lbs.

The corresponding yield load capacity is estimated as:

$$P_{sy} = .6\, P_{su} = 160776 \text{ lbs.}$$

The outer shell margin of safety against yield is:

$$M.S. = 160776/43500 - 1 = +2.70$$

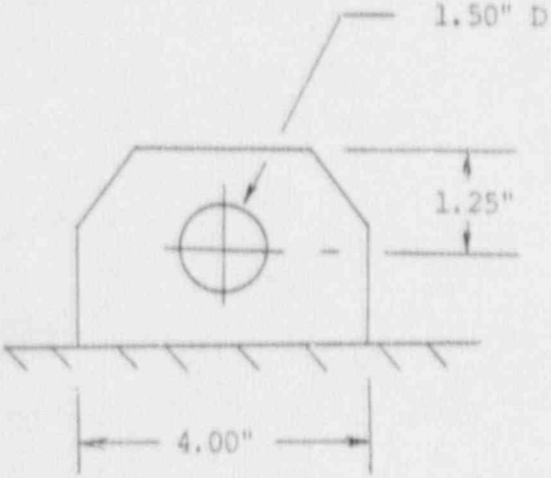
Therefore it can be safely concluded that the lifting lugs will not yield under a load equal to three times the weight of the package. Should the lugs experience a load in excess of 141,400 lbs., they will shear out locally through the eye and will have no adverse effects upon the package's abil.ty to meet other requirements.

<u>2.5.1.2 Lid Lifting Lugs</u> (Primary and Secondary)

The maximum lid weight is 4155 lbs. Using three lugs the load per lug is:

P = (4155 lbs) (3 g's)/3 lugs

P = 4155 lbs/lug



Using the conventional 40^0 shear out equation:

$P_s = F_{sy}\ 2t\ [E.M. - d/2 \cos 40^0]$

Where: F_{sy} = 22800 psi (yield)

t = 1 in.

d = 1-1/2 in.

EM = 1.25

$P_s = (22800)\ (2)\ (1)\ [1.25 - (.75) \cos 40^0]$

P_s = 30801 lbs.

Margin of Safety:

$M.S. = P_s/P-1$

= 30801/4155 - 1

= + 6.41

The capacity of the lug to lid weld may be estimated as:

$P_A = F_{sy} \cdot A_v;\ F_{sy} = 22800$ psi

$A_v = L_v . t_v$

$L_v = 2(4+1) = 10$

$t_v = (1/2)\ (\sqrt{2}/2) =$ (Fillet Weld)

$P_A = (22800)\ (10)\ (.354) = 77172$ lbs.

The lug to lid margin of safety is:

M.S. = 77172/4155 - 1 = + Large

Therefore, it can be concluded that the primary lid lifting lugs are more than adequate to resist a load equal to three times the weight of the lid. As for the package lifting lugs, the lid lifting lugs fail by local shearout through the eye and therefore have no adverse effect upon the packages ability to meet other requirements, [10CFR71.31 (C) (A)]. Since the lid lifting lugs are not capable of reacting the full package load, they will be covered during transit.

2.5.1.3 Secondary Lid Lifting Lug

The single secondary lid lifting lug is identical to the primary lid lugs evaluated in Section 2.5.1.2. The maximum weight of the secondary lid is 1375 lbs. Thus, the lug load is:

P = (1375) (3) = 4125 lbs.

Consequently the margin of safety of the secondary lid lug is:

M.S. = 30801/4125 - 1 = + 6.47

Therefore, the secondary lid lug is more than adequate to resist a load equal to three times the weight of the lid. The secondary lid lugs will be covered during transit, like the primary lid lugs.

2.5.2 Tiedowns

Four tiedown lugs are provided to resist transportation induced loads. The applied load factors are:

$A_x = 10_g$ (longitudinal)

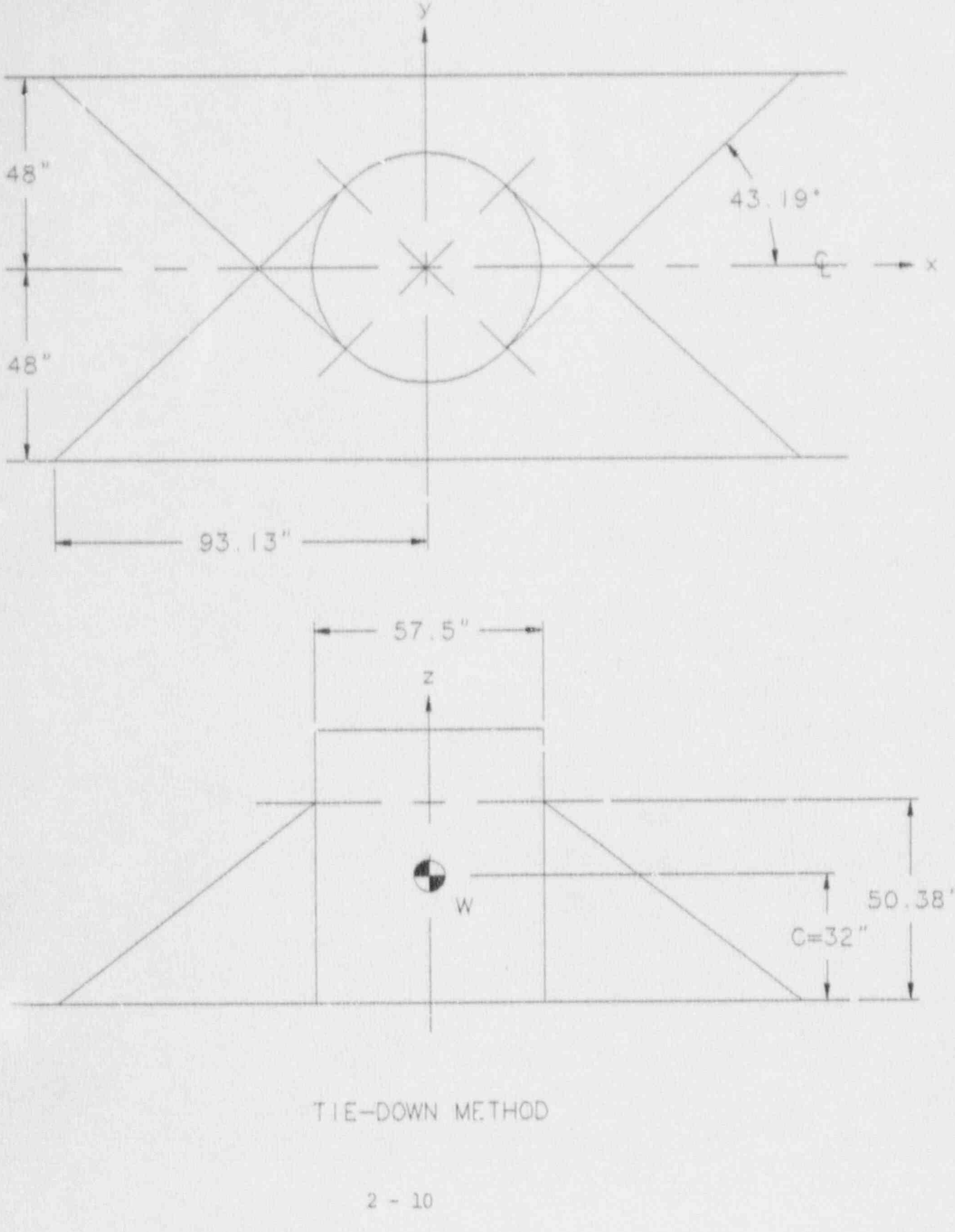
$A_y = 5$ (lateral)

$A_z = 2$ (vertical)

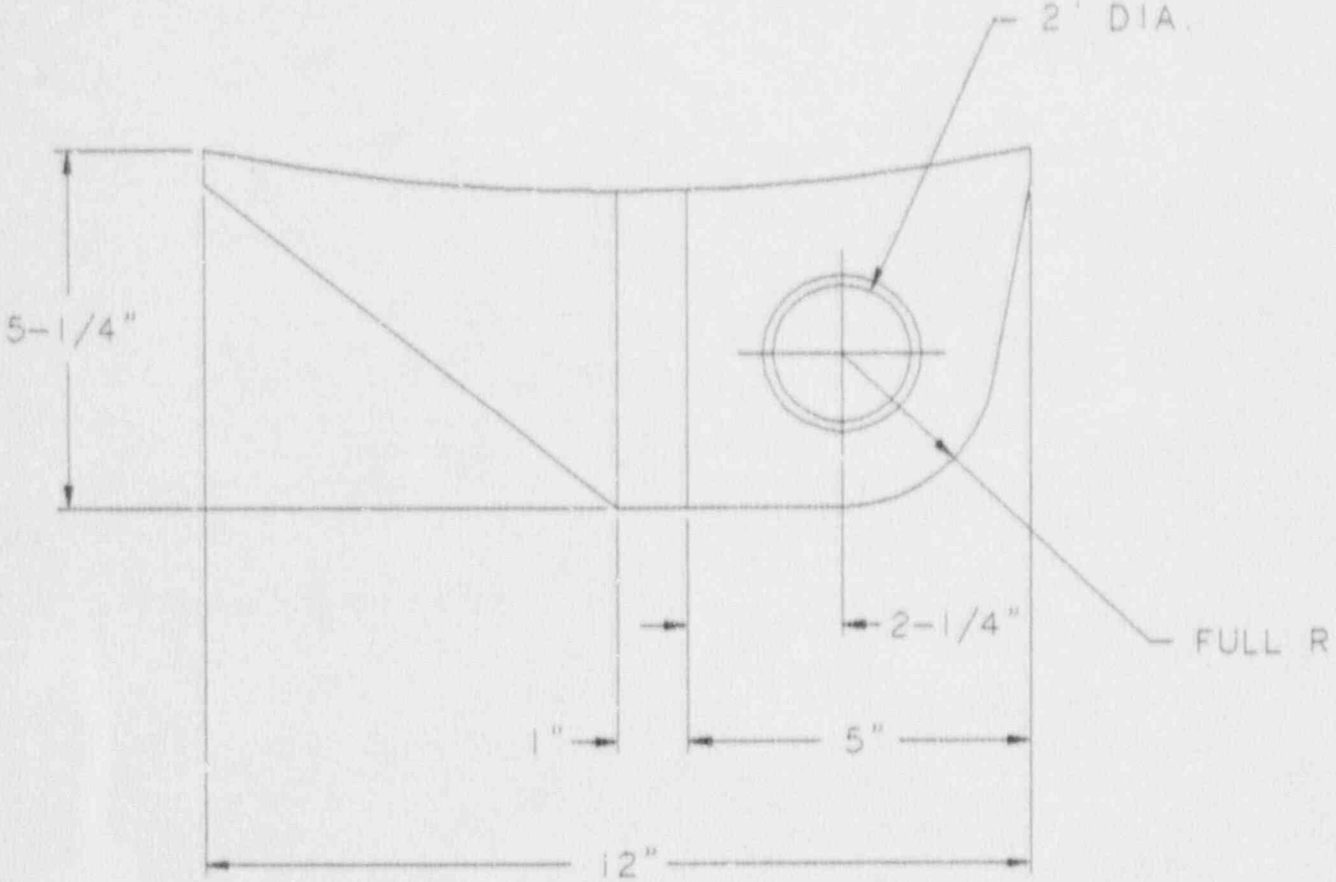
Each of the four tiedown lugs is located at 90^0 with respect to the package at an elevation above the package base which ranges from 46 5/8 inches to 50 3/8 inches, depending upon version. The NuPac 50-4.0L version is the heaviest and has its c.g. at maximum elevation above the base; consequently is most critical. The tiedown scheme for the NuPac 50-xxL assumes a modified basket hitch arrangement involving crossed cables tangent to the package body with a 2:1 horizontal to vertical aspect ratio. Tiedown cables are assumed to be tied to the transporter four feet each side of the transporter centerline. The geometry of the tiedown scheme used for loads evaluation is illustrated in the following sketch.

The tiedown cable geometry may be summarized as:

Direction	Length	Direction Cosine
Longitudinal	$l_x = 73.45$	$B_x = .652077$
Lateral	$l_y = 68.96$	$B_y = .612206$
Vertical	$l_z = 50.38$	$B_z = .447214$



TIE-DOWN METHOD



TIE-DOWN LUG

A vertical load produces a cable force of:

$P_{Tz} = WA_z/4B_z$; (4 cables acting)

A longitudinal load factor produces a cable force of:

$P_{Tx} = WA_x/2B_x\ [(c)/(h)]$; (2 cables acting)

Similarly a lateral load factor produces a cable force of:

$P_{Ty} = WA_y/2B_y\ [(c)/(h)]$; (2 cables acting)

For conservatism, these three loads may be assumed to coincide for the most severely loaded cable:

$$P_T = W\left[\frac{c}{2h}\left(\frac{A_x}{B_x}+\frac{A_y}{B_y}\right)+\frac{A_z}{4B_z}\right]$$

$$= 28500\left[\frac{32}{(2)(50.38)}\left(\frac{10}{0.6521}+\frac{5}{0.6122}\right)+\frac{2}{(4)(0.4472)}\right]$$

$$= 244{,}614 \text{ lbs.}$$

Using a 40^0 shearout the "T-1" lug capacity is:

$$P_Y = 2F_{sy}t(e_d - d/2 \cos 40^0)$$

$$= (2)\ (65{,}000)\ (2)\ (2.25 - \cos 40^0) = 385828 \text{ lbs.}$$

The margin of safety for lug yield is:

$$M.S. = 385828/244614 - 1 = +\ 0.58$$

The cable load consists of both horizontal and vertical components. The horizontal load component is transferred to the outer shell through the horizontal lug plates, whereas the vertical load component is transferred to the outer shell through the vertical lifting lug plate.

The horizontal component of the tie down load is:

$$P_H = \left[B_X^2 + B_Y^2 \right]^{1/2} \cdot P_T$$

$$= \left[(.652077)^2 + (.612206)^2 \right]^{1/2} (244614)$$

$$= 218789 \text{ lbs.}$$

The vertical component of the tiedown load is:

$$P_V = B_Z \cdot P_T$$

$$= (.447214)\ (244614) = 109395 \text{ lbs.}$$

The horizontal component of the tiedown load is reacted by a lug-to-cask weld whose yield capacity is estimated as:

$$P_W = F_{SU} A_W; \quad A_W = 2(12+2)\ (3/8)\sqrt{2} = 14.85 \text{ in}^2$$

$$= (22800)\ (14.85) = 338580 \text{ lbs.}$$

The associated lug-to-cask horizontal weld margin of safety is:

M.S. = 338580/218789 - 1 = <u>+ 0.57</u>

The vertical component of the tiedown load is reacted by the same load paths analyzed for lifting lugs, see Section 2.5.1.1. The lug-to-cask weld margin of safety is:

M.S. = 229596/109395 - 1 = <u>+ 1.10</u>

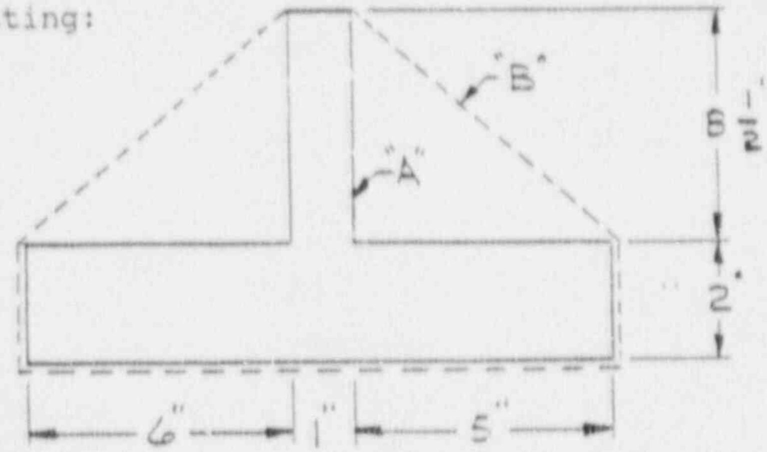
The total load applied to the outer shell is:

$$P_T = \left[P_V^2 + P_H^2 \right]^{1/2}$$

$$= \left[(109395)^2 + (218789)^2 \right]^{1/2} = 244614 \text{ lbs.}$$

oriented at 26.57° with respect to the horizontal.

The shear stress induced in the outer shell is estimated as the total force, P_T, divided by the minimum perimeter enclosure surrounding the tiedown fitting:



Perimeter estimates:

$P_A = (8.5+1)(2) + (6+5+2)(2) = 45$ in.

$P_B = 12+4+1+\sqrt{8.5^2+6^2} + \sqrt{8.5^2+5^2} = 37.27$ in.

Thus, the shell shear area is:

$A_S = (3/8") P_B = 13.98 \text{ in}^2$

The shear stress in the shell is:

$f_s = 244615/13.98 = 17502$ psi

The margin of safety in the shell is:

$M.S. = F_{sy}/f_s - 1 = 22800/17502 - 1 = \underline{+0.30}$

The weak link load path component is assessed as follows:

The ultimate shear-out capacity of the lug is estimated as:

$$P_{su} = 385828 \left(\frac{115000}{110000}\right) = 403365 \text{ lbs.}$$

The ultimate capacity of the lug-to-cask weld is:

$P_v = [548625^2 + 372030^2]^{1/2} = 662869$ lbs.

Where: vertical ultimate capacity = 229596 (35/21.6)

= 372030

horizontal ultim. capacity = 338580 (35/21.6)

= 548625

The ultimate capacity of the outer shell is:

$P_c = (42000)(13.98) = 587160$ lbs.

Thus, it can be concluded that the shear-out failure of the lug will occur prior to failure of other elements within the load path. This lug shear-out failure will have no adverse impact upon package ability to meet other requirements.

[10CFR71. (d) (3)]

2.6 Normal Conditions of Transport

The NuPac 50 packaging has been designed and constructed, and the contents are so limited (as described in Section 1.2.3 above) that the performance requirements specified in 10CFR71.35 will be met when the package is subjected to the normal conditions of transport specified in Appendix A of 10CFR71. The ability of the NuPac Model 50 packaging to satisfactorily withstand the normal conditions of transport has been assessed as described on the following pages.

2.6.1. Heat

A detailed thermal analysis can be found in Section 3.4 wherein the package was exposed to direct sunlight and 130^{0}F still air. The steady state analysis conservatively assumed a 24-hour day as maximum solar heat load. The maximum steady state temperature was found to 176^{0}F. These temperatures will have no detrimental effects on the package.

2.6.2 Cold

To maintain the cold weather capability of the NuPac Model 50, the shell and lid are constructed of A516. This material provides improved notch sensitivity and strength.

2.6.3 Reduced External Pressure

A differential pressure of .5 atmosphere will be reacted by the lid and its associated closures comprised of ratchet binders for the primary lid and studs for the secondary lid. Loads on the primary lid ratchet binders are calculated as:

$P_s = Ap/N;$ Where: $A = \frac{\pi D^2}{4}$

$P = 14.7/2$ psi

$N = 8$

$$P_s = \frac{\pi\ (48\ 1/2)^2}{4} \cdot \frac{14.7}{2} \cdot \frac{1}{8} = 1697 \text{ lbs.}$$

The tensile strength for the 1 inch ratchet binder is 45000 lbs. Thus the margin of safety is:

$$M.S. = \frac{45000}{1697} - 1 = + \text{Large}$$

For the secondary lid studs, the load is:

$$P_s = \frac{\pi\ (29.5)^2}{4} \quad \left(\frac{14.7}{2}\right) \frac{1}{8} = 628 \text{ lbs.}$$

The tensile strength of the 3/4-10UNC, AISI 303/304 studs is:

$$P_A = (85000)\ (.309) = 26270 \text{ lbs.}$$

Thus, the margin of safety is:

$$M.S. = 26270/628 - 1 = + \text{Large}$$

Stresses induced in the cylindrical portion of the cask are conservatively estimated by assuming the pressure differential is totally borne by the 3/8 inch thick inner shell. The hoop and longitudinal stresses are:

$$f_h = PR/t = \left(\frac{14.7}{2}\right) \left(\frac{24\ 1/4}{.375}\right) = 475 \text{ psi}$$

$$f_l = PR/2t = \left(\frac{14.7}{2}\right) \left(\frac{24\ 1/4}{.375}\right) \left(\frac{1}{2}\right) = 238 \text{ psi}$$

Assuming these biaxial stresses are additive,

$$F_{max} = 713 \text{ psi}$$

The margin of safety is:

$$M.S. = 38000/713 - 1 = + \text{Large}$$

Pressure across the end is carried in plate bending by the 2 inch (minimum) thick steel plates top and bottom. Assuming a circular plate, uniformly loaded and with edges simply supported, the stress can be calculated as follows:

$f_r = 3W(3M+1)/8\pi Mt^2$

(per "Formulas for Stress and Strain" by Roark)

Where: $W = (7.35)(\pi)(57.5)^2/4 = 19086$ lbs.

$t = 2"$

$M = 1/.33 = 3$

$f_r = (3)(19086)(10)/8\pi(3)(4)$

$f_r = 1899$ psi

Margin of Safety:

M.S. = 38,000/1899 - 1 = + Large

It can therefore be concluded that the packaging can safely react an atmospheric pressure of .5 times standard atmospheric pressure.

2.6.4 Increased External Pressure

An external pressure of 25 psig is reacted by the external shell in hoop compression. The stress can be calculated as follows:

$F = Pr/t$

Where:

$P = 25$ psi

$r = 28.75$ in.

$t = 3/8$ in (Outside shell only)

$F = (25)(28.75)/.375$

$F = 1,917$ psi

Margin of Safety:

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

$= 38,000/1,917 - 1$

= <u>+ Large</u>

The analysis is conservative due to the presence of the lead and internal shell. The lead assures buckling stability of the shell.

Pressure across the end is carried in plate bending by a minimum of one inch and 1 1/4 inch thick steel plates top and bottom. Assuming a circular plate, uniformly loaded and with edges simply supported, the stress can be calculated as follows:

$f_r = 3W(3M+1)/8\pi Mt^2$

(Per "Formulas for Stress and Strain" by Roark)

Where:

$W = (25)\pi(48.5)^2 4 = 46186$

$t = 1"$

$M = 1/.33 = 3$

$f_r = [(3)\ (46186)\ (10)]/[8\pi(3)\ (1)^2]$

$f_r = 18377$ psi

Margin of Safety:

M.S. = 38,000/18377 - 1

= <u>+ 1.07</u>

It is therefore safe to conclude that the containment vessel can react a 25 psig external pressure without loss of contents.

2.6.5 Vibration

Shock and vibration normally incident to transport are considered to have negligible effects on the NuPac 50-xxL packaging.

2.6.6 Water Spray

Since the package exterior is constructed of steel, this test is not required.

2.6.7 Free Drop

The free drop heights for the package prescribed by Appendix A.6 of 10 CFR 71 vary as a function of package version weight as follows:

Version	Gross Weight (lbs.)	Drop Height (in.)
NuPac 50-1.5	13300	36
NuPac 50-2.5	19400	36
NuPac 50-3.0	22200	24
NuPac 50-4.0	29000	24

Three drop orientations are possible: flat end drop, side drop and corner drop. For the flat end drop, the most critical condition will be settlement of the unbounded lead shield at the end opposite the point of impact. For the side drop, local flattening will be evaluated. For the corner drop, the most critical condition will be the lid closure. In addition to the analysis presented, a full scale drop test was also conducted (Reference Section 2.6.7.3 and Appendix 2.10.3).

2.6.7.1 Flat End Drop

The evaluation of flat end impact upon settlement of lead shielding closely follows Shappert's approach for a cylindrical load shield, outlined in Section 2.7.3 of his Cask Designer's Guide, ORNL-NSIC-68, February 1970. The lead settlement distance is given by:

$$\Delta H = \frac{RWH}{\pi (R^2 - r^2)\ (t_s\ \sigma_s + R\ \sigma_{pb})}$$

Where:

ΔH = Settlement depth (in)

H = Drop height (in)

R = Outer lead radius (in)

W = Weight of Lead (lbs)

r = Inner lead radius (in)

t_s = Thickness of external steel shell (in)

σ_s = Steel dynamic flow stress (psi)

σ_{pb} = Lead dynamic flow stress (psi)

For the four package versions, variables and settlement results are tabulated in the following table:

Version	Drop Height H (in)	Lead Weight W (lbs)	Outer Radius R (in)	Lead Settlement H (in)
50-1.5	36	4500	25.88	0.136
50-2.5	36	8500	26.88	0.141
50-3.0	24	10500	27.38	0.094
50-4.0	24	15500	28.38	0.101

For all versions:

r = [illegible]"

t_s = .375"

σ_s = 70000 psi

σ_{pb} = 5000 psi

These modest settlement "voids" in the lead shield cannot transmit radiation because of the stepped design of the package ends. The innermost solid steel end plates completely back (shield) lead settlement regions at both ends of the package. Thus, lead settlement due to flat end drop does not compromise, nor alter, the integrity of radiation shielding in any fashion.

2.6.7.2 Side Drop

Side drop is evaluated using the methods outlined in Section 2.7.2 of Shappert's Cask Designer's Guide, ORNL-NSIC-68. The governing equation (2.13) is:

$$\underbrace{\frac{WH}{L\sigma_s}}_{\alpha} = F_1(\theta) \cdot \underbrace{\left\{R/t_s\ (\sigma_{pb}/\sigma_s) + 2\ (R/L)\ (t_e/t_s) + F_2(\theta)\right\}}_{\beta}$$

where:

	W	=	cask weight (lbs)
	H	=	drop height
	$F_1(\theta)$	=	θ-1/2 sin 2θ
	$F_2(\theta)$	=	sin $\theta(2-\cos\theta) - \theta$
	σ_s	=	70000 psi
	σ_{pb}	=	5000 psi

The flattening of the cask is equal to:

$$d = R(1-\cos\theta)$$

Results are shown in Table 2.6.7.2-1.

Shielding is reduced by side impact as indicated below:

Version	% Shield Reduction[1]
50-1.5L	0.69%
50-2.5L	0.46
50-3.0I	0.28
50-4.0L	0.22

(1)Note: $\% = \frac{d}{T_s} \cdot \left(\frac{2\theta}{360}\right) \cdot 100$

Where T_s = Nominal Shield Thickness

Table 2.6.7.2-1

Side Impact deformation Predictions

Version	Drop Height H (in.)	Weight W(lbs.)	Radius R (in.)	Length L (in.)	Shell Thickness t_s (in.)	End Thickness t_e (in.)	α	β	θ (0)	Deformation d (in.)
50-1.5L	36	13,300	26.25	61.13	.375	1.00	1.137×10^{-2}	7.29	7.48	0.223
50-2.5L	36	19,400	27.25	65.38	.375	2.00	1.137×10^{-2}	9.64	7.48	0.231
50-3.0L	24	22,200	27.75	66.88	.375	2.00	1.137×10^{-2}	9.71	6.76	0.193
50-4.0L	24	29,000	28.75	70.38	.375	3.00	1.137×10^{-2}	12.01	6.67	0.194

This insignificant reduction of shielding demonstrates that side impact does not compromise the integrity of the package's shielding any measurable fashion.

2.6.7.3 Corner Drop

The impact energy associated with a corner drop will be absorbed by inelastic deformation of the corner. Using the "dynamic flow pressure" concept, total deformation of the corner is estimated and used to compute package deceleration. This deceleration is then used to check the integrity of the lid closure.

Both steel and lead components of the cask are distorted upon corner impacts. The assessment of deformation and resultant decelerations is based upon a careful consideration of detail corner geometry for a range of assumed deformations. It is assumed that the steel end plates of the cask undergo plastic flexural deformation and do not crush. This flexural deformation for the ends enforces a crushing of the contiguous lead side walls and the thin cylindrical external steel shell. The predictions of peak rigid body impact decelerations are based upon the crush geometry of the lead side walls and the associated external steel shell. Resultant deformation prediction estimates are based upon two energy balance techniques:

- The plastic flow pressure concept
- An integration of force - deflection relations based upon crush stress approaches.

For the plastic flow stress approach, properties of steel and lead are based upon recommended deformation basis values used by Shappert, Cask Designer's Guide, ORNL NSIC-68:

σ_{pb} = 5000 psi

σ_s = 70000 psi

For the crush stress approach, steel and lead crush properties are assumed to be equal to twice the yield stress. This conservative approach is intended to account for both strain rate effects and strain hardening. In effect, this provides a crush stress equivalent for steel of 76,000 psi that is 9% greater than established static ultimate values. For lead, the crush stress equivalent is again taken as twice yield, or 1380 x 2 - 2760 psi, reference Table 2.6, Shappert, Cask Designer's Guide, ORNL-NSIC-68.

Analytics used for these estimates are outlined in Appendix 2.10.2. Prediction results are summarized in Table 2.6.7.3-1; detail computer analysis results for all four configurations follow the table.

A full scale drop test of a similar cask constructed of ASTM A36 material was conducted to substantiate the accuracy of the analysis as well as demonstrate the leak tightness of the package after it undergoes a corner impact. Table 2.6.7.3-1 predicts a deformation of 1.25 in. to 1.40 in. Actual impact deformation was 1.30 in. For conservatism the package was dropped from a height 1.25 times higher than required. Cask and liner seal integrity were maintained. More details can be found in Appendix 1.10.3.

Table 2.6.7.3-1

Corner Impact Deformation & Deceleration Estimates

Version	Drop Height (in.)	Weight (lbs.)	Radius (in.)	Crush Zone Geometry			Load Factor (g's)
				Volume (in.^{3})	Area (in.^{2})	Depth (in.)	
50-1.5L	36	13,300	26.25	7.2-11.1	20.1-27.4	0.90-1.10	50.9-57.3
50-2.5L	36	19,400	27.25	10.8-22.2	25.7-39.5	1.05-1.40	38.9-46.3
50-3.0L	36	22,200	27.75	8.5-15.3	22.4-31.7	0.95-1.20	32.4-37.2
50-4.0L	36	29,000	28.75	11.1-20.8	26.5-38.5	1.05-1.35	26.8-31.1

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CASKCRN(CORNER)              CORNER IMPACT OF A CYLINDRICAL  SHIELDED CASK          12.16.10.   90/02/15.   PAGE   1

                   NUPAC 50-1.1 CASK

        PACKAGE WEIGHT              = 13300.00 (LBS)
        DROP HEIGHT                 =    36.000 (IN)
        PACKAGE RADIUS              =    24.250 (IN)

        STEEL DYNAMIC FLOW STRESS  = 70000.00 (PSI)
        STEEL CRUSH STRESS          = 76000.00 (PSI)
        LEAD DYNAMIC FLOW STRESS    =  5000.00 (PSI)
        LEAD CRUSH STRESS           =  2750.00 (PSI)

        STEEL SHELL THICKNESS       =      .375 (IN)
        STEEL BOTTOM THICKNESS      =     3.250 (IN)

        ORIENTATION ANGLE           =     42.20 (DEG)
```

CASRCRNICURRENT   CORNER IMPACT OF A CYLINDRICAL SHIELDED CASK   17.16.10.   90/02/15.   PAGE 2

NUPAC 50-1.5L CASK

CRUSH DEPTH (IN)	KINETIC ENERGY (IN-LB)	**CRUSH VOLUME** TOTAL (IN3)	STEEL (IN3)	LEAD (IN3)	*FLOW STRESS BASIS* STRAIN ENERGY ENERGY (IN-LB)	RATIO (SE/KE)	*** CRUSH AREA *** TOTAL (IN2)	STEEL (IN2)	LEAD (IN2)	** IMPACT ** FORCE (LBS)	ACCEL. (G)	**CRUSH STRESS BASIS** STRAIN ENERGY ENERGY (IN-LB)	RATIO (SE/KE)
.05	479475.	.0	.0	0.0	371.	.00	.3	.3	0.0	20119.	1.5	501.	.00
.10	480130.	.0	.0	0.0	2096.	.00	.7	.7	0.0	56982.	4.3	2570.	.01
.15	480795.	.1	.1	0.0	5775.	.01	1.4	1.4	0.0	104455.	7.9	5561.	.01
.20	481460.	.2	.2	0.0	11850.	.02	2.1	2.1	0.0	160750.	12.1	12092.	.03
.25	482125.	.3	.3	0.0	20696.	.04	3.0	3.0	0.0	224559.	16.9	22224.	.05
.30	482790.	.5	.5	0.0	32636.	.07	3.9	3.9	0.0	295064.	22.2	35715.	.07
.35	483455.	.7	.7	0.0	47965.	.10	4.9	4.9	0.0	371666.	27.9	53197.	.11
.40	484120.	1.0	1.0	0.0	65955.	.14	6.0	5.7	.3	411069.	32.5	72551.	.15
.45	484785.	1.3	1.3	0.0	89852.	.19	7.1	6.0	1.1	459369.	34.5	96711.	.20
.50	485450.	1.7	1.7	0.0	116904.	.24	8.1	6.1	2.0	486507.	36.6	119310.	.24
.55	486115.	2.1	2.1	0.0	149299.	.31	9.6	6.6	3.0	512651.	38.5	143337.	.29
.60	486780.	2.6	2.6	0.0	184280.	.38	11.0	6.9	4.0	537950.	40.4	169502.	.35
.65	487445.	3.2	3.2	0.0	225035.	.46	12.3	7.2	5.1	562520.	42.3	197115.	.40
.70	488110.	3.9	3.9	0.0	270756.	.55	13.9	7.5	6.3	586456.	44.1	225938.	.46
.75	488775.	4.6	4.6	0.0	321629.	.66	15.3	7.8	7.5	609829.	45.9	255745.	.52
.80	489440.	5.4	5.4	0.0	377826.	.77	16.8	8.0	8.8	632710.	47.6	286907.	.59
.85	490105.	6.3	6.3	0.0	439522.	.90	18.4	8.3	10.2	655149.	49.3	319065.	.65
.90	490770.	7.2	7.2	0.0	506881.	1.03	20.1	8.5	11.5	677193.	50.9	352116.	.72
.95	491435.	8.3	8.3	0.0	580063.	1.18	21.8	8.7	13.0	698881.	52.5	386216.	.79
1.00	492100.	9.4	9.4	0.0	659223.	1.34	23.5	8.9	14.5	720247.	54.2	421174.	.86
1.05	492765.	10.6	10.6	0.0	744512.	1.51	25.3	9.2	15.1	741320.	55.7	456733.	.93
1.10	493430.	11.9	11.9	0.0	836077.	1.69	27.1	9.4	17.7	762126.	57.3	498319.	1.01
1.15	494095.	13.3	13.3	0.0	934060.	1.89	28.9	9.6	19.3	782680.	58.6	535313.	1.09
1.20	494760.	14.8	14.8	0.0	1039602.	2.10	30.8	9.8	21.0	803026.	60.4	574392.	1.16
1.25	495425.	16.4	16.4	0.0	1149830.	2.32	32.4	10.0	22.7	823158.	61.9	615237.	1.24
1.30	496090.	18.1	18.1	0.0	1267903.	2.56	34.7	10.2	24.5	843100.	63.4	655397.	1.32
1.35	496755.	19.9	19.9	0.0	1392925.	2.80	36.7	10.4	26.3	862868.	64.9	697563.	1.41
1.40	497420.	21.8	21.8	0.0	1525031.	3.07	38.8	10.6	28.2	882474.	66.4	741176.	1.49
1.45	498085.	23.8	23.8	0.0	1664347.	3.34	40.9	10.8	30.1	901929.	67.8	787796.	1.58
1.50	498750.	25.9	25.9	0.0	1810996.	3.63	43.1	11.0	32.0	921245.	69.3	833365.	1.67
1.55	499415.	28.1	28.1	0.0	1965096.	3.93	45.1	11.1	34.0	940432.	70.7	879987.	1.76
1.60	500080.	30.4	30.4	0.0	2126765.	4.25	47.3	11.3	36.0	959498.	72.1	927566.	1.85
1.65	500745.	32.8	32.8	0.0	2296119.	4.59	49.5	11.5	38.0	978451.	73.6	975955.	1.95
1.70	501410.	35.3	35.3	0.0	2473271.	4.93	51.7	11.7	40.1	997300.	75.0	1025543.	2.04
1.75	502075.	38.0	38.0	0.0	2658333.	5.29	54.0	11.9	42.2	1016051.	76.4	1076587.	2.14
1.80	502740.	40.7	40.7	0.0	2851413.	5.67	56.3	12.0	44.3	1034711.	77.8	1128451.	2.24
1.85	503405.	43.5	43.5	0.0	3052620.	6.06	58.7	12.2	46.5	1053285.	79.2	1181551.	2.34
1.90	504070.	46.6	46.6	0.0	3262060.	6.47	61.0	12.3	48.7	1071780.	80.6	1237179.	2.44
1.95	504735.	49.7	49.7	0.0	3479837.	6.89	63.4	12.5	50.9	1090199.	82.0	1294227.	2.55
2.00	505400.	52.9	52.9	0.0	3706053.	7.33	65.8	12.7	53.1	1108548.	83.3	1351135.	2.65

NUPAC 50-2.1L CASK

```
PACKAGE WEIGHT               = 19400.02 (LBS)
DROP HEIGHT                  =    35.000 (IN)
PACKAGE RADIUS               =    27.250 (IN)

STEEL DYNAMIC FLOW STRESS    = 70000.00 (PSI)
STEEL CRUSH STRESS           = 76000.00 (PSI)
LEAD DYNAMIC FLOW STRESS     =  5000.00 (PSI)
LEAD CRUSH STRESS            =  2760.00 (PSI)

STEEL SHELL THICKNESS        =      .375 (IN)
STEEL BOTTOM THICKNESS       =     4.000 (IN)

ORIENTATION ANGLE            =    42.20 (DEG)
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NUPAC 50-2.5L CASK

		CRUSH VOLUME			*FLOW STRESS BASIS* STRAIN ENERGY		*** CRUSH AREA ***			** IMPACT **		**CRUSH STRESS BASIS** STRAIN ENERGY	
CRUSH DEPTH (IN)	KINETIC ENERGY (IN-LB)	TOTAL (IN3)	STEEL (IN3)	LEAD (IN3)	ENERGY (IN-LB)	RATIO (SE/KE)	TOTAL (IN2)	STEEL (IN2)	LEAD (IN2)	FORCE (LBS)	ACCEL. (G)	ENERGY (IN-LB)	RATIO (SE/KE)
.05	699370.	.0	.0	0.0	379.	.00	.1	.1	0.0	26499.	1.1	517.	.00
.10	700340.	.0	.0	0.0	2135.	.00	.9	.9	0.0	57957.	3.0	2474.	.00
.15	701310.	.1	.1	0.0	5834.	.01	1.4	1.4	0.0	106431.	5.5	6586.	.01
.20	702280.	.2	.2	0.0	12075.	.02	2.2	2.2	0.0	153793.	8.4	13339.	.02
.25	703250.	.3	.3	0.0	21087.	.03	3.0	3.0	0.0	228914.	11.8	23154.	.03
.30	704220.	.5	.5	0.0	33754.	.05	4.0	4.0	0.0	300669.	15.5	36331.	.05
.35	705190.	.7	.7	0.0	49975.	.07	5.0	5.0	0.0	374719.	19.5	53176.	.08
.40	706160.	1.0	1.0	0.0	68224.	.10	6.1	5.8	.3	439195.	22.6	73923.	.10
.45	707130.	1.3	1.3	0.0	91557.	.13	7.3	6.1	1.1	459041.	24.1	98505.	.14
.50	708100.	1.7	1.7	0.0	119113.	.17	8.5	6.4	2.1	495692.	25.6	120997.	.17
.55	709070.	2.2	2.2	0.0	151116.	.21	9.9	6.8	3.0	522331.	26.9	146069.	.21
.60	710040.	2.7	2.7	0.0	187782.	.26	11.2	7.1	4.1	548109.	28.3	172903.	.24
.65	711010.	3.3	3.3	0.0	229315.	.32	12.6	7.4	5.2	573143.	29.5	200460.	.28
.70	711980.	3.9	3.9	0.0	275909.	.39	14.1	7.6	6.4	597531.	30.8	230107.	.32
.75	712950.	4.7	4.7	0.0	327752.	.46	15.6	7.9	7.7	621349.	32.0	260377.	.37
.80	713920.	5.5	5.5	0.0	383025.	.54	17.2	8.2	9.0	644563.	33.2	292279.	.41
.85	714890.	6.4	6.4	0.0	447901.	.63	18.9	8.4	10.4	667529.	34.4	325034.	.45
.90	715860.	7.4	7.4	0.0	516550.	.72	20.5	8.7	11.8	690991.	35.6	359072.	.50
.95	716830.	8.4	8.4	0.0	591135.	.82	22.2	8.9	13.3	712090.	36.7	394024.	.55
1.00	717800.	9.6	9.6	0.0	671914.	.94	23.9	9.1	14.8	733862.	37.9	430173.	.60
1.05	718770.	10.9	10.9	0.0	758741.	1.06	25.7	9.3	16.4	755335.	38.9	467402.	.65
1.10	719740.	12.2	12.2	0.0	852065.	1.18	27.6	9.6	18.0	776537.	40.0	505709.	.70
1.15	720710.	13.6	13.6	0.0	951934.	1.32	29.5	9.8	19.7	797490.	41.1	545050.	.76
1.20	721680.	15.1	15.1	0.0	1059488.	1.47	31.4	10.0	21.4	818216.	42.2	585443.	.81
1.25	722650.	16.7	16.7	0.0	1171864.	1.62	33.4	10.2	23.2	838732.	43.2	625967.	.87
1.30	723620.	18.5	18.5	0.0	1292209.	1.79	35.4	10.4	25.0	859055.	44.3	665311.	.92
1.35	724590.	20.3	20.3	0.0	1419654.	1.96	37.4	10.6	26.8	879199.	45.3	712769.	.98
1.40	725560.	22.2	22.2	0.0	1554103.	2.14	39.5	10.8	28.7	899177.	46.3	757227.	1.04
1.45	726530.	24.2	24.2	0.0	1696313.	2.33	41.6	11.0	30.7	919007.	47.4	802682.	1.10
1.50	727500.	26.4	26.4	0.0	1845799.	2.54	43.8	11.2	32.6	938692.	48.4	849174.	1.17
1.55	728470.	28.6	28.6	0.0	2002883.	2.75	46.3	11.4	34.6	958246.	49.4	896559.	1.23
1.60	729440.	31.0	31.0	0.0	2167697.	2.97	48.2	11.5	36.7	977677.	50.4	944766.	1.30
1.65	730410.	33.4	33.4	0.0	2340327.	3.20	50.5	11.7	38.7	996994.	51.4	995312.	1.36
1.70	731380.	36.0	36.0	0.0	2520019.	3.45	52.7	11.9	40.8	1016204.	52.4	1044442.	1.43
1.75	732350.	38.7	38.7	0.0	2709577.	3.70	55.1	12.1	43.0	1035316.	53.4	1095930.	1.50
1.80	733320.	41.5	41.5	0.0	2905414.	3.96	57.5	12.2	45.2	1054334.	54.3	1148172.	1.57
1.85	734290.	44.5	44.5	0.0	3111539.	4.24	59.9	12.4	47.4	1073265.	55.3	1201367.	1.64
1.90	735260.	47.5	47.5	0.0	3325060.	4.52	62.2	12.6	49.6	1092116.	56.3	1255426.	1.71
1.95	736230.	50.7	50.7	0.0	3547245.	4.82	64.7	12.7	51.9	1110890.	57.3	1310571.	1.79
2.00	737200.	54.2	54.2	0.0	3777717.	5.12	67.1	12.9	54.2	1129593.	58.2	1366593.	1.85

NUPAC 50-3.0L CASK

```
PACKAGE WEIGHT             = 22200.00 (LBS)
DROP HEIGHT                =    24.000 (IN)
PACKAGE RADIUS             =    27.750 (IN)

STEEL DYNAMIC FLOW STRESS  = 70000.00 (PSI)
STEEL CRUSH STRESS         = 76000.00 (PSI)
LEAD DYNAMIC FLOW STRESS   =  5000.00 (PSI)
LEAD CRUSH STRESS          =  7760.00 (PSI)

STEEL SHELL THICKNESS      =      .375 (IN)
STEEL BOTTOM THICKNESS     =     4.500 (IN)

ORIENTATION ANGLE          =    42.20 (DEG)
```

CASKCRN(ICORNER) CORNER IMPACT OF A CYLINDRICAL SHIELDED CASK 17.16.10. 90/07/15. PAGE 6

NUPAC 50-3.0L CASK

CRUSH DEPTH (IN)	KINETIC ENERGY (IN-LB)	**CRUSH VOLUME** TOTAL (IN3)	STEEL (IN3)	LEAD (IN3)	*FLOW STRESS BASIS* STRAIN ENERGY ENERGY (IN LB)	RATIO (SE/KE)	*** CRUSH AREA *** TOTAL (IN2)	STEEL (IN2)	LEAD (IN2)	** IMPACT ** FORCE (LBS)	ACCEL. (G)	**CRUSH STRESS BASIS** STRAIN ENERGY ENERGY (IN-LB)	RATIO (SE/KE)
.05	533910.	.0	.0	0.0	381.	.00	.1	.1	0.0	20687.	.9	517.	.00
.10	535020.	.0	.0	0.0	2155.	.00	.3	.8	0.0	58487.	2.6	2497.	.00
.15	536130.	.1	.1	0.0	5039.	.01	1.4	1.4	0.0	137405.	4.8	5654.	.01
.20	537240.	.2	.2	0.0	17185.	.02	2.2	2.2	0.0	165204.	7.4	11361.	.03
.25	538350.	.3	.3	0.0	21280.	.04	3.0	3.0	0.0	230712.	10.4	21165.	.04
.30	539460.	.5	.5	0.0	33557.	.06	4.0	4.0	0.0	303417.	13.7	36725.	.07
.35	540570.	.7	.7	0.0	49323.	.09	5.3	5.3	0.0	382197.	17.2	53865.	.10
.40	541680.	1.0	1.0	0.0	68850.	.13	6.1	5.8	.3	443197.	20.0	75500.	.14
.45	542790.	1.3	1.3	0.0	92398.	.17	7.3	6.2	1.2	472318.	21.3	97398.	.18
.50	543900.	1.7	1.7	0.0	120207.	.22	8.6	6.5	2.1	500221.	22.5	121761.	.22
.55	545010.	2.2	2.2	0.0	152505.	.28	9.7	6.8	3.1	527104.	23.7	147386.	.27
.60	546120.	2.7	2.7	0.0	189509.	.35	11.3	7.1	4.1	553118.	24.9	174370.	.32
.65	547230.	3.3	3.3	0.0	231425.	.42	12.7	7.4	5.3	578382.	26.1	202679.	.37
.70	548340.	4.0	4.0	0.0	279449.	.51	14.2	7.7	6.5	602993.	27.2	232217.	.42
.75	549450.	4.7	4.7	0.0	330772.	.60	15.7	8.0	7.8	627029.	28.2	262962.	.48
.80	550560.	5.6	5.6	0.0	388574.	.71	17.1	8.2	9.1	650558.	29.3	294963.	.54
.85	551670.	6.5	6.5	0.0	452033.	.82	19.0	8.5	10.5	673632.	30.3	329007.	.59
.90	552780.	7.4	7.4	0.0	521318.	.94	20.6	8.7	11.9	696301.	31.4	362255.	.66
.95	553890.	8.5	8.5	0.0	596594.	1.08	22.4	9.0	13.4	719604.	32.4	397629.	.72
1.00	555000.	9.7	9.7	0.0	678022.	1.22	24.2	9.2	15.0	740576.	33.4	434157.	.78
1.05	556110.	10.9	10.9	0.0	765756.	1.38	26.0	9.4	16.6	762247.	34.3	471674.	.85
1.10	557220.	12.3	12.3	0.0	859848.	1.54	27.8	9.7	18.2	783643.	35.3	510172.	.92
1.15	558330.	13.7	13.7	0.0	960746.	1.72	29.9	9.7	19.9	804790.	36.3	550036.	.99
1.20	559440.	15.3	15.3	0.0	1069272.	1.91	31.7	10.1	21.6	825706.	37.2	593779.	1.06
1.25	560550.	16.9	16.9	0.0	1182729.	2.11	33.7	10.3	23.4	846411.	38.1	637801.	1.13
1.30	561660.	18.6	18.6	0.0	1304192.	2.32	35.7	10.5	25.2	866922.	39.1	675435.	1.20
1.35	562770.	20.5	20.5	0.0	1432817.	2.55	37.9	10.7	27.1	887252.	40.0	719793.	1.28
1.40	563880.	22.4	22.4	0.0	1568733.	2.78	39.9	10.9	29.0	907417.	40.9	764156.	1.36
1.45	564990.	24.5	24.5	0.0	1712071.	3.03	42.3	11.1	30.9	927427.	41.8	810027.	1.43
1.50	566100.	26.6	26.6	0.0	1862955.	3.29	44.2	11.3	32.9	947295.	42.7	856895.	1.51
1.55	567210.	28.9	28.9	0.0	2021512.	3.56	46.4	11.5	35.0	967030.	43.6	904734.	1.60
1.60	568320.	31.3	31.3	0.0	2187861.	3.85	48.7	11.6	37.0	986641.	44.4	953305.	1.68
1.65	569430.	33.7	33.7	0.0	2362120.	4.15	50.9	11.8	39.1	1006137.	45.3	1003314.	1.76
1.70	570540.	36.3	36.3	0.0	2544408.	4.46	53.2	12.0	41.2	1025526.	46.2	1054208.	1.85
1.75	571650.	39.1	39.1	0.0	2734840.	4.78	55.6	12.2	43.4	1044815.	47.1	1105766.	1.93
1.80	572760.	41.9	41.9	0.0	2933528.	5.12	58.0	12.3	45.6	1064010.	47.9	1158695.	2.02
1.85	573870.	44.9	44.9	0.0	3140584.	5.47	60.3	12.5	47.9	1083117.	48.8	1212461.	2.11
1.90	574980.	47.9	47.9	0.0	3356117.	5.84	62.9	12.7	50.1	1102143.	49.6	1266993.	2.20
1.95	576090.	51.1	51.1	0.0	3580235.	6.21	65.3	12.9	52.4	1121092.	50.5	1322274.	2.30
2.00	577200.	54.5	54.5	0.0	3813044.	6.61	67.9	13.0	54.8	1139970.	51.3	1378162.	2.39

NUPAC 50-4.0L CASK

```
PACKAGE WEIGHT              = 29000.00 (LBS)
DROP HEIGHT                 =   24.000 (IN)
PACKAGE RADIUS              =   29.750 (IN)

STEEL DYNAMIC FLOW STRESS   = 70000.00 (PSI)
STEEL CRUSH STRESS          = 76000.00 (PSI)
LEAD DYNAMIC FLOW STRESS    =  5030.00 (PSI)
LEAD CRUSH STRESS           =  2760.00 (PSI)

STEEL SHELL THICKNESS       =     .375 (IN)
STEEL BOTTOM THICKNESS      =    6.000 (IN)

ORIENTATION ANGLE           =    47.20 (DEG)
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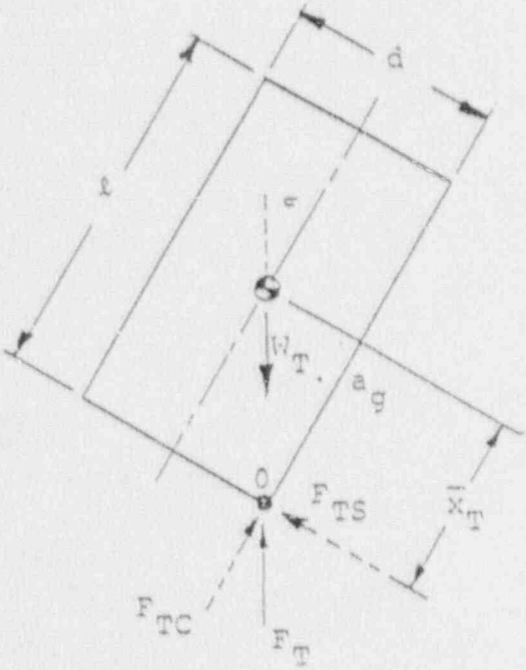
CASKCRHICORNER1 CORNER IMPACT OF A CYLINDRICAL SHIELDED CASK 17.16.10. 90/02/15. PAGE 8

NUPAC 50-4.0L CASK

CRUSH DEPTH (IN)	KINETIC ENERGY (IN-LB)	**CRUSH VOLUME** TOTAL (IN3)	STEEL (IN3)	LEAD (IN3)	*FLOW STRESS BASIS* STRAIN ENERGY ENERGY (IN-LB)	RATIO (SE/KE)	*** CRUSH AREA *** TOTAL (IN2)	STEEL (IN2)	LEAD (IN2)	** IMPACT ** FORCE (LBS)	ACCEL. (G)	**CRUSH STRESS BASIS** STRAIN ENERGY ENERGY (IN-LB)	RATIO (SE/KE)
.05	697450.	.0	.0	0.0	388.	.00	.3	.3	0.0	21056.	.7	525.	.00
.10	698900.	.0	.0	0.0	2194.	.00	.9	.9	0.0	59534.	2.1	2541.	.00
.15	700350.	.1	.1	0.0	6044.	.01	1.4	1.4	0.0	109328.	3.8	6763.	.01
.20	701800.	.2	.2	0.0	12403.	.02	2.2	2.2	0.0	168255.	5.9	13702.	.02
.25	703250.	.3	.3	0.0	21662.	.03	3.1	3.1	0.0	235052.	8.1	23785.	.03
.30	704700.	.5	.5	0.0	34160.	.05	4.1	4.1	0.0	308964.	10.7	37393.	.05
.35	706150.	.7	.7	0.0	50208.	.07	5.1	5.1	0.0	389061.	13.4	55091.	.08
.40	707600.	1.0	1.0	0.0	70085.	.10	6.3	5.9	.3	451115.	15.6	75835.	.11
.45	709050.	1.3	1.3	0.0	94056.	.13	7.5	6.3	1.2	490756.	16.6	99132.	.14
.50	710500.	1.7	1.7	0.0	122366.	.17	8.7	6.5	2.1	509150.	17.6	123440.	.17
.55	711950.	2.2	2.2	0.0	155246.	.22	10.1	6.9	3.1	516523.	18.5	150927.	.21
.60	713400.	2.8	2.8	0.0	192917.	.27	11.5	7.3	4.2	553003.	19.4	177910.	.25
.65	714850.	3.4	3.4	0.0	235589.	.33	12.9	7.5	5.4	588712.	20.3	206303.	.29
.70	716300.	4.0	4.0	0.0	283462.	.40	14.4	7.8	6.6	613771.	21.2	235355.	.33
.75	717750.	4.9	4.9	0.0	336730.	.47	16.0	8.1	7.9	638239.	22.0	267564.	.37
.80	719200.	5.7	5.7	0.0	395577.	.55	17.5	8.4	9.3	662199.	22.8	300177.	.42
.85	720650.	6.6	6.6	0.0	460185.	.64	19.3	8.6	10.7	685678.	23.6	333973.	.46
.90	722100.	7.6	7.6	0.0	530725.	.73	21.0	8.9	12.1	708754.	24.4	368735.	.51
.95	723550.	8.7	8.7	0.0	607365.	.84	22.9	9.1	13.7	731457.	25.2	404737.	.56
1.00	725000.	9.9	9.9	0.0	690270.	.95	24.6	9.4	15.2	753824.	26.0	441371.	.61
1.05	726450.	11.1	11.1	0.0	779597.	1.07	26.5	9.6	16.9	775884.	26.8	480115.	.66
1.10	727900.	12.5	12.5	0.0	875501.	1.20	28.4	9.9	18.5	797666.	27.5	519453.	.71
1.15	729350.	14.0	14.0	0.0	978131.	1.34	30.3	10.0	20.3	819193.	28.2	557874.	.77
1.20	730800.	15.5	15.5	0.0	1087636.	1.49	32.3	10.3	22.0	840496.	29.0	601366.	.82
1.25	732250.	17.2	17.2	0.0	1204157.	1.64	34.3	10.5	23.8	861565.	29.7	643018.	.88
1.30	733700.	19.0	19.0	0.0	1327834.	1.81	36.4	10.7	25.7	882445.	30.4	687518.	.94
1.35	735150.	20.9	20.9	0.0	1459805.	1.98	38.5	10.9	27.6	903153.	31.1	732157.	1.00
1.40	736600.	22.9	22.9	0.0	1597204.	2.17	40.6	11.1	29.5	923672.	31.9	777824.	1.06
1.45	738050.	24.9	24.9	0.0	1743161.	2.36	42.8	11.3	31.5	944044.	32.6	824521.	1.12
1.50	739500.	27.1	27.1	0.0	1896806.	2.56	45.0	11.5	33.5	964271.	33.3	872227.	1.18
1.55	740950.	29.4	29.4	0.0	2058265.	2.78	47.3	11.7	35.6	984363.	33.9	920354.	1.24
1.60	742400.	31.9	31.9	0.0	2227660.	3.00	49.5	11.9	37.7	1004329.	34.6	970562.	1.31
1.65	743850.	34.4	34.4	0.0	2405115.	3.23	51.9	12.0	39.8	1024179.	35.3	1021374.	1.37
1.70	745300.	37.0	37.0	0.0	2590758.	3.48	54.2	12.2	42.0	1043919.	36.0	1073377.	1.44
1.75	746750.	39.8	39.8	0.0	2784677.	3.73	56.6	12.4	44.2	1063558.	36.7	1125764.	1.51
1.80	748200.	42.7	42.7	0.0	2987017.	3.99	59.0	12.6	46.5	1083107.	37.3	1177410.	1.59
1.85	749650.	45.7	45.7	0.0	3197882.	4.27	61.5	12.7	48.7	1102557.	38.0	1236072.	1.65
1.90	751100.	48.9	48.9	0.0	3417282.	4.55	64.0	12.9	51.1	1121929.	38.7	1293494.	1.72
1.95	752550.	52.1	52.1	0.0	3645630.	4.84	66.5	13.1	53.4	1141223.	39.4	1348763.	1.79
2.00	754000.	55.5	55.5	0.0	3982733.	5.15	69.3	13.2	55.8	1160445.	40.0	1403906.	1.86

These decelerations impose body force loads upon the cask, payload and lid as indicated in the following free body diagrams:



Where:

α = $\tan^{-1}(d/\ell)$

W_T = total weight

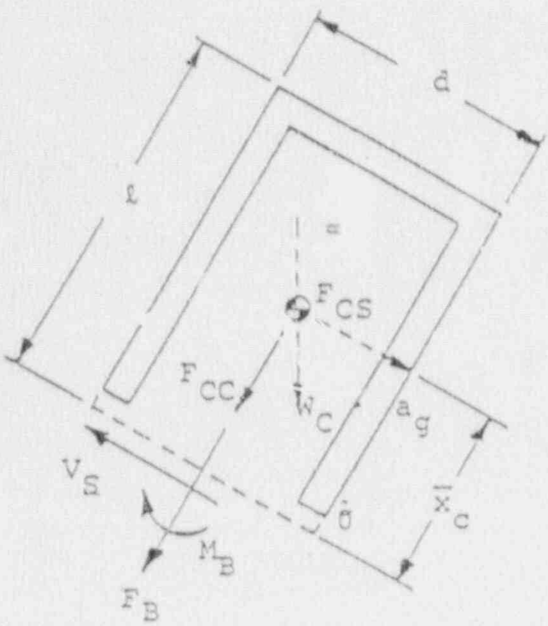
a_g = load factor

F_T = $W_T a_g$, total impact force

F_{TC} = $F_T \cos\alpha$, longitudinal impact force

F_{TS} = $F_T \sin\alpha$, lateral impact force

The cask body (sides and bottom) internal forces are:



Where:

W_c = weight of cask

F_{cc} = $W_c \cdot a_g \cos\alpha$

F_{cs} = $W_c \cdot a_g \sin\alpha$

F_B, V_S & M_B are unknown lid interface forces and moments, respectively

Similarly the payload forces are:

$$F_{pc} = W_p a_g \cos\alpha$$

$$F_{ps} = W_p a_g \sin\alpha \qquad \text{at } \overline{x}_p$$

Where:

W_p = payload weight

Now, based upon the payload and cask body forces, the lid interface forces F_B, V_B and M_B can be estimated:

<u>Longitudinal</u>:

$$F_B + F_{cc} + F_{pc} = 0$$

$$F_B = -a_g(W_c + W_p) \cos\alpha$$

<u>Lateral</u>:

$$V_S - F_{cs} - F_{ps} = 0$$

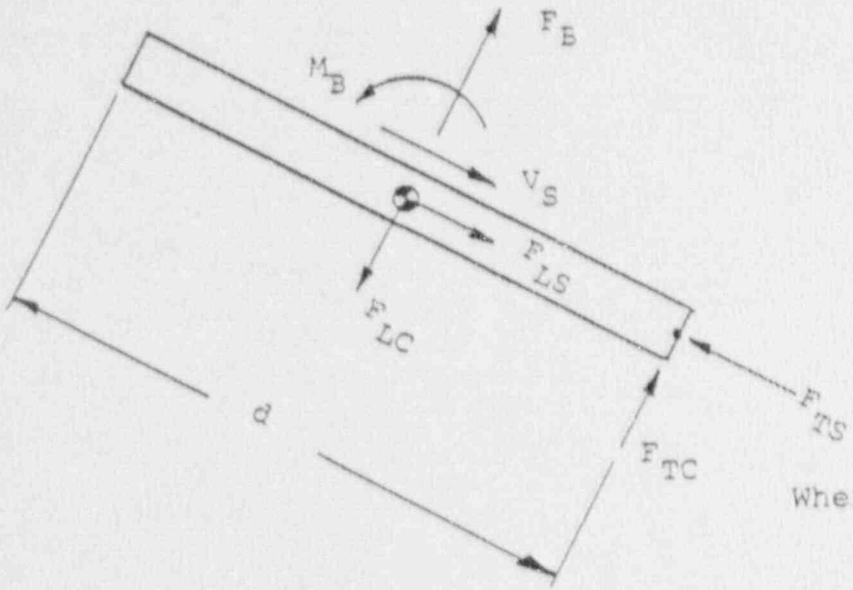
$$V_S = a_g(W_c + W_p) \sin\alpha$$

<u>Moment</u>:

$$M_B + F_{cs} \cdot \overline{x}_c + F_{ps} \cdot \overline{x}_p = 0$$

$$\underline{M_B = -a_g(W_c\overline{x}_c + W_p\overline{x}_p) \sin\alpha}$$

Comparable relations can be derived from lid equilibrium:



Where: W_L = weight of lid

$F_{LS} = W_L a_g \sin\alpha$

$F_{LC} = W_L a_g \cos\alpha$

Longitudinal: $F_{TC} - F_{LC} + F_B = 0$

$F_B = F_{LC} - F_{TC}$

$F_B = a_g(W_L - W_T)\cos\alpha$

But: $W_T = W_L + W_p + W_C;\ (W_T - W_L) = (W_p + W_C)$

Thus: $F_B = -a_g(W_C + W_p)\cos\alpha$

Lateral: $F_{TS} - V_X - F_{LS} = 0$

$V_S = F_{TS} - F_{LS}$

$V_S = a_g(W_T - W_L)\sin\alpha$

or: $V_S = a_g(W_P + W_C)\sin\alpha$

<u>Moment</u>: $M_B + F_{TC}\ (d/2) = 0$

$$M_B = \frac{-d}{2} a_g(W_T) \cos\alpha$$

But: $\frac{d}{\ell} = \tan\alpha$; $d = \tan\alpha = \ell \frac{\sin\alpha}{\cos\alpha}$

$$M_B = -\frac{\ell}{2} a_g\ (W_T) \sin\alpha$$

This appears to differ from the expression derived on the basis of the cask and payload free body which was:

$$M_B = -a_g(W_C\bar{x}_C + W_p\bar{x}_p) \sin\alpha$$

However:

$$\bar{x}_T = \bar{x}_p = \ell/2 \ ; \ \bar{x}_L = 0$$

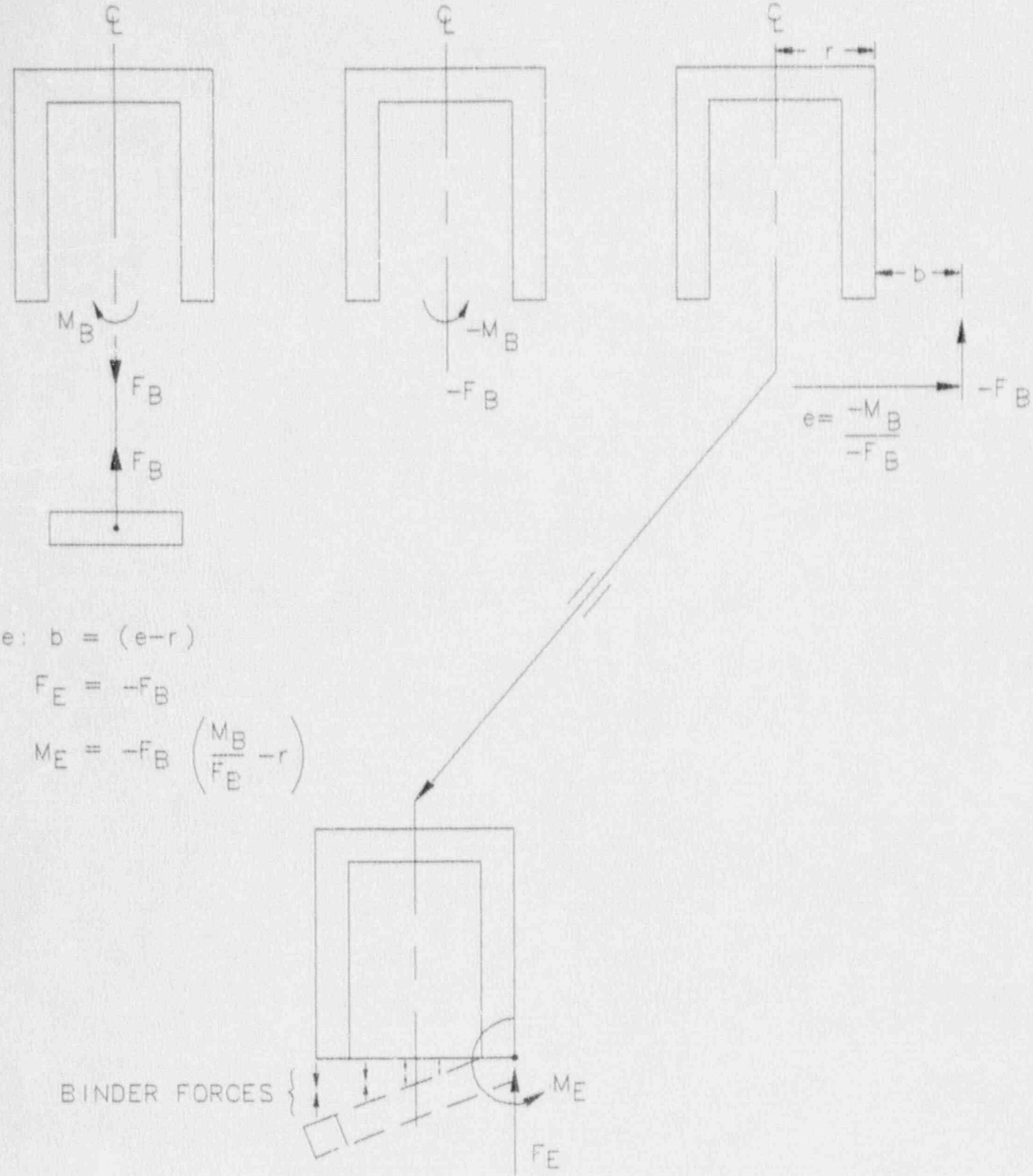
And:

$$W_T \cdot \bar{x}_T = W_C \cdot \bar{x}_C + W_p \cdot \bar{x}_p + W_L \cdot \cancel{\bar{x}_L}^{\,0}$$

$$W_T \cdot \bar{x}_T = (W_C\bar{x}_C + W_p\bar{x}_p) = W_T\ell/2$$

Thus, the two moment expressions are identical.

Ratchet binders, together with the bearing ring, react the interface axial force, F_B, and moment, M_B. Compressive loads are carried in bearing, whereas tensile forces are carried by the ratchet binders. Shear forces, associated with V_S are transferred by the lid step in bearing. The ratchet binder forces are calculated from the interface force, F_B, and moment, M_B, as follows:

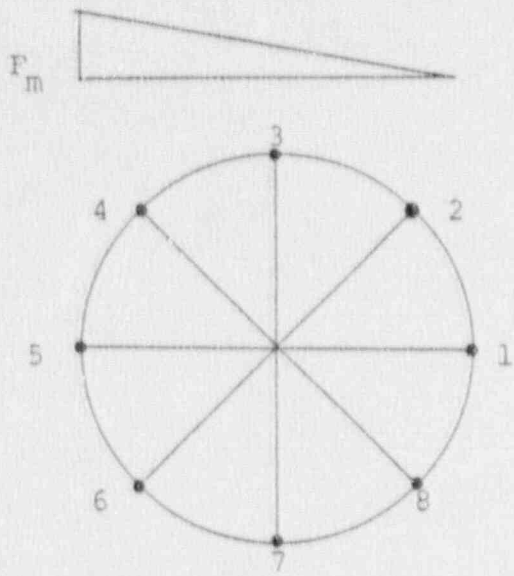


Where: $b = (e - r)$

$$F_E = -F_B$$

$$M_E = -F_B \left(\frac{M_B}{F_B} - r \right)$$

Binder forces are calculated by referring to the following sketch:



$$F_i = F_M \frac{1-\cos\theta_i}{2}$$

$$\theta_i = \frac{\pi}{4}(i-1)$$

$$M_i = F_i R\,(1-\cos\theta_i)$$

$$M_B = \frac{F_M R}{2} \sum_{i=1}^{8} (1-\cos\theta_i)^2 = \frac{F_M R}{2}(12)$$

$$F_M = \frac{M_B}{6R}$$

For the four versions, the interface loads and binder forces, F_B, are listed in the following table.

Lid Interface Forces

Version	Dimensions		Load Factor	Weights		Lid Interface Forces			Binder Forces
	d (in)	l (in)	(g's)	Total W_T (lbs)	Lid W_L (lbs)	Axle Tension W_L (lbs)	Moment M_B (in-lbs)	Shear V_S (lbs)	F_M (lbs)
50-1.5L	52.5	57	57.3	13,300	1,410	-501,125	-14,714,479	461,562	9,904
50-2.5L	54.5	60.5	46.3	19,400	2,615	-577,410	-18,185,760	520,147	14,993
50-3.0L	55.5	61.5	37.2	22,200	2,935	-532,042	-17,013,468	580,135	13,509
50-4.0L	57.5	64.5	31.1	29,000	4,155	-576,767	-19,355,189	514,172	16,076

Where:

$$\alpha = \tan^{-1}(d/l)$$

$$F_B = -a_g (W_T - W_L) \cos \alpha$$

$$M_B = -l/2 \, a_g W_T \sin \alpha$$

$$V_S = a_g (W_T - W_L) \sin \alpha$$

$$F_M = \frac{M_E}{6R}$$

$$M_E = -F_B \left(\frac{M_B}{F_B} - R \right)$$

$$R = d/2$$

Thus, in this instance, the maximum binder force is 16,076 lbs.

The ultimate strength of the binder is rated at 50,000 lbs. reference W. W. Patterson Catalog, Page R-6. The binders are fabricated from carbon steel, thus the yield load is:

F_y = (36,000/58,000) (50,000) = 31,035 lbs.

Thus, the Margin of Safety is:

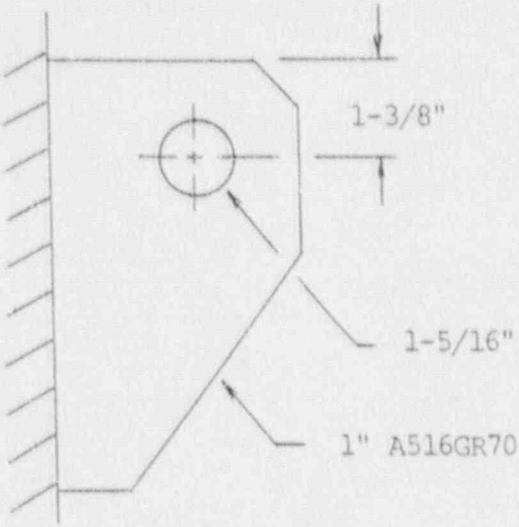
M.S. = 31,035/16,076 -1 = +0.93

The capacities stated for the binders are established static allowables. They are manufactured from standard carbon steels and fail in the same manner as a bolt. Numerous studies have been conducted on the behavior of bolts under dynamic or impact loading. RNL-TM-1312 Volume 12 Structural Analysis of Shipping Casks states that carbon steel bolts "possess better physical properties under conditions of shock than indicated by static tests. Increase in the value of stress by a factor of 1.3 and a greater amount of strain before necking occurs were reported". This is substantiated by references 5, 8, 9, 10 and 11 of the same document.

Therefore, it can be concluded that the binders static allowable capabilities will not be lower under shock or dynamic loading.

Thus, it can be concluded that the binders will react the impact load and retain the lid.

The lugs at each end of the binder will possess the following ultimate capability.



Body Lugs

Shear out:

Using the standard 40^0 shear out:

$P_s = F_s 2t\ (E.\ M.\ -d/2\ \cos 40^0)$

Where:

$F_s = 42{,}000$ psi

$t = 1.0$ in

$EM = 1.375$

$d = .9375$ in.

$P_s = (42{,}000)\ (2)\ (1.0)\ (1.375 - .469\ \cos 40^0)$

$= 85{,}320$ lbs. shear out

Weld Area:

$P_v = F_s A_v$

Where:

$F_s = 42{,}000$ psi

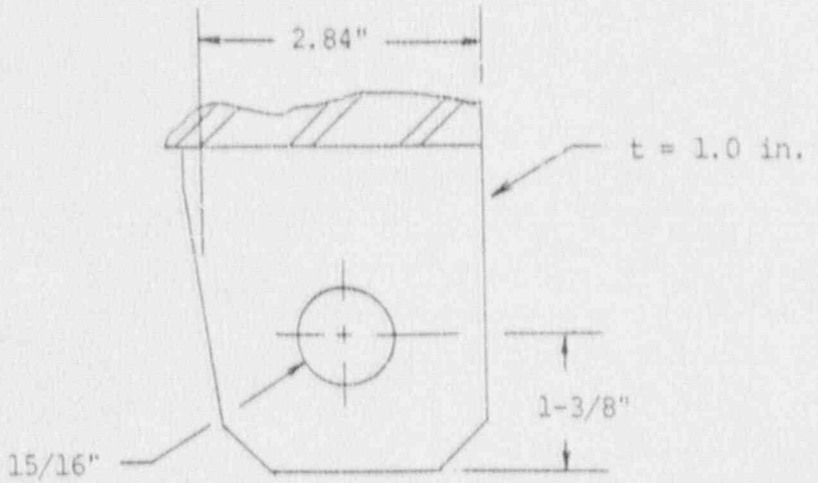
$A_v = (18 \text{ in}) (.375) (\sin 45^0)$

$= 4.77 \text{ in}^2$

$P_v = (42,000) (4.77 \text{ in}^2)$

$P_v = 200,340$ lbs. weld shear

Lid Lugs



The lug capability in net area is:

$P_t = F_{tu}A$

Where:

$F_{tu} = 70,000$ psi

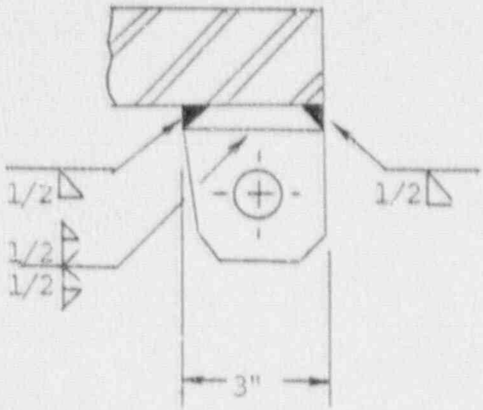
$A = (2.84 - .9375) (1.0)$

$= 1.906$

$P_t = (70,000 \text{ psi}) (1.906 \text{ in}^2)$

$P_t = 133,420$ lbs. (Net Area)

Lug to lid attachment



Weld Shearing:

$P_s = F_s A$ weld

Where:

$F_s = 42{,}000$ psi

$A = (2)(1)(1/2)\left(\frac{\sqrt{2}}{2}\right) + (2)(3)(1/2)(\sqrt{2})$

$= 4.95 \text{ in}^2$

$P_s = (42{,}000 \text{ psi})(4.95 \text{ in}^2)$

$P_s = 207{,}900$ lbs/lug

The critical load path binder fitting exists at the cask body lug. The corresponding yield load is:

$F_y = 85{,}320\ (36/58) = 52{,}957$ lbs.

At this location, the minimum Margin of Safety is:

$M.S. = \frac{52957}{16076} - 1 = \underline{+2.29}$

The ratchet binders load the lid top plate (Plate E) with a series of edge moments. The one inch plate of the NuPac 50 version will be evaluated fc these loads. Both local and gross effects on this lid t\~ late are evaluated.

For a maximum ratchet binder load of 16,076 lbs., the associated moment introduced in to the top plate of the lid is estimated as:

$$M = (16,076)\,(.25 + 3.00 - 1.375) = 30,143 \text{ in-lb.}$$

The local moment capability of an octagonal lid cover is estimated as follows:

$$M = \frac{\sigma I}{c}$$

Where: $\sigma = 42,000$ psi

$c = 0.5$ inch

$$I = \frac{bh^3}{12} = \frac{(14.485)\,(1)^3}{12} = 1.207 \text{ in.}^4$$

$$b = (2)\,(3")\tan 67.5^0$$

Local moment capability is:

$$M = \frac{(42,000)\,(1.207)}{.5} = 101,388 \text{ in-lb.}$$

Thus, local moment yield margin of safety of the lid is:

$$M.S. = \frac{101,388}{30,143} - 1 = \underline{+2.36}$$

Gross moment capability is assessed using both the exterior and interior lid plates. For a uniform edge moment the expression relating stress to moment in a circular plate is given by Roark as:

$$\sigma = \frac{6M}{t^2}\ ;\ M = \frac{\sigma t^2}{6}$$

For the 1" exterior plate:

$$M = \frac{42,000\ (1)}{6} = 7,000 \text{ in-lb/in}$$

For the 1.25" interior plate:

$$M = \frac{42{,}000\ (1.25)^2}{6} = 10{,}938 \text{ in-lb/in}$$

The total edge moment capability is: 17,937 in-lb/in.

For a circular lid of 52.5" diameter the corresponding concentrated moment acting on 1/8th of the edge is:

$$M_g = \frac{(17{,}937)\ (52.5)\ (\pi)}{8} = 369812 \text{ in-lb}$$

Thus the gross moment yield Margin of Safety of the lid is:

$$M.S. = \frac{369{,}812}{30{,}143} - 1 = \underline{+11.27}$$

It can be concluded that the binders and their fittings can safely react the maximum loads produced during impact.

The secondary lid closure studs are examined in a comparable fashion. The studs must resist forces associated with the lid and some fraction of the payload. Assuming a "loose" payload, the payload force carried by the studs can be conservatively estimated on a proportional area basis as 19% of total payload force. Thus, the total secondary lid stud load is estimated as:

$$R = (W_T + W_p) a_? \cos \alpha$$

$$= [515 + (.19)\ 4200]\ [57.3] \cos 42.4^\circ = 55{,}248 \text{ lbs.}$$

Since there are eight secondary lid studs 3/4-10 UNC, AISI 303/304, each stud load is 6,906 lbs. The tensile strength of the stud is:

$$P = F_t A = (35{,}000)\ (.309) = 10{,}815 \text{ lbs.}$$

Thus, the Margin of Safety of the secondary lid is:

$$M.S. = 10,815/6,906 - 1 = \underline{+0.57}$$

When impacts occur on the lid end, a normal compressive load of 576,767 lbs. (NuPac 50-4.0L) is transferred from the lid to the lid closure ring. This load is then transferred to the cask via direct compression of the lead shielding and a pair of 3/8" bevel welds. The loaded length is:

$$\ell = 2R\theta$$

Where: $R = 28.75$ in.

$$\theta = \cos^{-1}\left(\frac{r}{R}\right) \qquad \text{See Appendix 2.10.2}$$

$$r = R - \frac{\delta}{\sin \alpha}$$

$$\delta = 1.40$$

$$\alpha = 42.2^0$$

$$R = 28.75 - \frac{1.40}{\sin 42.2} = 26.67 \text{ in.}$$

$$\theta = \cos^{-1}\left(\frac{26.67}{28.75}\right) = 0.3831 \text{ rad.}$$

$$\ell = (2)(28.75)(.3831) = 22.03 \text{ in.}$$

The yield bearing capacity of the 1/8" x 3/4" bearing ring is:

$$F_B = (22.03)(3/4)(42,000) = 693,945 \text{ lbs.}$$

The associated Margin of Safety is:

$$M.S. = \frac{693,945}{576,767} - 1 = \underline{+0.20}$$

The yield capability of these welds is:

$$F_W = (2)\ 22,800)\ (22.03)\ (3/8)\ \sqrt{2} = 532,752 \text{ lbs.}$$

The yield bearing capacity of the lead (3.75 inches thick) is:

$$F_L = (22.03 \text{ in})\ (3.75 \text{ in})\ (1{,}380 \text{ psi}) = 114{,}005 \text{ lbs.}$$

The associated yield Margin of Safety in the impact zone is:

$$M.S. = \frac{(532{,}752 + 114{,}005)}{576{,}767} - 1 = \underline{+0.12}$$

The lateral load transferred between the lid and the cask is estimated as 514,172 lb (the Model 50). The load is initially transferred from the exterior lid plate to the interior lid plate via a 1/2" circumferential bevel weld. The interior lid plate transfers this load to the cask body by direct compression. This compressive load is transferred across a deeply stepped recess of the interior lid plate within the cask inner cavity. The load yield capability of the circumferential lid weld is:

$$F_V = F_s A_s = F_s \cdot \pi D \cdot t_V$$
$$= (22{,}800)\ (\pi)\ (48.5)\ (1/2) = 1{,}645{,}566 \text{ lbs.}$$

The associated Margin of Safety is:

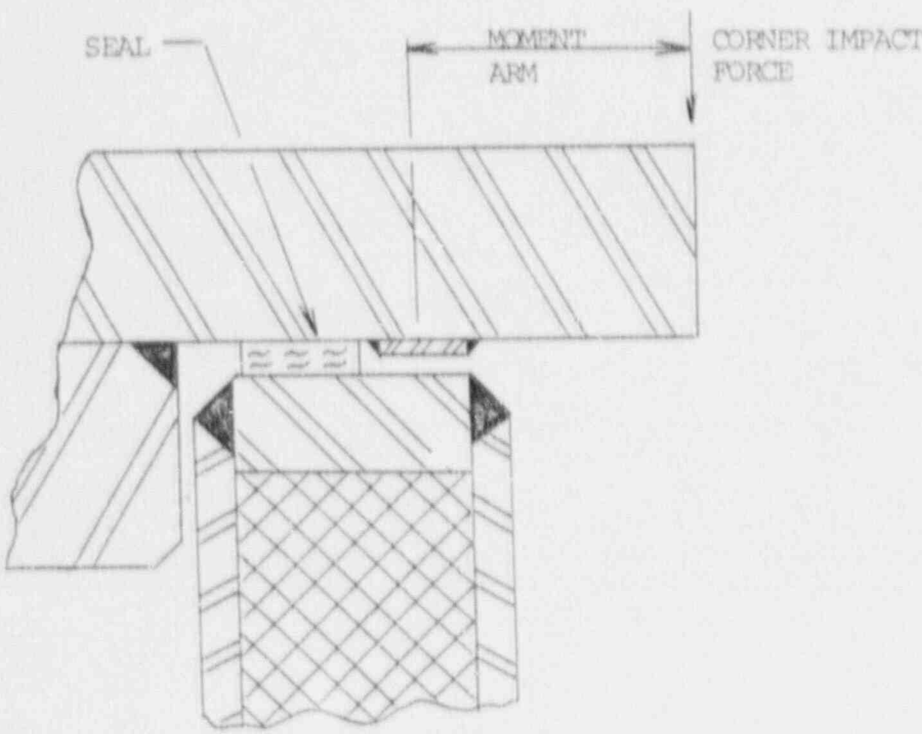
$$M.S. = \frac{1{,}736{,}987}{514{,}172} - 1 = \underline{+2.38}$$

Therefore, it can be safely concluded that the package can survive a normal corner drop.

2.6.7.4 Drop Effects on Lid Integrity

The lid consists of two steel plates attached together with a circumferential weld. The outer plate is of octagonal shape to accommodate the ratchet binders, whereas the inner steel plate is circular and fitted within I.D. of the cask cavity. A circumferential seal is bonded to the outer plate just inboard of the bearing surface (a 1/8" x 3/4" ring).

From the stand point of containment vessel seal integrity, impacts on the outstanding corners of the octagonal lid are considered to be most severe. This is because the cantilevered corner provides a moment arm about the bearing surface ring. The associated moment deforms the (near) circular plate and consequently unloads the pre-compressed seal, as shown below.



In order to assess this deformation, or seal unloading phenomena, a nonlinear ANSYS finite element analysis model was developed, as shown in Figure 2.6.7.4-1, to represent the previously licensed NP 50-1.5L, constructed of a mild steel (A-36). It is the same general configuration as the Model NuPac 50-1.5L, which is the most critical of the four configurations.

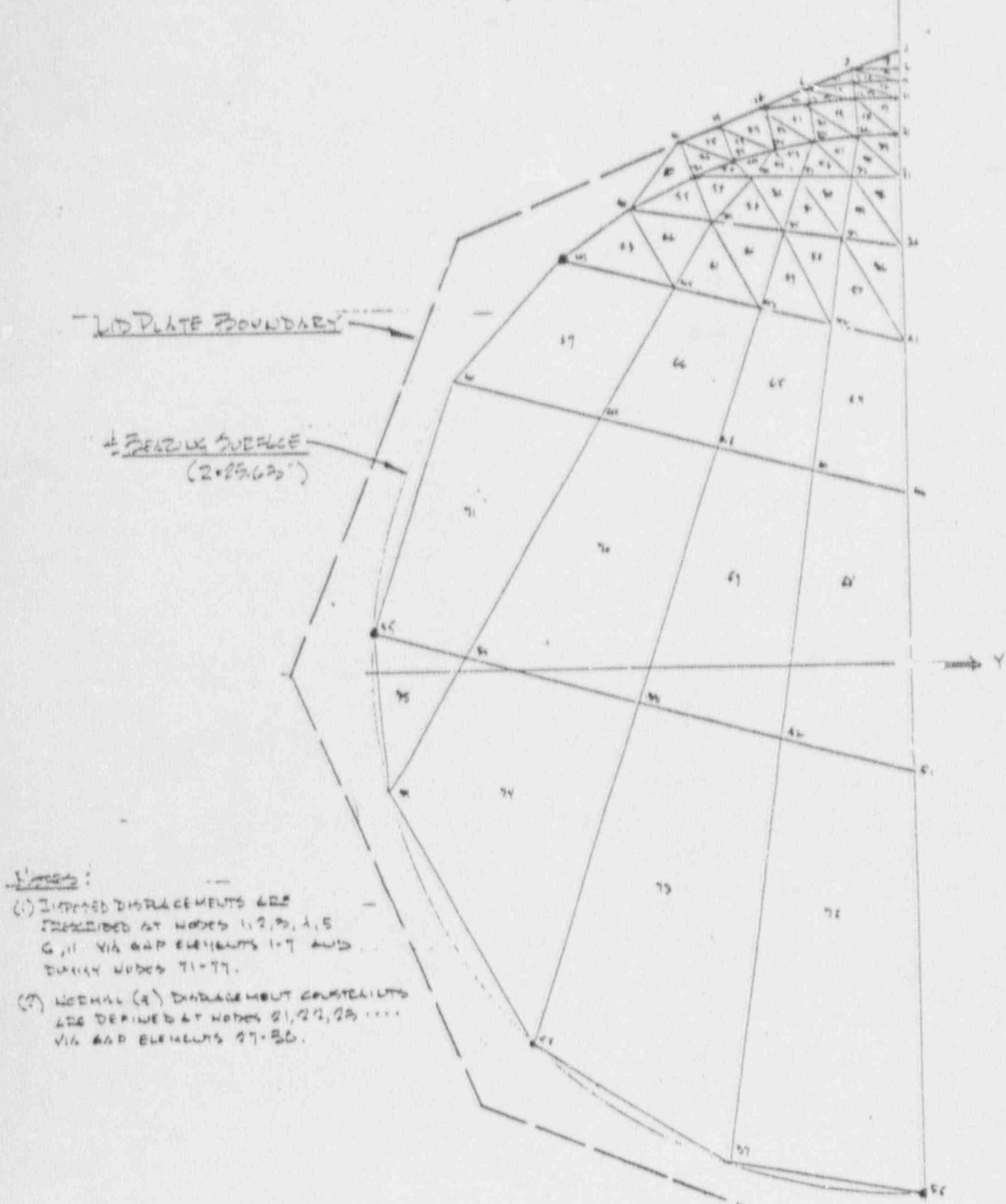
The model consists of a symmetric one-half idealization of the outer plate. Octagonal corners and overhand were neglected excepting at the impacted corner. Plastic triangular finite elements were used to represent the 1" thick plate near the impact zone. Elsewhere, elastic quadrilateral finite elements were employed to represent the plate.

Symmetric boundary conditions were imposed along the X-axis (plane of symmetry). Normal restraints (Z deformations) were imposed at all locations corresponding to the center line of the bearing surface (r = 25.63"), nodes 21, 22, 23, 24....56. These bearing surface normal restraints were introduced via compression-only gap elements allowing unrestrained lift-off and compression-only deformations consistent with the elastic-plastic behavior of the bearing ring and plate corresponded to those of mild steel A-36):

s_y = 36,000 psi; $E = 29 \times 10^6$

s_u = 58,000 psi; ϵ_u = .23

Figure 1.6.6.4-1
Lid Finite Element Analysis
Model (ANSYS)



The analysis model was realistically loaded with displacements imposed upon the cantilevered octagonal corner via a unique crush front analytic mechanism. This crush front mechanism corresponded to an unyielding planar surface oriented at 42.2 degrees to the plane of the plate. This crush front was then displaced incrementally up to a normal (with respect to the crush plane) deformation of 1.15 inches corresponding to the maximum predicted deformation of the NP 50-1.5L corner. As successive nodes of the plate model encountered the crush front, compression- only gaps imposed deformations upon the plate consistent with this moving crush front.

Output of the final non-linear analysis iteration are provided following this discussion. Important analysis conclusions are as follows:

- Maximum Strain in Plate

  At element #8 ϵ_{Max} = .051203

  $$M.S. = \frac{.23}{.051203} - 1 = \underline{+3.49}$$

- Unloading Deformation at Seal (r = 24.88)

  Node 21 (r = 25.63) = .128169 x 10^{-3}

  Node 31 (r = 23.5) = -.212740

  Seal (r - 24.88) = -0.0748 (unload)

  The seal is precompressed 1/8 inch. Thus, the sealing Margin of Safety is:

  $$M.S. = \frac{.125}{.0748} - 1 = \underline{+0.67}$$

The integrity of the lid and its seal assure that containment is not compromised by the most extreme of impact events. Four factors assure the conservatism of this prediction:

1) The inner lid plate has been ignored. If present, this plate would reduce outer plate deformations, thus reduce the amount of seal unloading.

2) Plate bearing support was assumed at the center line of the bearing ring. In fact, the center of bearing pressure would be out-board of the center line of the bearing surface thereby reducing the cantilevered impact force moment arm. This would reduce the moment introduced into the plate; hence, reduce late deformations and seal unloading tendencies.

3) The plastic finite elements used ignor in-plane shear yielding. If present, this in-plane shear yielding would reduce the displacement imposed cantilevered impact force; hence, reduce both the moment introduced into the plate and the associated seal unloading tendencies.

4) The solution results correspond to iteration #18, a nearly converged solution. Greater numbers of iterations would continue the trends of earlier iterations and reduce the tendency of the seal to unload (by 5-7%).

2.6.8 Corner Drop

This requirement is not applicable since the NuPac 50-xxL packaging is fabricated of steel.

2.6.9 Penetration

From previous container tests, as well as engineering judgement, it can be concluded that the 13 pound rod would have a negligible effect on the heavy gauge steel shell overpack or cask.

2.7 Hypothetical Accident Conditions

Not applicable for Type "A" packages.

2.8 Special Form

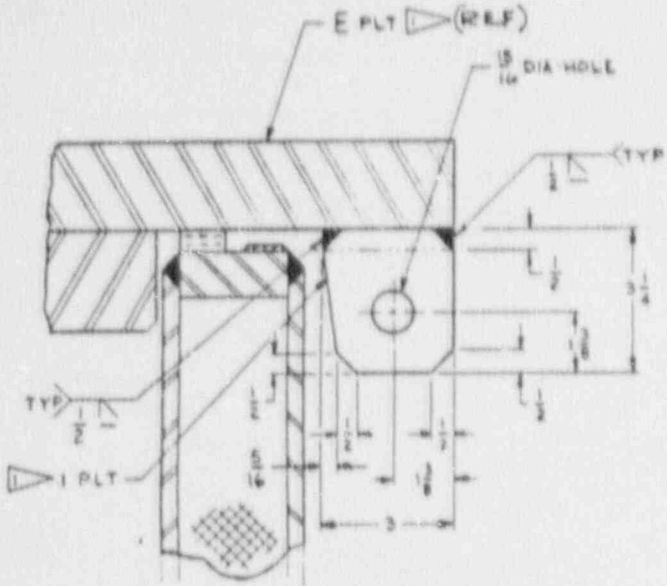
Since no special form is claimed, this section, is not applicable.

2.9 Fuel Rods

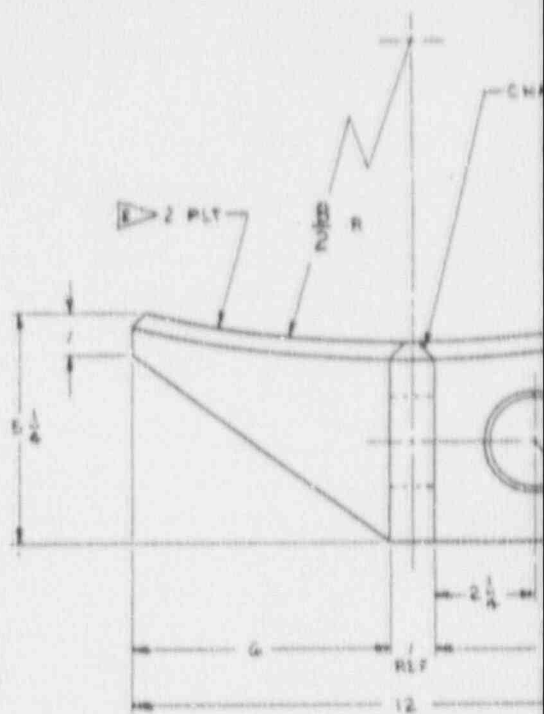
Not applicable.

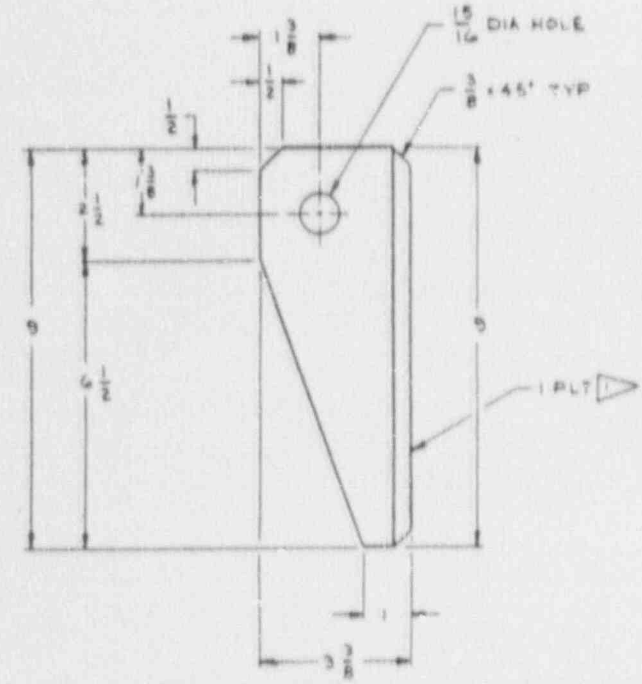
2.10 Appendix

2.10.1 General arrangement drawing of NuPac 50-xxL packaging.

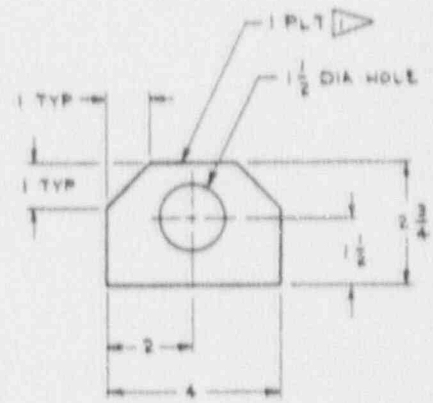


SECTION D-D
SCALE: 1/2





DETAIL - F
SCALE: 1/2



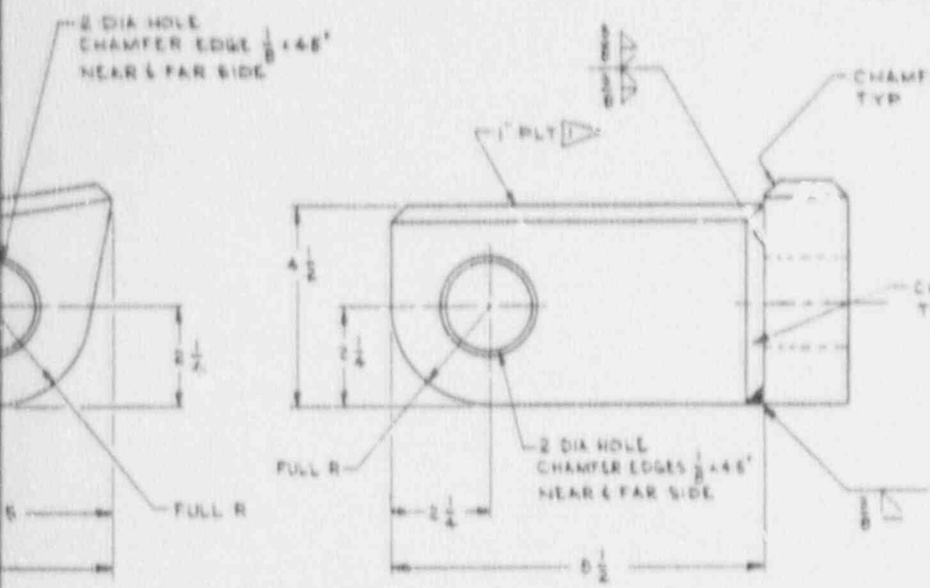
VIEW G-G
SCALE: 1/2

VIEW H-H
SCALE: 1/2

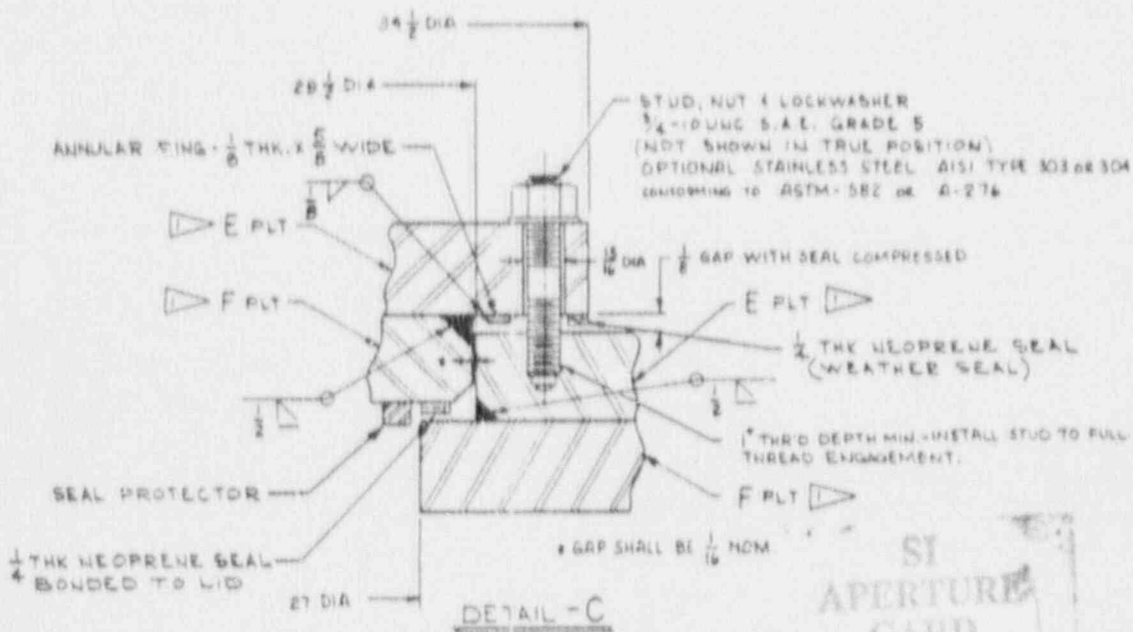
NOTES: UNLESS OTHERWISE SPECIFIED

8 7 6 5

ZONE	LTR	DESCRIPTION	DATE	APPROVED
	B	REVISED DWG TO CORRECT DRAFTING ERROR [illegible]	[illegible]	[illegible]
	C	REVISED DWG TO CHANGE LIFT/TIE [illegible] LID LOCATION DIMENSION; WAS [illegible] FROM BASE	[illegible]	[illegible]



DETAIL - E
SCALE : 1/2



DETAIL - C
SCALE : 1/2
(GASKET SHOWN UNCOMPRESSED)

SI APERTURE CARD

Also Available On Aperture Card

9102260200-01

ITEM	PART NO.	DESCRIPTION	MATERIAL

LIST OF MATERIAL

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ASSEMBLY & QUANTITY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMALS ±

DO NOT SCALE THIS DRAWING

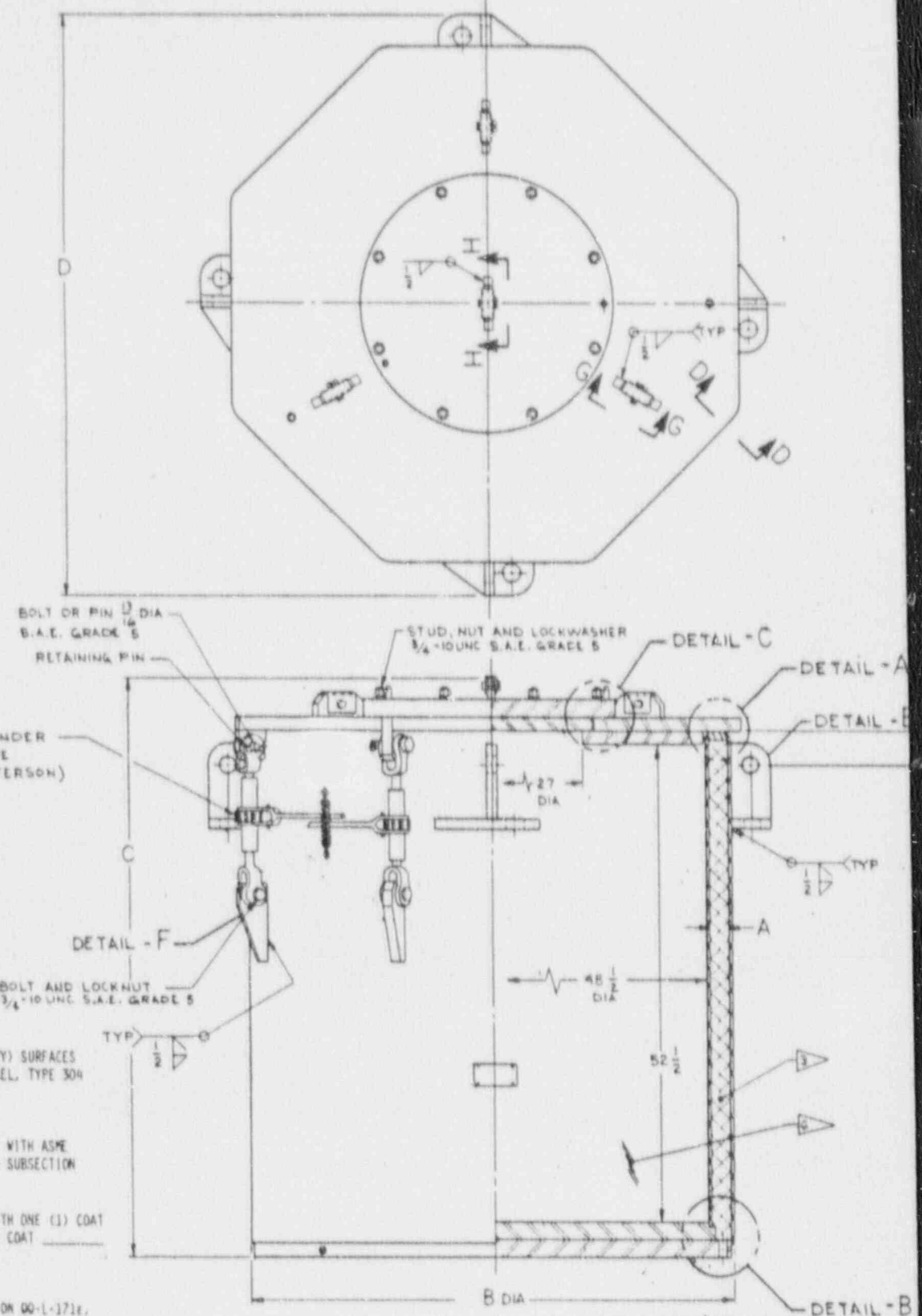
NEXT ASSY | USED ON
APPLICATION

NUCLEAR PACKAGING, INC.
TACOMA, WASHINGTON

TRANSPORTATION SHIELD
TYPE A
MODEL "NUPAC 50"

DRAWN CULTUM	8-28-80	QA [signature]	9-11-80	SCALE 1/4 & NOTED	WT. SEE [illegible]
CHECK [signature]	9-11-80	DWG REL. [signature]	9-11-80	REV C	SHEET 2 OF 2
ENGR. [signature]	9-11-80	PROG. REL.		DWG SIZE D	DWG NO. X-20-201D

X-20-201D C



6 OPTIONAL: CASK INTERIOR (CAVITY) SURFACES LINED WITH 12GA. STAINLESS STEEL, TYPE 304 CONFORMING TO ASTM - A240.

5. WELDING SHALL BE IN ACCORDANCE WITH ASME CODE SECTION IX, PER ARTICLE 4 SUBSECTION QW-400.

4 PAINT ALL EXTERIOR SURFACES WITH ONE (1) COAT ______________ AND ONE (1) COAT ________
COLOR: ______________

3 LEAD: PER FEDERAL SPECIFICATION QQ-L-171e, GRADE A OR C

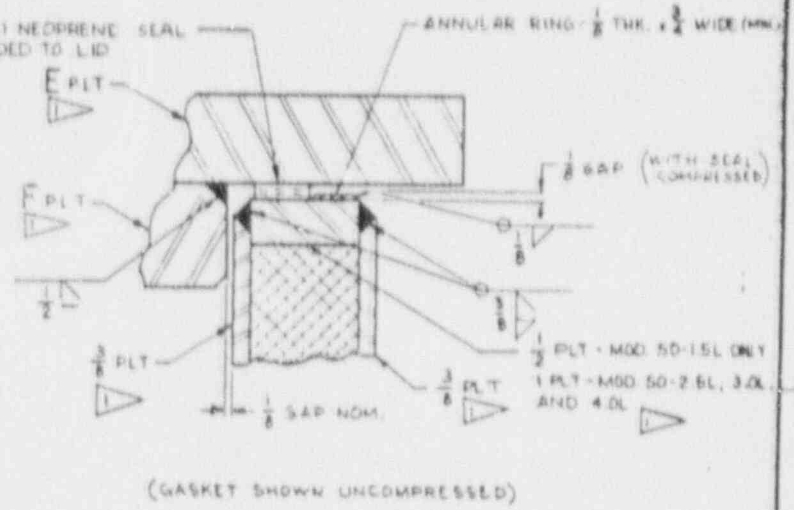
2 MATERIAL: U.S. T-1 STEEL ASTM - A514

1 MATERIAL: STEEL PER ASTM - A516 GRD. 70.

NOTES: UNLESS OTHERWISE SPECIFIED

CASK MODEL	DIMENSIONAL DATA						REF
	A	B	C	D	E	F	CASK WT.
50-1.5L	1.25	52.50	61.13	61.50	1.00	1.25	8965
50-2.5L	2.25	54.50	65.38	63.50	2.00	2.00	15125
50-3.0L	2.75	55.50	66.88	64.50	2.00	2.50	17850
50-4.0L	3.75	57.50	70.38	66.50	3.00	3.00	24615

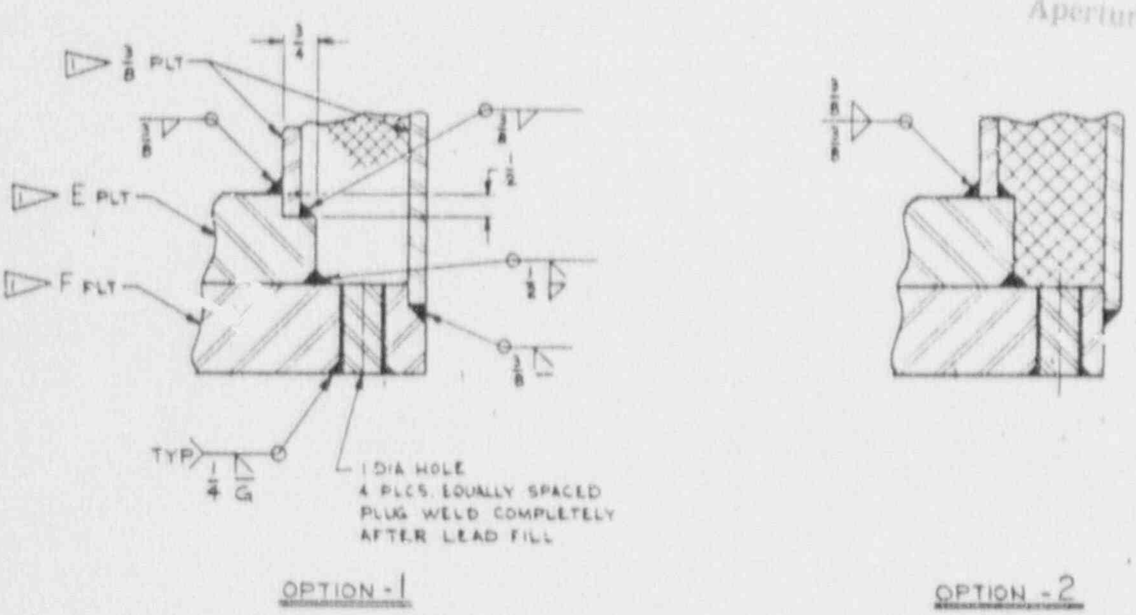
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED
	A	REV PER LANE REQUEST		



DETAIL - A
SCALE: 1/2

SI APERTURE CARD

Also Available On Aperture Card



DETAIL - B
SCALE: 1/2

X-20-201D C

9102260200-02

REFERENCE DATA	
PAY LOAD	GROSS WT.
4200	13165
	19325
	22050
4200	28815

ITEM	PART NO	DESCRIPTION	MATERIAL
		LIST OF MATERIAL	

ASSEMBLY & QUANTITY

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS ±
ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±
1 PLACE DECIMALS ±
DO NOT SCALE THIS DRAWING

NEXT ASSY | USED ON
APPLICATION

NUCLEAR PACKAGING, INC.
TACOMA, WASHINGTON

TRANSPORTATION SHIELD
TYPE A
MODEL "NUPAC 50"

DRAWN	CULTUM	8-28-80	QA		3-11-80	SCALE AS NOTED	WT SEE CHART
CHECK		3-11-80	DWG REL		3-11-80	REV C	SHEET 1 OF 2
ENGR		3-11-80	PROD REL			DWG SIZE D	DWG NO. X-20-201D

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4 3 2 1

Appendix 2.10.2

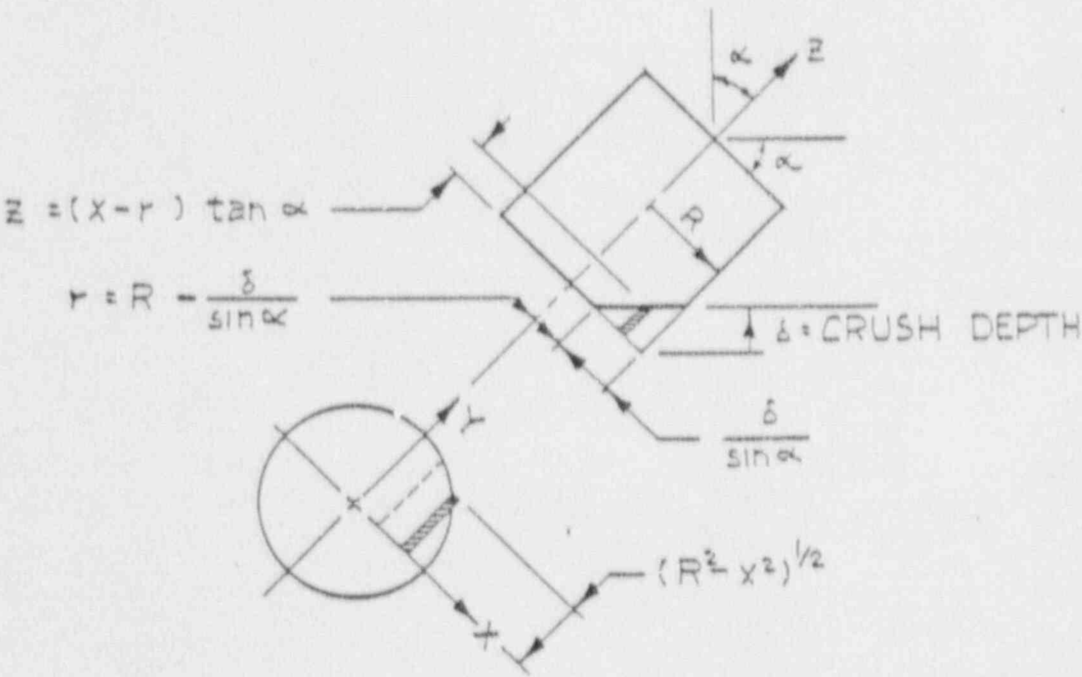
Volume and Area Estimates

Corner Impact on a Cylinder

1. Volume Estimates

1.1 Total Volume

The geometry and nomenclature of this model is:



The volume of the shaded differential slice shown is:

$dV = (R^2-x^2)^{1/2} \ (x-r) \sin \alpha \, dx$

The total volume is:

$V_t = 2 \tan \alpha \int_r^R (R^2-x^2)^{1/2} \ (x-r) \, dx$

Evaluation gives:

$$V_t = 2 \tan \alpha \left\{ \frac{(R^2-r^2)^{3/2}}{3} + \frac{r^2}{2}(R^2-r^2)^{1/2} - \frac{rR^2}{2}\left[\frac{\pi}{2} - \sin^{-1}\left(\frac{r}{R}\right)\right]\right\}$$

Or:

$$V_t = 2 \tan \alpha \left(\frac{t^3}{3} + \frac{r^2 t}{2} - \frac{rR^2}{2} \left[\frac{\pi}{2} - \sin^{-1} \left(\frac{r}{R}\right)\right]\right)$$

Where:

$$t = (R^2 - r^2)^{\frac{1}{2}}; \quad r = R - \frac{\delta}{\sin \alpha}$$

1.2 Component Volumes

The steel volume is composed of side and bottom portions:

$$V_s = V_{side} + V_{bot}$$

$$V_{side} = R\theta(R-r)t_s \tan \alpha$$

$$V_{bot} = t_b \cdot [\theta R^2 - rR \sin\theta]$$

Where: $\theta = \cos^{-1} \left(\frac{r}{R}\right)$

t_s = external steel side thickness (in)

t_b = steel and thickness (in)

The lead area represents the residual

$$V_\ell = V_t - V_s \; ; \; (V_t - V_s) > 0$$

$$= 0 \; ; \; (V_t - V_s) < 0$$

2. <u>Area Estimates</u>

2.1 Total Area

The differential contact area is:

$$dA = \frac{(R^2 - x^2)^{\frac{1}{2}}}{\cos \alpha} \cdot dx$$

The total area is:

$$A_t = \frac{2}{\cos \alpha} \int_r^R (R^2 - x^2)^{\frac{1}{2}} \, dx$$

2.2 Component Areas

The steel area (of the side walls) is:

$$A_s = 2t_s R\theta \cdot [1 + \frac{\sin\theta}{\theta} \cdot (\frac{1}{\cos\alpha} - 1)]$$

The lead area is the residual:

$$A = A_t - A_s \;;\; (A_t - A_s) > 0$$

$$= 0 \;;\; (A_t - A_s) < 0$$

3. <u>Strain Energy Estimates</u>

3.1 Flow Stress Approach

$$S.E. = V_s \cdot \sigma_{sp} + V_\ell \cdot \sigma_{\ell p}$$

Where: σ_{sp} = steel flow stress

$\sigma_{\ell p}$ = lead flow stress

3.2 Crush Stress Approach

$$S.E. = \frac{1}{2} \sum_i [(F_i + F_{i-1}) \; (\delta_i - \delta_{i-1})]$$

Where: $F_i = A_{s_i} \sigma_{sc} + A_{\ell_i} \sigma_{\ell c}$

σ_{sc} = Steel crush stress

$\sigma_{\ell c}$ = lead crush stress

δ_i = assumed crush depth at the i^{th} step

Appendix 2.10.3

Test Report, Corner Drop

1.0 Purpose

The purpose of the drop test was to evaluate the effects of a 45" corner drop on the lid.

2.0 Test Set-up

The test article was a NuPac 50 cask manufactured from A-36 material. New gaskets were installed and the cask was pressure tested to 7.2 psi for 4 hours. No loss of pressure was recorded. A standard NuPac 50 cubic foot, snap-on lid liner, was filled with 4000 lbs. of wet sand. The liner plus the sand payload totaled 4200 lbs. The liner was also pressure tested, with no loss of pressure noted. Upon completion of the pressure test the liner was placed in the cask and transported to the drop site. The drop pad was constructed in 1973 for Type "B" testing of the 37,500 lb. Paducah Tiger (C of C No. 6553). It consists of a 2" thick steel plate grouted onto a massive reinforced concrete pad. The pad closely approximates the "unyielding surface".

3.0 Drop Test

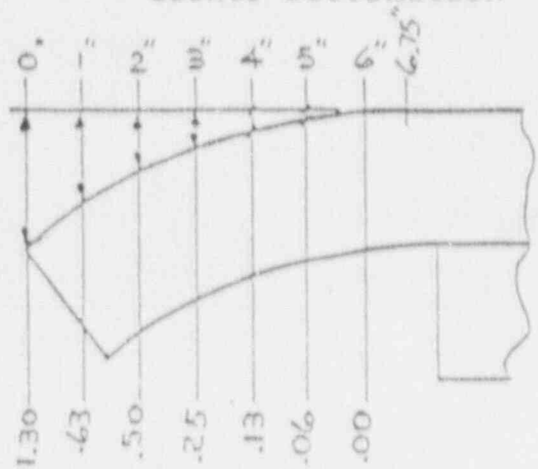
A heavy steel lug was welded to the bottom corner of the cask such that the c.g. will be directly above a corner tab on the cask lid. In order to provide conservatism, the N.R.C. suggested that the regulation height of 36" be increased by 25%. Therefore, the cask was raised to a height of 45" and released.

4.0 Test Results

The analysis predicted local corner deformation of 1.25 to 1.40". From the attached photo's, it can be seen that actual deformation was 1.30". There was no indication of brittle fracture or cracking of any kind. Temperature of the cask was 51°F. Damage was restricted to the cask lid corner. After the drop, the cask was subjected to the same differential pressure and freon test. No leakage was detected. On removal of the lid, the gasket and spacer ring were unaffected. Local deformations of the lid in the area of the spacer ring were matched by local deformations in the cask lip. Using a straight edge, these deformations were limited to less than .06 over 8" of length. *See attached figure. Since this deformation matched the lid configuration, the seal remained unaffected. The liner was removed and tested. No leakage was noted. From the photos, it can be seen that liner suffered minimal damage. Deformations were only slightly larger than those allowed by normal manufacturing tolerances.

Figure 1.10.3.1

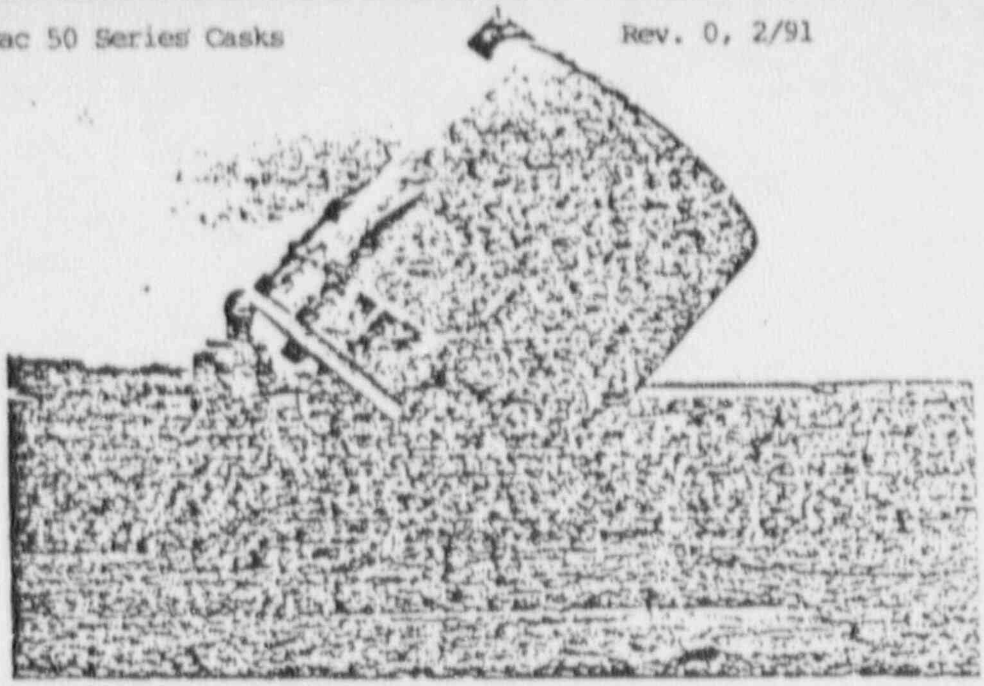
Corner Deformation



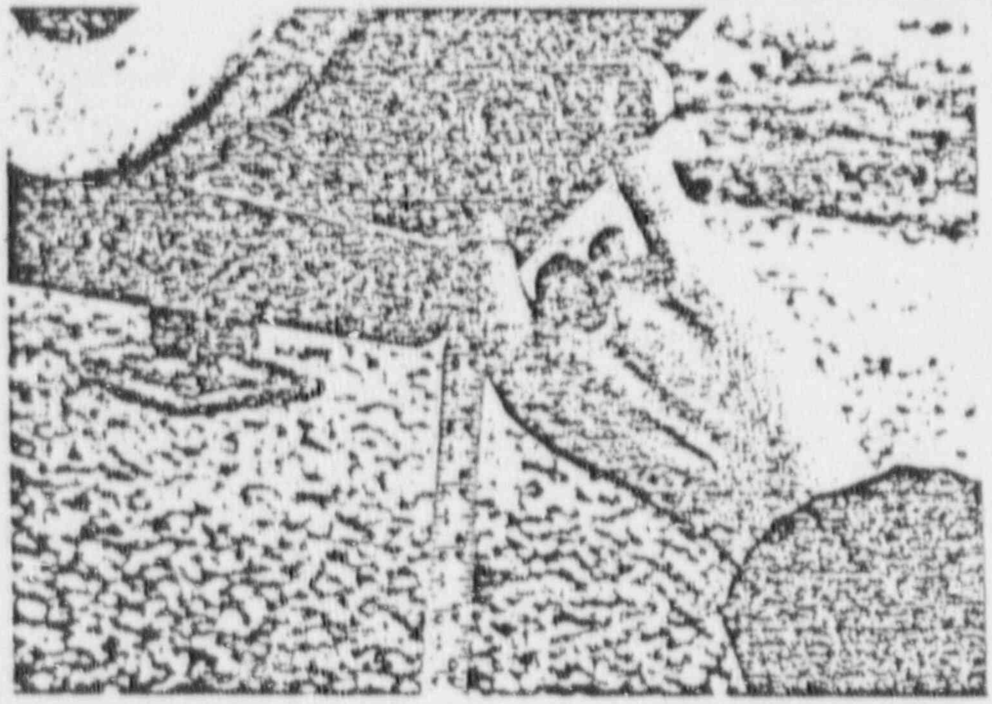
5.0 Conclusion

The NP 50, manufactured from A-36, was dropped from a height 1.25 times higher than required by 10 CFR 71. Damage sustained was limited to local deformation and had no impact on the packages' ability to retain its contents. Since the package successfully demonstrated its ability in meeting the requirement of 10 CFR 71 Appendix A, Paragraph 6, it can be safely assumed that the Model NuPac 50, constructed of ASTM A516 Gr. 70 will also meet these requirements.

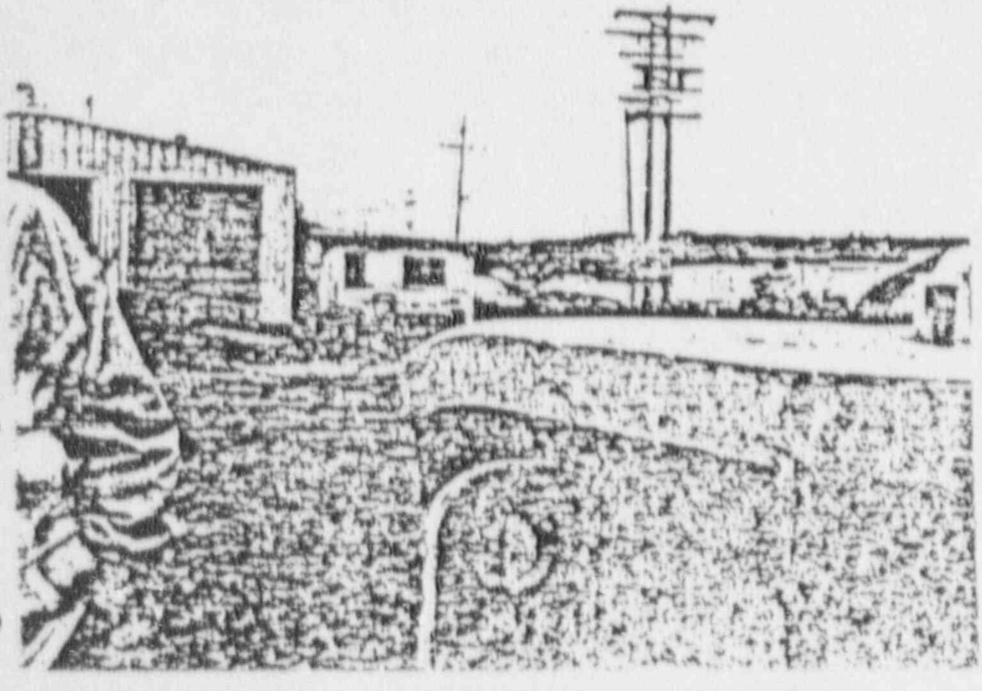
NP50-2.5L DROP TEST



DROP ANGLE 42°

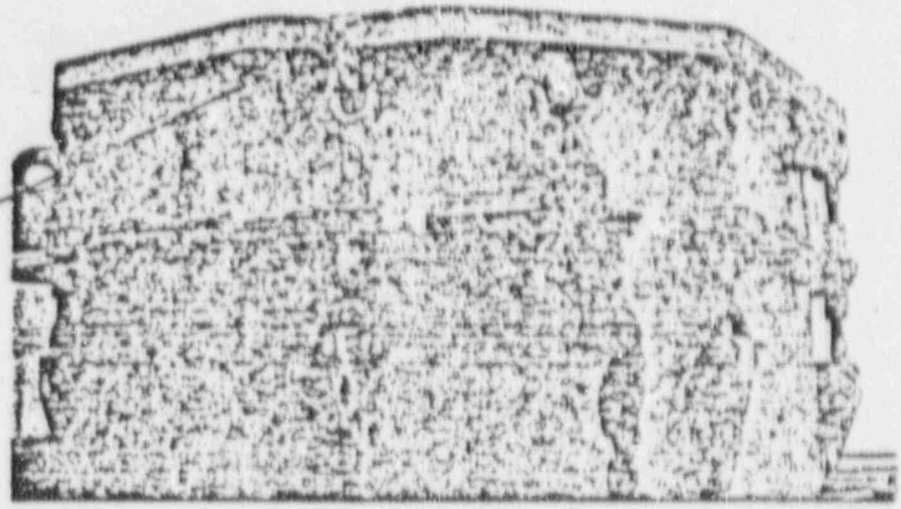


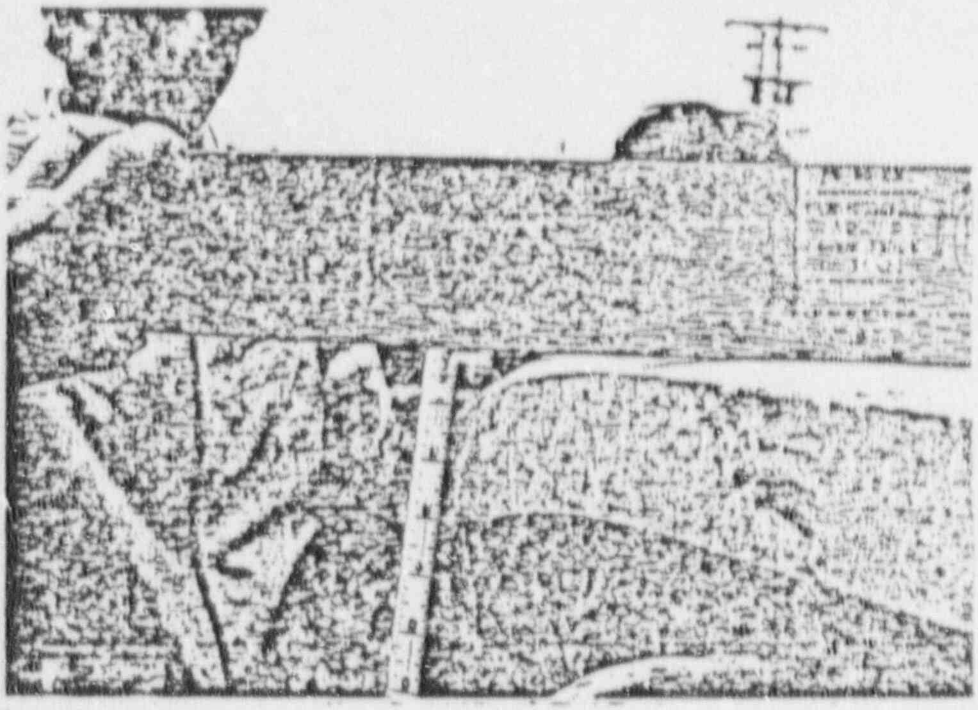
DROP HEIGHT 46"



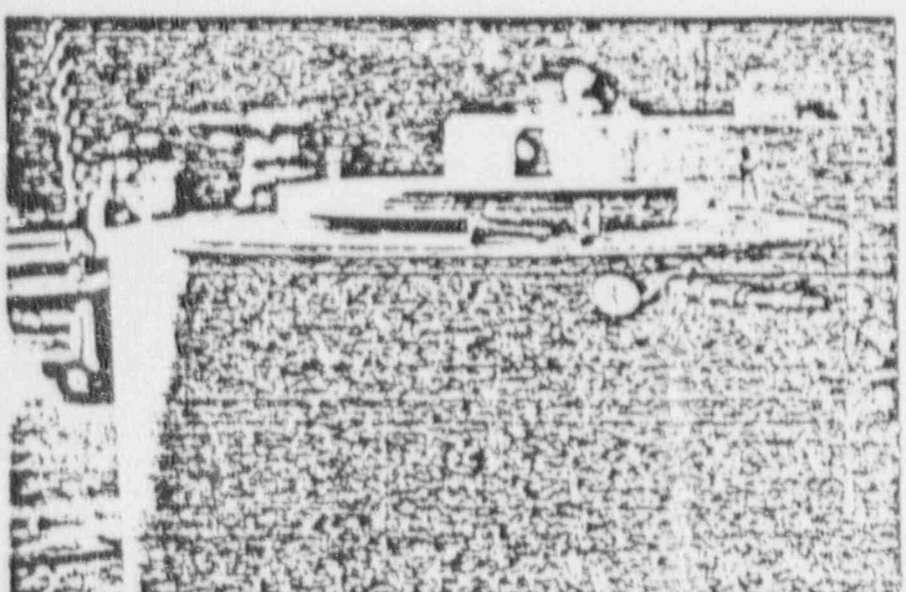
LOCAL CORNER DEFORMATION

DEFORMATION





DEFLECTION: 1.3"



POST DROP LINER PRESSURE TEST

3.0 THERMAL EVALUATION

A thermal analysis for the NuPac 50 packaging has been conducted for normal transport conditions. The performance of the packaging under normal conditions of transport is described below:

3.1 Discussion

The mechanical features of the packaging have been described in Section 1.2.1. There are no special thermal protection sub-systems or features.

The external surface of the packaging is predicted to exhibit maximum temperatures ranging from 168° to 176°F, depending upon the quantity of internal decay heat assumed. The lower temperature prediction assumes no internal heat, whereas the higher temperature assumes an internal decay heat load of 400 watts. These maximum temperature predictions assume conditions consistent with the Normal Transport "Heat" requirements, specifically:

- o Direct sunlight (mid-summer)
- o Ambient Air at 130°F
- o Still air

For conservatism, the "peak" solar flux has been assumed to exist continuously. This is equivalent to assuming 24 hours sunlight of maximum intensity. Further conservatism is incorporated in the analysis by assuming the cask base is an adiabatic boundary (no heat loss).

The analysis also shows that the internal decay heat (400 watts) raises inside surface temperatures above the external temperatures by less than 0.3°F.

3.2 Summary of Thermal Properties of Materials

Only three basic properties of the cask materials were employed in this analysis. They were obtained from conventional handbooks as follows:

Thermal Conductivity

Steel	25 Btu/hr ft-°F
Lead	18.6 Btu/hr ft-°F

Surface Emissivity/Absorptivity

Steel	0.8

3.3 Technical Specification of Components

Not applicable -- no special thermal sub-systems.

3.4 Thermal Evaluation for Normal Conditions of Transport

The thermal analysis for Normal Transport "Heat" and "Cold" conditions is presented in Section 3.6, Appendix. The analyses show little differences between the four individual casks which comprise the NuPac 50 series of packages.

3.4.4 Maximum Internal Pressures

Assuming the package contains water loaded at 70°F. Under maximum temperature conditions (176.8°F), the pressure would increase as shown below:

The partial pressures of water and air at 70°F are:

$P_{Va} = 0.36$ psi

$P_{ac} = 14.7 - .36 = 14.34$ psi

The partial pressures at 177° are:

$P_{Vb} = 7.05$ psi

$P_{Ac} = 14.34\ (177 + 460)/(70 + 460) = 17.25$ psi

The internal pressure differential is thus:

$P = 7.05 + 17.24 - 14.7 = 0.59$ psi

3.4.5 Maximum Thermal Stresses

In Section 2.6.3, the critical elements of the cask were evaluated for a pressure differential of 0.5 atm (7.35 psi). The internal pressure due to maximum temperatures, therefore increase stresses predicted in Section 2.6.3 by the factor: 9.59/7.35 = 1.30. The loads and margins of safety thus become:

Item	Load/ Stress	Allowable Load/Stress	Margin
Secondary Lid Stud	816	26270	Large
Primary Lid Binders	2214	45000	Large
Shell	930	38000	Large
Lid	2599	38000	Large

3.4.6 Evaluation of Package Performance for Normal Conditions of Transport

As the result of the above assessment, it is concluded that under normal conditions of transport:

1) There will be no release of radioactive material from the containment vessel;
2) The effectiveness of the packaging will not be substantially reduced;
3) There will be no mixture of gases or vapors in the package which could, through any credible increase in pressure or an explosion, significantly reduce the effectiveness of the package.

3.5 Hypothetical Thermal Accident Evaluation

Not applicable for Type "A" packages.

3.6 Appendix

3.6.1 Thermal Analysis - Normal Conditions of Transport

The controlling assumptions for the two cases analyzed are:

- o Heat - Direct sunlight (summer, latitude 42^0N)
  Ambient S.R. @ 130^0F
  Internal Heat Load = 0 & 400 watts

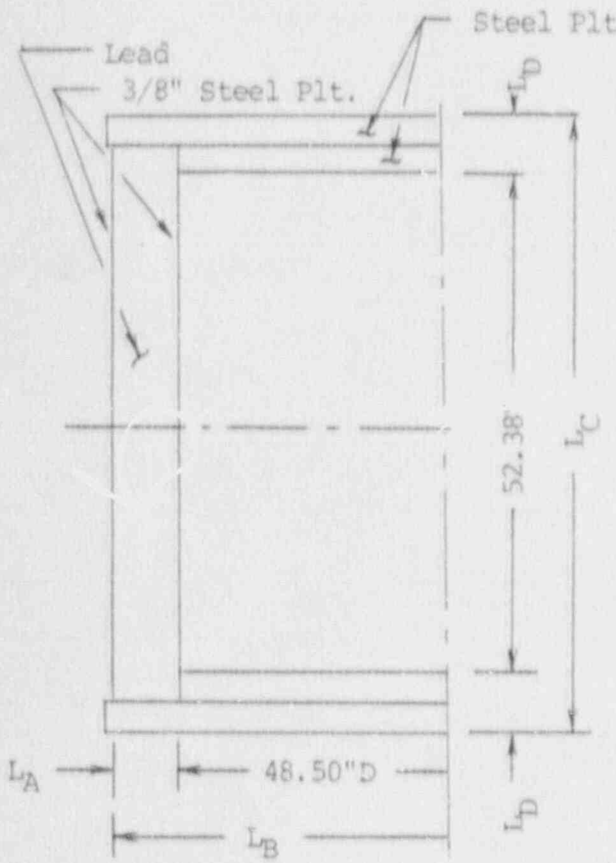
o <u>Cold</u> - Shade

Ambient Air @ -40°F

Internal Heat = 0 & 400 watts

Both analyses employ steady state (equilibrium) solutions and "peak" conditions thus assuring conservative predictions.

<u>Geometry Assumptions (Simplified for Analysis)</u>



Cask Version	L_A (in)	L_B (in)	L_C (in)	L_D (in)
50-1.5	1 1/4	52 1/2	56 7/8	2 1/4
50-2.5	2 1/4	54 1/2	60 3/8	4
50-3.0	2 3/4	55 /12	61 3/8	4 1/2
50-4.0	3 3/4	57 1/2	64 3/8	6

<u>External Convective & Radiant Heat Transfer</u>

The cask looses heat to the surrounding air via convection and radiation heat transfer. Heat is assumed to be lost only via the top and sides; adiabatic assumptions are imposed upon the base.

Convection

$q = hA\ (T_{ext} - T_{00})$; $\Delta T = T_{ext} - T_{00}$

For "free"convection McAddys gives: [L = FT]

$h = .29\ \left(\frac{\Delta T}{L}\right)^{1/4}$; vert. cylinders

$= .27\ \left(\frac{\Delta T}{L}\right)^{1/4}$, horiz. plates (up-heated)

Thus:

$$q = h_S A_S\ \Delta T + h_T A_T\ \Delta T = (h_S A_S + h_T A_T)\ \Delta T$$

$$= \underbrace{\left[(.29)\left(\frac{\Delta T}{L_C}\right)^{1/4} \cdot A_S + (.27)\left(\frac{\Delta T}{L_B}\right)^{1/4} \cdot A_T\right]}_{\overline{hA}} \cdot \Delta T$$

Evaluating the linearized term $\overline{hA}$ @ $T_{ext} = 170^0$ gives:

Cask Version	L_C (ft)	L_B (ft)	$A_S^{(1)}$ (ft^2)	$A_T^{(2)}$ (ft^2)	$(\overline{hA})^{(3)}$ $(BTU/HR\text{-}^0F)$	$A_\Sigma^{(4)}$ (ft^{-2})
50-1.5	4.74	4.38	65.14	15.03	39.26	80.18
50-2.5	5.0[illegible]	4.54	71.79	16.20	42.49	87.99
50-3.0	5.11	4.63	74.31	16.80	43.82	91.11
50-4.0	5.36	4.79	80.76	18.03	46.98	98.79

Notes: (1) $A_S = \pi D = \pi \cdot L_B \cdot L_C\ /144$;

(2) $A_T = \frac{\pi D^2}{4} = \frac{\pi}{4} \cdot L_B^2\ /\ 144$

(3) Δ_T other temps: $(\overline{hA}) \approx (\overline{hA}) \cdot (\Delta T\ /40)^{1/4}$

(4) $A_\Sigma = A_S + A_T$

Radiation

$q = \sigma A_\Sigma \epsilon (T_{ext}^4 - T_{00}^4) = K\ (T_{ext}^4 - T_{00}^4)$

$\sigma = .1714 \times 10^{-8}$

$\epsilon = .8$

Thus:

Version	A_Σ	K
50-1.5	80.18	109.94×10^{-9}
50-2.5	87.99	120.65×10^{-9}
50-3.0	91.11	124.93×10^{-9}
50-4.0	98.79	135.48×10^{-9}

Solar Heat Load

Loads are estimated by use of Shapperts' normal incident solar energy curve given in Figure 5.3, ORNL-NSIC-68, Cask Designers Guide. [Assumptions include: clear sky, mid-summer, latitude 42^0N].

The total solar heat load absorbed by a body is:

$Q = A_n \cdot q_{si} \cdot \alpha$; A_n = normal x-section area

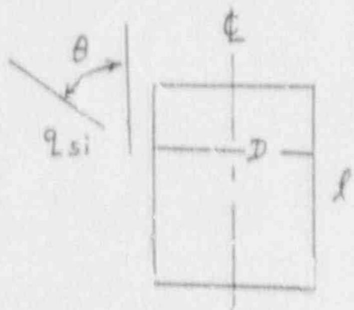
q_{si} = solar intensity (normal)

α = surface absorbtivity ($\approx$ .8)

For a right circular cylinder:

$$A_N = A_T \cos\theta + A_S \sin\theta$$

$$A_T = \frac{\pi D^2}{4} \; ; \; A_S = D\,\ell$$



Thus:

$$\frac{Q}{A_\Sigma} = \frac{q_{si}\,\alpha}{A_\Sigma}\left(A_T \cos\theta + A_S \sin\theta\right), \; (\mathrm{BTU/HR \cdot FT^2})$$

Evaluating at various times (solar angles) for the 4 cask versions:

Solar Time	Elev. Angle θ (o)	Solar Intensity q_{si} (BTU/HR·FT^2)	Solar Load vs. Cask Version (BTU/HR·FT^2) (Q/A_Σ) 50-1.5	50-2.5	50-3.0	50-4.0
4:30AM	90	0.	0.			
5:00	84	100.	22.2			
5:30	78	150.	35.1			
6:00	72	180.	43.8			
6:30	[illegible]	210.	52.5			
7:00	60	225.	57.2			
7:30	54	238.	60.9			
8:00	48	250.	63.6			
8:30	42	250.	65.0	64.6	64.[illegible]	64.4
9:00	36	270.	65.6	65.1	65.2	64.9
9:30	30	275.	64.2	63.6	63.7	63.4
10:00	24	280.	61.9			
10:30	18	285.	58.9			
11:00	2	290	55.0			
11:30		293	50.0			
12N		295	44.2			
(r_2)		A_T:	15.03	16.20	16.8[illegible]	18.03
(r_3)		A_S:	20.76	22.84	23.66	25.67
(r_1)		A_Σ:	80.18	87.99	91.11	[illegible]8.79

Steady State Solution

The steady state (equilibrium) solution is cast in a form suitable for solution using Newton's method. Specifically:

$$F(T_{ext}) = (q_{in} - q_{out}) \rightarrow 0; \ A_s \ T \rightarrow T_{ext}$$

Where:

$$q_{in} = q_{solar} + q_{internal} = (Q/A) \cdot A_\Sigma + 400 \text{ watt}$$

$$q_{out} = q_{radiation} + q_{convection} = K(T_{ext}^4 - T_{oo}^4) + (\overline{hA})(T_{ext})$$

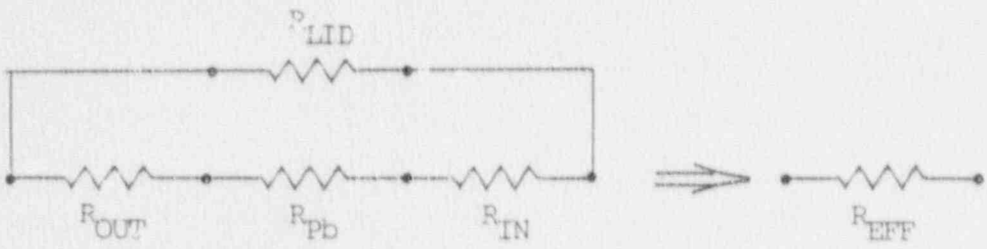
$$F(T) = 1 - \frac{K}{q_{in}}(T^4 - T_{00}^4) - \frac{(\overline{hA})}{q_{in}}(T - T_{00}) \qquad ; \qquad T = T_{ext}$$

$$= \underbrace{\left[1 + \frac{K}{q_{in}} T_{00}^4 + \frac{(\overline{hA})}{q_{in}} T_{00}\right]}_{r_5} - \underbrace{\frac{K}{q_{in}}}_{r_6} \cdot T^4 - \underbrace{\frac{(\overline{hA})}{q_{in}}}_{r_7} \cdot T$$

Several Solutions are Summarized:

Case	Cask Version	q_{in} (BTU/HR)	K	$(\overline{hA})$ @$\Delta T=40^0$	$(\overline{hA})$ @T_{ext}	T_{ext} (^0F)
Summer Sun	50-1.5	6625	109.94×10^{-9}	39.26	40.78	176.6
$T_{00}=130^0F$	50-2.5	7093	120.65×10^{-9}	42.49	43.93	175.7
Out Heat=400W	50-3.0	7305	124.93×10^{-9}	43.82	45.27	175.6
	50-4.0	7770	135.46×10^{-9}	46.98	48.38	175.0
Summer Sun	50-1.5	5260	Same	Same	38.75	168.1
$T_{00}=130^0F$	50-2.5	5728			41.94	168.0
No Int Heat	50-3.0	5940			43.26	168.1
	50-4.0	6411			46.43	168.0
Winter Shade	50-1.5	1365	Same	Same	33.05	-19.9
$T_{00}=-40^0F$	50-2.5	1365			35.03	-21.3
Int Heat=400W	50-3.0	1365			35.96	-21.9
	50-4.0	1365			37.85	-23.0
Winter Shade						
$T_{00}=-40^0F$	All	-0-	---	---	---	-40^0F
No Int Heat						

<u>Conductive Heat Transfer Evaluation</u>



$$R_{EFF} = \frac{R_{LID} \cdot R_{WALL}}{R_{LID} + R_{WALL}} \qquad ; \qquad R_{WALL} = R_{OUT} + R_{Pb} + R_{in}$$

Steel

$R_{LID} = \frac{t}{KA}$; $k = 25$ BTU/HR·FT·°F
; $A = \frac{\pi}{4}(48\ 1/2)^2/144 = 12.83$ FT^2
; $t = L_D^*/12$

$R_{IN} = \frac{t}{KA} = \frac{(3/8)/12}{(25)[\pi(48\ 1/2)(52\ 3/8)/(2)(144)]}$

$R_{OUT} = \frac{t}{KA} = \frac{(3/8)/12}{(25)[\pi(L_B^*)(52\ 3/8)/(2)(144)]}$

Lead

$R_{Pb} = \frac{\ln(r_o/r_i)}{2\pi k \ell}$; $r_o = L_B^*/2$; $r_i = (48\ 1/2)/2$
$K = 18.6$; $\ell = 52\ 3/8\ /\ 12$

-Half Model-
Conductive resistance (°F-HR/BTU)

Cask Version	R_{LID}	R_{IN}	R_{OUT}	R_{Pb}	R_{EFF}	ΔT^{**} Payload
50-1.5	581.59×10^{-6}	45.111×10^{-6}	41.674×10^{-6}	155.37×10^{-6}	171.23×10^{-6}	0.12°
50-2.5	1.0393×10^{-3}	"	40.145×10^{-6}	228.67×10^{-6}	241.10×10^{-6}	0.17°
50-3.0	1.1692×10^{-3}	"	39.422×10^{-6}	264.31×10^{-6}	268.68×10^{-6}	0.19°
50-4.0	1.5589×10^{-3}	"	38.051×10^{-6}	333.12×10^{-6}	328.92×10^{-6}	0.23°

* Dimension shown on prev. page.

** = ΔT (°F) above container surface @ 400 watt payload

$\Delta T = q R_{EFF}$; $q = \frac{(400)}{2}(3.41) = 683$ BTU/HR

4.0 CONTAINMENT

This chapter identifies the package containment for the normal conditions of transport.

4.1 Containment Boundary

4.1.1 Containment Vessel

The containment vessel claimed for the NuPac 50 package is the shielded transportation cask as described in Section 1.2 and the general arrangement drawing in Appendix 2.10.1.

4.1.2 Containment Penetration

There are no penetrations into the containment vessel.

4.1.3 Seals and Welds

A silicone seal is placed between the primary lid to body interface. It is described in Section 1.2.1.3, above. All joints are arc welded.

4.1.4 Closure

The closure devices for the lid consist of 8-1 inch diameter high strength ratchet binders as described in Section 1.2, above.

4.2 Requirements for Normal Conditions of Transport

The following is an assessment of the package containment under normal conditions of transport as a result of the analysis performed in Sections 2.0 and 3.0, above. In summary, the containment vessel was not affected by these tests. (Refer to Section 2.6, above.)

4.2.1 Release of Radioactive Material

There was no release of radioactive material from the containment vessel.

4.2.2 Pressurization of Containment Vessel

Normal conditions of transport will have no effect on pressurizing the containment vessel.

4.2.3 Coolant Contamination

This section is not applicable since there are no coolants involved.

4.2.4 Coolant Loss

Not applicable.

4.3 Containment Requirements for the Hypothetical Accident Conditions

Not applicable for Type "A" packages.

5.0 SHIELDING EVALUATION

5.1 Discussion and Results

The NuPac 50 packaging consists of a lead and steel containment vessel which provides the necessary shielding for the various radioactive materials to be shipped within the package. (Refer to Section 1.2.3 for packaging contents.) Tests and analysis performed under Sections 2.0 and 3.0 above have demonstrated the ability of the containment vessel to maintain its shielding integrity under normal conditions of transport. Prior to each shipment, radiation readings will be taken based on individual loadings to assure compliance with applicable regulations.

6.0 CRITICALITY EVALUATION

Not applicable for the NuPac 50 packaging.

7.0 OPERATING PROCEDURES

This chapter generally describes the procedures to be used for loading and unloading the NuPac 50 packaging.

7.1 Procedures for Loading the Package

1) Loosen and remove the ratchet binders which secure the primary lid.

2) Remove the lid by attaching suitable hooks to the lid lifting lugs. Care should be taken during the operation so as not to damage the lid to body interface seal while setting the lid down.

3) Inspect the inside of the shielded cask to assure there are no loose articles within the packaging.

4) Place the liners or other packaging into the cask. Contents should fit snugly within the cask body using shoring or bracing when required.

5) Inspect and clean seals attached to underside of lid. Brush off and clean thoroughly the seal to body interface. Replace seals upon signs of wear and deterioration. Replace the lid and secure it to the body by fastening the eight ratchet binders.

6) Inspect the package for proper labeling necessary to meet all applicable regulations.

7) Install an approved security seal.

8) Using suitable material handling equipment, transfer the package to the transport vehicle.

9) Secure package to the transport vehicle using the appropriate tie down devices.

7.2 Procedures for Unloading the Package

1) Move the unopened package to the appropriate unloading area. Place it in a suitable unloading attitude.

2) Perform an external inspection of the unopened package. Record any significant or potentially significant observations.

3) Remove the security seal.

4) Repeat steps 1 and 2 in Section 6.1, above, for removing the lid.

5) Remove the contents.

8.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 Acceptance Tests

The NuPac 50 packaging shall be inspected and released for use by a responsible operating personnel prior to loading. The following items will be included in such inspections:

1) The entire package, both inside and out, shall be visually inspected and assured that it has not been significantly damaged (no cracks, puncture, holes, nor broken welds).

2) The exterior stencils must be in place and legible.

3) Bolts and gaskets must be present and free of defects.

4) Follow all applicable operating procedures and complete all necessary records for the handling and operation of the NuPac 50 packaging.

8.2 Maintenance Program

A good sound industrial maintenance program should be followed to assure the integrity of the NuPac 50 packaging. Components such as gaskets, ratchet binders, bolts and other equipment necessary for the safe and easy operation of the packaging should be given regular inspection and repaired or replaced as necessary.

9.0 QUALITY ASSURANCE

NuPac's Quality Assurance Program used for the design, fabrication, assembly, testing, use and maintenance of the NuPac 50 packaging is designed and administered to meet the 18 criteria of 10 CFR 71, Appendix E. A description of this program has been submitted to the NRC under NuPac letter No. QA-78-1, Rev. 3, dated September 25, 1990.

9.1 Appendix

9.1.1 Quality Assurance Program Approval

NRC FORM 311

U. S. NUCLEAR REGULATORY COMMISSION

QUALITY ASSURANCE PROGRAM APPROVAL
FOR RADIOACTIVE MATERIAL PACKAGES

1. APPROVAL NUMBER: 0192

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: Pacific Nuclear Systems, Inc.

STREET ADDRESS: 1010 South 336th Street

CITY: Federal Way

STATE: WA

ZIP CODE: 98003

3. EXPIRATION DATE: September 30, 1995

4. DOCKET NUMBER: 71-0192

5. QUALITY ASSURANCE PROGRAM APPLICATION DATE(S): September 13 and 25, 1990

6. CONDITIONS

Activities conducted under applicable criteria of Subpart H of 10 CFR Part 71 to be executed in accordance with the QA Program for Radioactive Material Shipping Packages, letter No. QA-78-1, with regard to transportation packages.

UNITED STATES NUCLEAR REGULATORY COMMISSION

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Charles E. MacDonald

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

DATE: SEP 26 1990

RECEIVED OCT 1 1990

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

SEP 25 1990

SGTB:LLG
71-0192

Pacific Nuclear Systems, Inc.
ATTN: Mr. R. Howard Smith, Director
Corporate Quality Assurance
1010 South 336th Street
Federal Way, WA 98003

Dear Mr. Smith:

Enclosed is Quality Assurance (QA) Program Approval for Radioactive Material Packages No. 0192, Revision No. 3.

Please note the conditions in the approval.

Sincerely,

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

Enclosure:
As stated

9.1.2 Statement of Policy

STATEMENT OF POLICY AND AUTHORITY

PACIFIC NUCLEAR SYSTEMS

The Pacific Nuclear Systems, Inc. (PNSI) Quality Assurance Manual states the policies, assigns the responsibilities, and describes and summarizes the procedures governing the design, procurement, construction, testing and operations of safety-related components, systems and structures for nuclear applications as defined by contract or licensing/certification regulations. The PNSI Quality Assurance Program is also applicable to energy, research and development and military projects when regulatory or contractually specified.

Compliance with the PNSI Quality Assurance Program as described in this Quality Assurance Manual is mandatory for all PNSI subsidiaries and personnel whose activities affect quality.

The policies herein implement the requirements of Title 10, Code of Federal Regulations, Part 50, Appendix B; Part 71, Subpart H, and Part 72, Subpart G as well as additional requirements of ANSI, ASME, Regulatory Guides, and Military Standards as applied to organizations performing design, procurement, construction, testing and operational activities for nuclear applications to the extent specified by contract or licensing/certification regulations.

The President of PNSI retains the responsibility for implementation of all activities performed in accordance with this Manual except those specifically assigned to the Director, Corporate Quality Assurance.

The Subsidiary Quality Assurance Managers are assigned responsibility for QA activities of the PNSI Quality Assurance Program at their location(s) and are given authority for assuring implementation of those activities.

The Director, Corporate Quality Assurance, reporting to the President, is given full responsibility for maintaining this Manual and for assuring uniform implementation of the quality assurance program throughout PNSI and its subsidiaries. He has the authority to initiate management action to limit further processing on items of indeterminate quality, to initiate corporate management action to resolve any deficiencies and to assure that satisfactory resolutions have been achieved prior to authorizing further processing.

Attainment of quality objectives is the responsibility of all personnel at PNSI.

By: ______________________
Albert J. Baciocco, Jr.
President

Date: 14 January 1991

9.1.3 Quality Assurance Manual

SUMMARY OF REVISION

PACIFIC NUCLEAR SYSTEMS, INC. QUALITY ASSURANCE MANUAL

EDITION 2, REVISION 2

As a holder of a controlled copy of a Pacific Nuclear Systems, Inc. (PNSI) Quality Assurance Manual, attached is Revision 2 of Edition 2 of that document. This revision was developed to resolve some comments received from our customers and the Nuclear Regulatory Commission (NRC) as well as some internal comments. None of these comments is considered to be significant. Revisions are as follows:

- Changed the generic title of the various PNSI companies from "divisions" to "subsidiaries" to comply with advice from our legal counsel
- Revised the organization description and charts to reflect our current organization
- Clarified the actual location of the various NUTECH offices
- Changed a number of definitions in the glossary for compatibility with ANSI/ASME NQA-1
- Added some additional qualification requirements for PNSI QA Managers to address an NRC comment
- Changed "safety-related" to "quality-related" in one place for consistency with other references in the manual
- Added the 1975 version of SNT-TC-1A to our list of applicable criteria documents to address an NRC comment
- Added a commitment for a periodic review of the manual by the Director, Corporate QA to assure its continued consistency with the appropriate QA criteria to address an NRC comment
- Clarified who has responsibility for Quality Procedure approval and distribution
- Clarified how design reviewer independence is assured to address an NRC comment
- Clarified that PNSI suppliers may be approved based on an ASME Quality System Certificate to correct an administrative error
- Clarified when the Project Manager is responsible for assuring that supplier generated documentation is provided to PNSI to address an NRC comment

- Changed responsibility for inspection records maintenance from QA to projects to address an NRC comment
- Added requirement for the Project Manager to approve special process procedures for use on his project to address an NRC comment
- Changed nondestructive examination/inspection requirement so that only Level II or III personnel can evaluate inspection/examination results to address an NRC comment
- Added "preservation" to the scope of "Handling, Storage and Shipping" controls to correct an administrative error
- Clarified when nonconformance dispositions are to be provided to PNSI customers to address an NRC comment
- Discussed how the Material Review Board and the Project Engineer interact for developing nonconformance dispositions to address an NRC comment
- Included examples of the type of programmatic QA records which are maintained by the QA Manager to address an NRC comment.

PACIFIC NUCLEAR SYSTEMS	QUALITY ASSURANCE MANUAL	SECTION i REVISION 1 PAGE 1 OF 1
TITLE **TABLE OF CONTENTS**	DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91 PRESIDENT DATE 14 Jan 1991	

EDITION NUMBER 2

APPROVAL - The act of endorsing or authorizing an action, document or related activity. As used in this manual approval requires a signature and date.

AS-BUILT DATA - Data recorded into documents that describe the conditions actually acheived in a completed product.

AUDIT - A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents, and the effectivess of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

CERTIFICATION - The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with specified requirements.

CONTROLLED DOCUMENT - A document that has been reviewed for adequacy, approved for release by authorized personnel, and distributed to, and used at, the location where the prescribed activity is performed. Controlled documents are typically finalized technical documents, procedures or instructions.

CRITERIA - Technical requirements describing performance objectives, operating conditions and requirements, limitations regarding materials, compliance with codes or standards and any technical requirements for design, fabrication, installation, testing, operation, maintenance or quality assurance.

RECORDS - Documentary evidence of the quality of items and activities affecting quality. For purposes of this manual, a document is considered to be a record only after the document is final.

REPAIR - The process of restoring a non-conforming characteristic to a condition such that the capability of an item to function reliably and safely is unimpaired, even though that item still does not conform to the original requirement.

REVIEW - A technical assessment that a document or activity complies with the appropriate requirements. As used in this manual, review requires a signature and date.

REWORK - The process by which an item is made to conform to original requirements by completion or correction.

SMALL PROJECT - A project with one technical discipline managed and executed by one PNSI office.

SUBSIDIARY - A wholly owned operating unit or other identifiable segment of the company's business operations, having its own management hierarchy reporting to corporate management.

SURVEILLANCE - The act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

SPECIFICATION - A concise statement of the requirements a product, material or process must satisfy in order to be acceptable.

TITLE: ORGANIZATION

DIRECTOR, CORPORATE QUALITY ASSURANCE — DATE 1-14-91

PRESIDENT — DATE 14 Jan 1991

1.0 SCOPE

This section identifies the functional organization and assigns the responsibilities to assure effective execution of the PNSI Quality Assurance Program.

1.1 General

Pacific Nuclear Systems, Inc. (PNSI), located in Federal Way, Washington, is a parent company organized to effectively manage its operating subsidiaries. As the parent company, PNSI establishes business and quality assurance policy for each subsidiary, as appropriate. It is intended that the responsible contracted subsidiary utilize the resources of other PNSI subsidiaries when the scope of work requires those resources.

The functional and reporting relationships between PNSI and each subsidiary is shown on Figure 1-1 and is further explained in subsequent sections of this manual. The operating subsidiaries are responsible for proper implementation of the PNSI Quality Assurance Program, as appropriate, within their scope of responsibility. The organizational structure of a typical PNSI subsidiary, regional or branch office is shown in Figures 1-2 and 1-3. It is recognized that changes in the organizational structure, or newly created positions with varying responsibilities, may occur within a PNSI operating subsidiary.

1.2 **Pacific Nuclear Systems, Inc. (PNSI)**

1.2.1 President

The President of Pacific Nuclear Systems, Inc. is responsible for the following activities with regard to the PNSI QA Program:

a. Issuing the Corporate Statement of Policy and Authority which requires the use of the PNSI QA Manual by the individual subsidiaries as determined by contract.

b. Maintaining final authority for the implementation of the requirements of the Quality Assurance Program except for those functions specifically assigned to the Director, Corporate Quality Assurance.

c. Approving the PNSI Quality Assurance Manual.

1.2.2 Director, Corporate Quality Assurance

The Director, Corporate Quality Assurance shall have demonstrated management capabilities and shall meet the qualification requirements of ANSI N45.2.23 and NQA-1, Supplement 2S-3 for Lead Auditor with the exception of "Audit Participation" and "Examination Requirements".

The Director, Corporate Quality Assurance is responsible to the President for defining corporate quality assurance policy in the PNSI Quality Assurance Manual consistent with applicable codes, standards, and regulatory criteria. He has the authority and organizational freedom to perform the following activities:

1.3 **PNSI Subsidiaries**

The Corporation (PNSI) is organized into several operating subsidiaries to address various needs in the nuclear industry.

PNSI, operating under the requirements of this Quality Assurance Program Manual includes:

SUBSIDIARY	DESIGNATION
Pacific Nuclear Systems, Inc.	(PNSI)
ALARON Corporation	(ALARON)
Nuclear Packaging, Inc.	(NUPAC)
NuPac Services, Inc.	(NPSD)
NUTECH Engineers, Inc.	(NUTECH)
Pacific Nuclear Fuel Services, Inc.	(PNFS)
PN Services, Inc.	(CCD)

Each subsidiary of PNSI is comprised of several distinct functions required to effectively manage work activities at that location.

1.3.1 Operations

Each PNSI subsidiary is operated under the direction of a Subsidiary Executive Director (President/Vice President/General Manager). This Subsidiary Executive Director is responsible to the President of PNSI for the proper implementation of the PNSI QA Program within his subsidiary.

PNSI subsidiary projects are managed by an organizational structure uniquely suited to the nature, scope and complexity of project work activities.

1.3.1.3 Manager of Licensing/Analysis

When a PNSI subsidiary has responsibility for licensed products, a Manager of Licensing/Analysis shall exist to manage the licensing function. The Manager of Licensing/Analysis is also responsible for reviewing reports of nonconformances to assess the nonconformances impact on the licensed product. He initiates required actions to reconcile those issues deemed to be significant for licensing considerations. The Manager of Licensing/Analysis shall indicate by his signature on the report of nonconformance that all licensing (including Safety Analysis Reports) considerations have been reviewed and no significant impact exists or if reconciliation is required, a plan has been put in place to reconcile the changes.

1.3.1.4 Project Engineer

Except for simple procurement projects, each project is assigned a Project Engineer(s) who reports to the Project Manager. The Project Engineer is responsible for ensuring that project related activities under his cognizance are carried out in accordance with the project criteria received from the Project Manager. The Project Manager shall perform these activities for simple procurement projects.

1.3.2 Regional and Branch Offices

When PNSI subsidiaries establish regional and branch offices remote from their central location, these remote locations shall function in full compliance with this Quality Assurance Program. Regional and branch offices are managed by office General Managers. A Quality their respective subsidiary, regional or branch office. "Monitoring" includes performing audits, surveillance, identifying and reporting noncompliances, and verifying implementation of corrective actions.

The Quality Assurance Manager shall meet the qualification requirements of ANSI N45.2.23 and NQA-1, Supplement 2S-3 for Lead Auditor within ninety (90) days of assuming the position. In addition, Quality Assurance Managers shall possess either:

a. A Bachelor's Degree in a specialty which is applicable to the performance of quality assurance activities and three (3) years of direct quality assurance experience, or;

b. Ten (10) years of experience in progressively responsible quality assurance positions.

The Quality Assurance Manager has the authority and organizational freedom to conduct the following activities:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions and verify implementation of solutions.

c. Control or stop further processing, delivery, or installation of a nonconforming item, deficiency, or unsatisfactory condition until proper dispositioning has occurred. The stop-work process shall be implemented when the QA Manager, Field QA Supervisor or Director, Corporate Quality Assurance determines that a significant condition adverse to

PACIFIC NUCLEAR SYSTEMS	QUALITY ASSURANCE MANUAL	SECTION 21 REVISION 2 PAGE 1 OF 4

TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE / DATE	PRESIDENT / DATE
GLOSSARY	[signature] 1-14-91	[signature] 14 Jan 1991

APPROVAL - The act of endorsing or authorizing an action, document or related activity. As used in this manual approval requires a signature and date.

AS-BUILT DATA - Data recorded into documents that describe the conditions actually acheived in a completed product.

AUDIT - A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents, and the effectivess of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

CERTIFICATION - The act of determining, verifying, and attesting in writing to the qualifications of personnel, processes, procedures, or items in accordance with specified requirements.

CONTROLLED DOCUMENT - A document that has been reviewed for adequacy, approved for release by authorized personnel, and distributed to, and used at, the location where the prescribed activity is performed. Controlled documents are typically finalized technical documents, procedures or instructions.

CRITERIA - Technical requirements describing performance objectives, operating conditions and requirements, limitations regarding materials, compliance with codes or standards and any technical requirements for design, fabrication, installation testing, operation, maintenance or quality assurance.

EXAMINATION - An element of inspection consisting of investigation of materials, components, supplies or services to determine conformance to specified requirements that can be determined by such investigation. Examination is usually nondestructive and includes physical manipulation, gauging and measuring.

INSPECTION - Examination or measurement to verify whether an item or activity conforms to specified requirements.

ITEM - A broadly used term describing an appurtenance, assembly, component, equipment, material, module, part, structure, subassembly, subsystem, system or unit.

NON-CONFORMANCE - A deficiency in the characteristics, documentation or procedure which renders the quality of an item or activity unacceptable or indeterminate.

PROCUREMENT DOCUMENTS - Purchase requisitions, purchase orders, drawings, contracts, specifications or instructions used to define requirements for purchase.

QUALITY ADMINISTRATION - Coordination of the quality-related activities of personnel and determination that such activities are performed in the prescribed manner.

QUALITY ASSURANCE - The planned and systematic actions necessary to provide adequate confidence that a material, component, system or service meets the established requirements. Quality assurance includes quality administration and quality control.

QUALITY CONTROL - Those quality assurance actions performed to measure and control the characteristics of an or process to established requirements.

RECEIVING - Taking delivery of an item at a designated location.

RECORDS - Documentary evidence of the quality of items and activities affecting quality. For purposes of this manual, a document is considered to be a record only after the document is final.

REPAIR - The process of restoring a non-conforming characteristic to a condition such that the capability of an item to function reliably and safely is unimpaired, even though that item still does not conform to the original requirement.

REVIEW - A technical assessment that a document or activity complies with the appropriate requirements. As used in this manual, review requires a signature and date.

REWORK - The process by which an item is made to conform to original requirements by completion or correction.

SMALL PROJECT - A project with one technical discipline managed and executed by one PNSI office.

SUBSIDIARY - A wholly owned operating unit or other identifiable segment of the company's business operations, having its own management hierarchy reporting to corporate management.

SURVEILLANCE - The act of monitoring or observing to verify whether an item or activity conforms to specified requirements.

SPECIFICATION - A concise statement of the requirements a product, material or process must satisfy in order to be acceptable.

TECHNICAL DOCUMENTS - Documents that translate technical requirements into reports, calculations, drawings, specifications, instructions and procedures necessary for procurements, fabrication, installation, testing, operation and maintenance.

USE-AS-IS or ACCEPT-AS-IS - A disposition which may be imposed upon a non-conforming item, when it is established that the discrepancy will not adversely affect the item's performance or interfaces to it.

A use-as-is or accept-as-is disposition must provide justification that indicates the item under consideration will continue to meet all engineering and functional requirements, including performance, maintainability, fit and safety.

TITLE

ORGANIZATION

DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91

PRESIDENT DATE 14 Jan 1991

1.0 SCOPE

This section identifies the functional organization and assigns the responsibilities to assure effective execution of the PNSI Quality Assurance Program.

1.1 General

Pacific Nuclear Systems, Inc. (PNSI), located in Federal Way, Washington, is a parent company organized to effectively manage its operating subsidiaries. As the parent company, PNSI establishes business and quality assurance policy for each subsidiary, as appropriate. It is intended that the responsible contracted subsidiary utilize the resources of other PNSI subsidiaries when the scope of work requires those resources.

The functional and reporting relationships between PNSI and each subsidiary is shown on Figure 1-1 and is further explained in subsequent sections of this manual. The operating subsidiaries are responsible for proper implementation of the PNSI Quality Assurance Program, as appropriate, within their scope of responsibility. The organizational structure of a typical PNSI subsidiary, regional or branch office is shown in Figures 1-2 and 1-3. It is recognized that changes in the organizational structure, or newly created positions with varying responsibilities, may occur within a PNSI operating subsidiary.

However, prescribed duties, as defined in this Manual and related implementing procedures, are specifically designated to certain individuals. Therefore, in order to comply with the requirements set forth herein, it is incumbent upon management to assign the appropriate responsibilities to those individuals assuming newly created or revised functions. The project planning document (see QA Manual Section 2.0) assigns these responsibilities.

It is also recognized that situations may arise, particularly with small projects, that require one individual to assume more than one role. For example, Project and Engineering Management may be the same individual. This is permitted by the Quality Assurance Program, provided that an equally qualified individual, other than the originator, performs the reviewing, checking and/or design verifying functions.

The levels of management required to manage a project are dependent upon the scope and complexity of the work. For example, on large multidisciplined projects, a specific Project Manager may be assigned. Smaller projects, however, do not warrant this level of management and several small projects may be efficiently managed by a single individual.

The extent of QA related activities performed at the job site is dependent upon the nature, scope and complexity of the contracted scope of work and will be as defined in the Project Planning Document.

1.2 <u>Pacific Nuclear Systems, Inc. (PNSI)</u>

1.2.1 President

The President of Pacific Nuclear Systems, Inc. is responsible for the following activities with regard to the PNSI QA Program:

a. Issuing the Corporate Statement of Policy and Authority which requires the use of the PNSI QA Manual by the individual subsidiaries as determined by contract.

b. Maintaining final authority for the implementation of the requirements of the Quality Assurance Program except for those functions specifically assigned to the Director, Corporate Quality Assurance.

c. Approving the PNSI Quality Assurance Manual.

1.2.2 Director, Corporate Quality Assurance

The Director, Corporate Quality Assurance shall have demonstrated management capabilities and shall meet the qualification requirements of ANSI N45.2.23 and NQA-1, Supplement 2S-3 for Lead Auditor with the exception of "Audit Participation" and "Examination Requirements".

The Director, Corporate Quality Assurance is responsible to the President for defining corporate quality assurance policy in the PNSI Quality Assurance Manual consistent with applicable codes, standards, and regulatory criteria. He has the authority and organizational freedom to perform the following activities:

a. Identify quality problems.

b. Initiate, recommend or provide solutions, and verify implementation of solutions.

c. Control or stop further processing, delivery, or installation of a nonconforming item, deficiency, or unsatisfactory condition until proper dispositioning has occurred.

d. Maintaining and controlling the PNSI Quality Assurance Manual and Quality Procedures.

e. Reviewing Quality Procedures to assure correct interpretation of the requirements set forth in this manual.

f. Establishment of Corporate Policy for development of qualification and certification programs for personnel required to be certified.

g. Reviewing Corrective Action Reports to determine reportability under the provisions of 10CFR21.

h. Conducting annual Quality Assurance Management Audits of each division to verify implementation of quality assurance responsibilities and to determine the status and effectiveness of the PNSI Quality Assurance Program.

i. Maintaining liaison with regulatory jurisdictional agencies and customers to obtain acceptance of the quality assurance program.

1.3 **PNSI Subsidiaries**

The Corporation (PNSI) is organized into several operating subsidiaries to address various needs in the nuclear industry.

PNSI, operating under the requirements of this Quality Assurance Program Manual includes:

SUBSIDIARY	DESIGNATION
Pacific Nuclear Systems, Inc.	(PNSI)
ALARON Corporation	(ALARON)
Nuclear Packaging, Inc.	(NUPAC)
NuPac Services, Inc.	(NPSD)
NUTECH Engineers, Inc.	(NUTECH)
Pacific Nuclear Fuel Services, Inc.	(PNFS)
PN Services, Inc.	(CCD)

Each subsidiary of PNSI is comprised of several distinct functions required to effectively manage work activities at that location.

1.3.1 Operations

Each PNSI subsidiary is operated under the direction of a Subsidiary Executive Director (President/Vice President/General Manager). This Subsidiary Executive Director is responsible to the President of PNSI for the proper implementation of the PNSI QA Program within his subsidiary.

PNSI subsidiary projects are managed by an organizational structure uniquely suited to the nature, scope and complexity of project work activities.

1.3.1.1 Engineering/Technology Department

The engineering/technology department provides services and qualified personnel to the project teams for accomplishing the required scope of work. Engineering Managers are responsible for the quality of work accomplished in accordance with the requirements of the project.

1.3.1.2 Project Manager

The Project Manager is the primary contact with customers on matters including progress, budgets, schedules, changes and procedures. The Project Manager is responsible for the determination of quality requirements in accordance with contractual and regulatory requirements.

The Project Manager has overall responsibility and authority for the proper definition and execution of work required for the completion of his project in accordance with contractual and regulatory requirements. The Project Manager is responsible for developing a Project Planning Document for projects within the scope of this QA Manual. When required by contract, the Project Manager has the authority to issue a Certificate of Conformance and/or Compliance in conjunction with the QA Manager attesting that the items or services provided comply with contractual requirements.

The Project Manager is also responsible for stopping work on his project when so directed by the Field Quality Assurance Supervisor, Quality Assurance Manager or Director, Corporate Quality Assurance.

1.3.1.3 Manager of Licensing/Analysis

When a PNSI subsidiary has responsibility for licensed products, a Manager of Licensing/Analysis shall exist to manage the licensing function. The Manager of Licensing/Analysis is also responsible for reviewing reports of nonconformances to assess the nonconformances impact on the licensed product. He initiates required actions to reconcile those issues deemed to be significant for licensing considerations. The Manager of Licensing/Analysis shall indicate by his signature on the report of nonconformance that all licensing (including Safety Analysis Reports) considerations have been reviewed and no significant impact exists or if reconciliation is required, a plan has been put in place to reconcile the changes.

1.3.1.4 Project Engineer

Except for simple procurement projects, each project is assigned a Project Engineer(s) who reports to the Project Manager. The Project Engineer is responsible for ensuring that project related activities under his cognizance are carried out in accordance with the project criteria received from the Project Manager. The Project Manager shall perform these activities for simple procurement projects.

1.3.2 Regional and Branch Offices

When PNSI subsidiaries establish regional and branch offices remote from their central location, these remote locations shall function in full compliance with this Quality Assurance Program. Regional and branch offices are managed by office General Managers. A Quality

Assurance Manager is assigned responsibility for Quality Assurance at each regional and branch office. The Quality Assurance Managers report to the Director, Corporate Quality Assurance with a line of communication to the office General Manager. Quality Assurance Managers are responsible for verifying implementation of the PNSI Quality Assurance Program at their respective regional or branch offices.

Regional and Branch Office Locations

NUTECH Engineers, Atlanta (NEA) is located in Roswell, Georgia.

NUTECH Engineers, Washington (NEW) is located in Gaithersburg, Maryland.

NUTECH Engineers, Chicago (NEC) is located in Westmont, Illinois.

NUTECH Engineers, Minneapolis (NEM) is located in Plymouth, Minnesota.

NUTECH Engineers, San Jose (NES) is located in San Jose, California.

NUTECH Engineers, International (NEI) is located in Seoul, Korea.

1.3.3 Quality Assurance Manager

A Quality Assurance Manager is assigned Quality Assurance responsibilities for each subsidiary, regional or branch office. The Quality Assurance Managers are responsible for monitoring the PNSI Quality Assurance Program in their respective subsidiary, regional or branch office. "Monitoring" includes performing audits, surveillance, identifying and reporting noncompliances, and verifying implementation of corrective actions.

The Quality Assurance Manager shall meet the qualification requirements of ANSI N45.2.23 and NQA-1, Supplement 2S-3 for Lead Auditor within ninety (90) days of assuming the position. In addition, Quality Assurance Managers shall possess either:

a. A Bachelor's Degree in a specialty which is applicable to the performance of quality assurance activities and three (3) years of direct quality assurance experience, or;

b. Ten (10) years of experience in progressively responsible quality assurance positions.

The Quality Assurance Manager has the authority and organizational freedom to conduct the following activities:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions and verify implementation of solutions.

c. Control or stop further processing, delivery, or installation of a nonconforming item, deficiency, or unsatisfactory condition until proper dispositioning has occurred. The stop-work process shall be implemented when the QA Manager, Field QA Supervisor or Director, Corporate Quality Assurance determines that a significant condition adverse to quality (reference Section 16.0 of the QA Manual) warrants work stoppage. The Project Manager is notified to stop work by acknowledging a "Stop Work Order" (Exhibit 1-1). The Project Manager is responsible for assuring that the work has been stopped. The Quality Assurance Manager is responsible for verifying that work has been stopped by performing surveillance.

A Corrective Action Report is generated in accordance with Section 16.0 of the QA Manual to document and correct the condition, and to determine the root cause and action to be taken to preclude recurrence.

The Quality Assurance Managers are responsible for verifying implementation of the PNSI Quality Assurance Program for work performed in their respective subsidiary, branch or regional office. In addition, other responsibilities include the following:

a. Reviewing contract-related documents to approve applicable quality assurance requirements.

b. Conducting training and indoctrination in quality assurance program requirements.

c. Interfacing with customers and regulators during audits.

d. Conducting audits of quality-related activities to verify proper implementation of the quality assurance program.

e. Developing, reviewing, and controlling Quality Procedures to implement the requirements of the quality assurance program when those procedures are specific to that location or subsidiary.

f. Reviewing and approving project instructions.

g. Analyzing nonconformance reports to identify adverse quality trends and root causes of nonconformances for management review and assessment.

h. Signing Certificates of Conformance and/or Compliance when those documents are contractually required.

The Quality Assurance Manager receives technical direction and corporate quality assurance policy interpretations from the Director, Corporate Quality Assurance. The Quality Assurance Manager reports the status and adequacy of the quality assurance program at his respective location to the Director, Corporate Quality Assurance through distribution of audit reports, Corrective Action Reports, informal status reports, meetings, and telephone contact.

The Quality Assurance Manager of each PNSI subsidiary, regional or branch office is subject to annual Quality Assurance Management Audits conducted by the Director, Corporate Quality Assurance to verify the status and effectiveness of the quality assurance program at their respective location and to verify implementation of quality assurance responsibilities.

1.3.4 Field Quality Assurance Supervisor

When determined necessary by the QA Manager for protracted field applications of this QA Program, a Field QA Supervisor shall be designated by the QA Manager. The Field QA Supervisor, reporting to the QA Manager, shall exercise QA Manager responsibilities for a specific project when at a field site.

The field Quality Assurance Supervisor shall be trained in the principles and techniques of quality assurance and in the nature of the field work being performed to adequately execute his responsibilities.

The Field Quality Assurance Supervisor has the authority and organizational freedom to conduct the following functions for quality-related activities performed at the field site:

a. Identify quality problems.

b. Initiate, recommend, or provide solutions and verify implementation of solutions.

c. Control or stop further [illegible]ssing, delivery or installation of a nonconfo[illegible] item, deficiency or unsatisfactory condition until proper dispositioning has occurred.

The Field Quality Assurance Supervisor is responsible for performing surveillance on quality-related site activities under PNSI's control, including surveillance of PNSI site subcontractors. In addition, other responsibilities include the following:

a. Reviewing procurement documents for items and services procured at the job site.

b. Conducting training and indoctrination in quality assurance requirements for site personnel.

c. Interfacing with customer and regulatory auditors and other quality assurance personnel during site audits and surveillances.

d. Concurring with dispositions of Nonconformance Reports.

e. Monitoring implementation of PNSI's QA Program at the field site.

The Field Quality Assurance Supervisor reports directly to the Quality Assurance Manager of the applicable subsidiary, regional or branch office as determined by the contract.

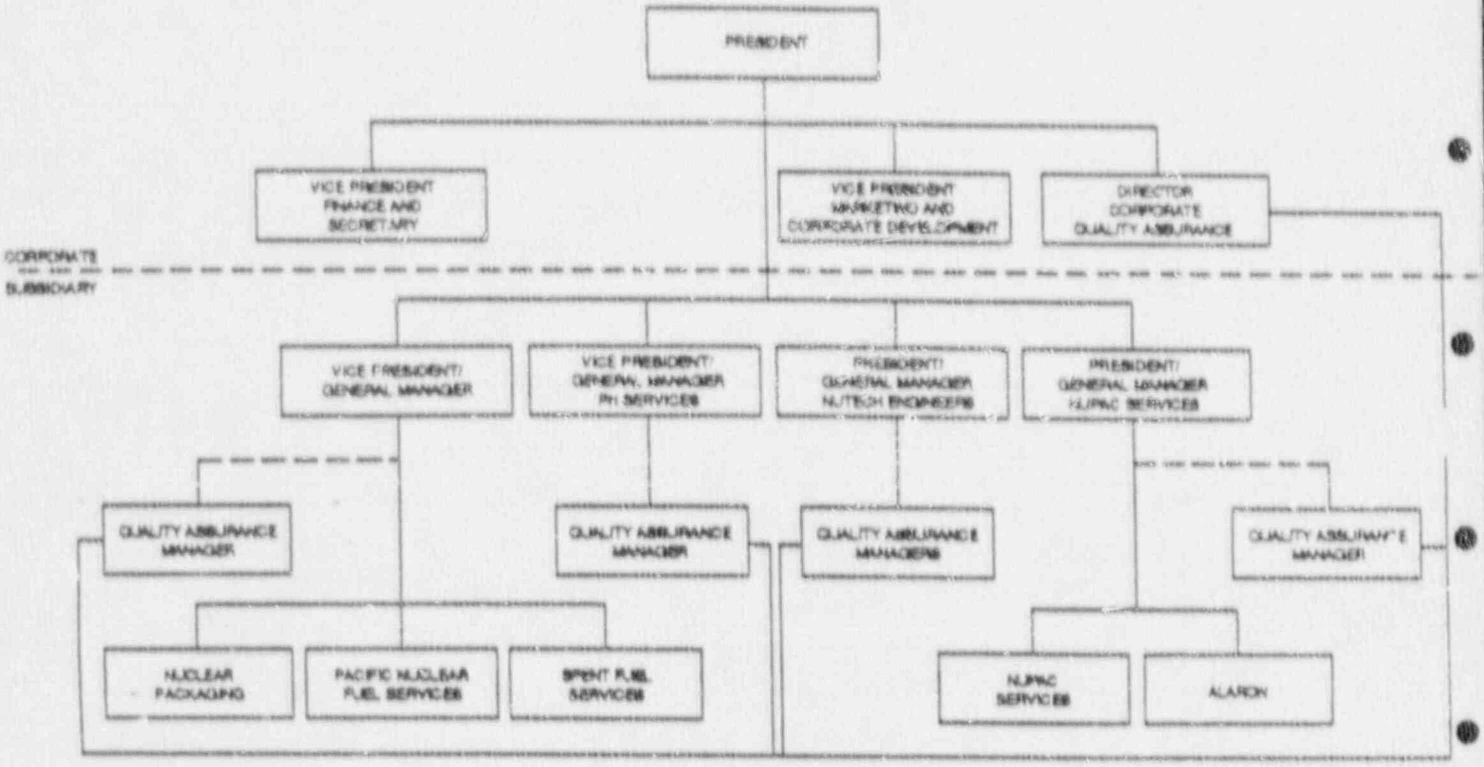
The Field Quality Assurance Supervisor is delegated Quality Assurance Manager responsibilities when the prescribed activity is performed at the field site.

1.4 Disputes Involving Quality

Disagreements involving quality between quality assurance personnel and other PNSI department personnel (engineering, projects, etc.) are resolved by referring the matter upwards through the chain of command of both the quality assurance department and the department involved until the concern has been properly resolved.

Figure 1-1

ORGANIZATION CHART
PACIFIC NUCLEAR SYSTEMS, INC.



NOTES

- SEE FIGURE 1-[illegible] FOR TYPICAL SUBSIDIARY ORGANIZATION (INCLUDING REGIONAL OR BRANCH OFFICES)
- DOTTED LINE DENOTES LINE OF COMMUNICATION

Figure 1-2
FUNCTIONAL ORGANIZATION CHARTS

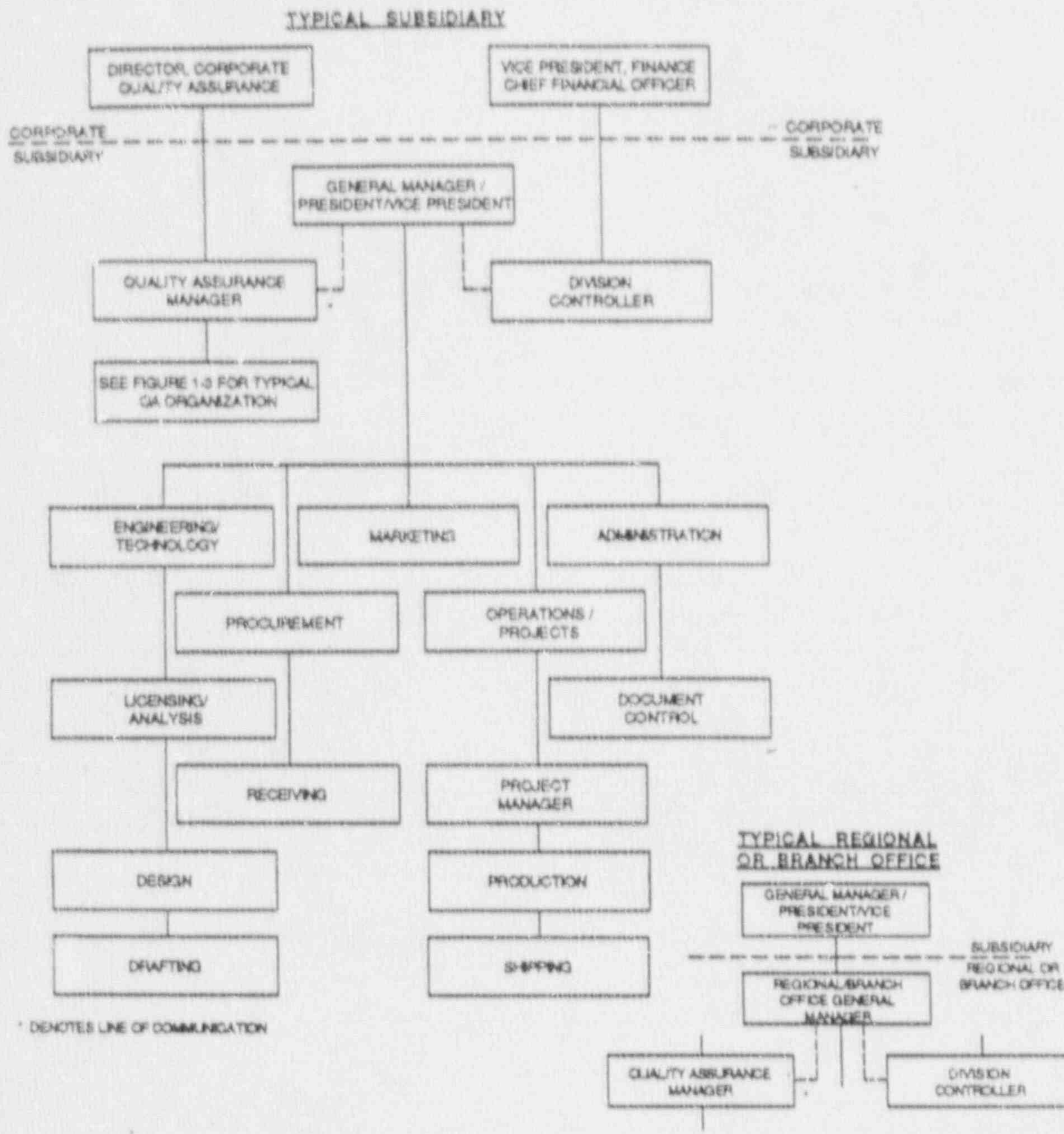
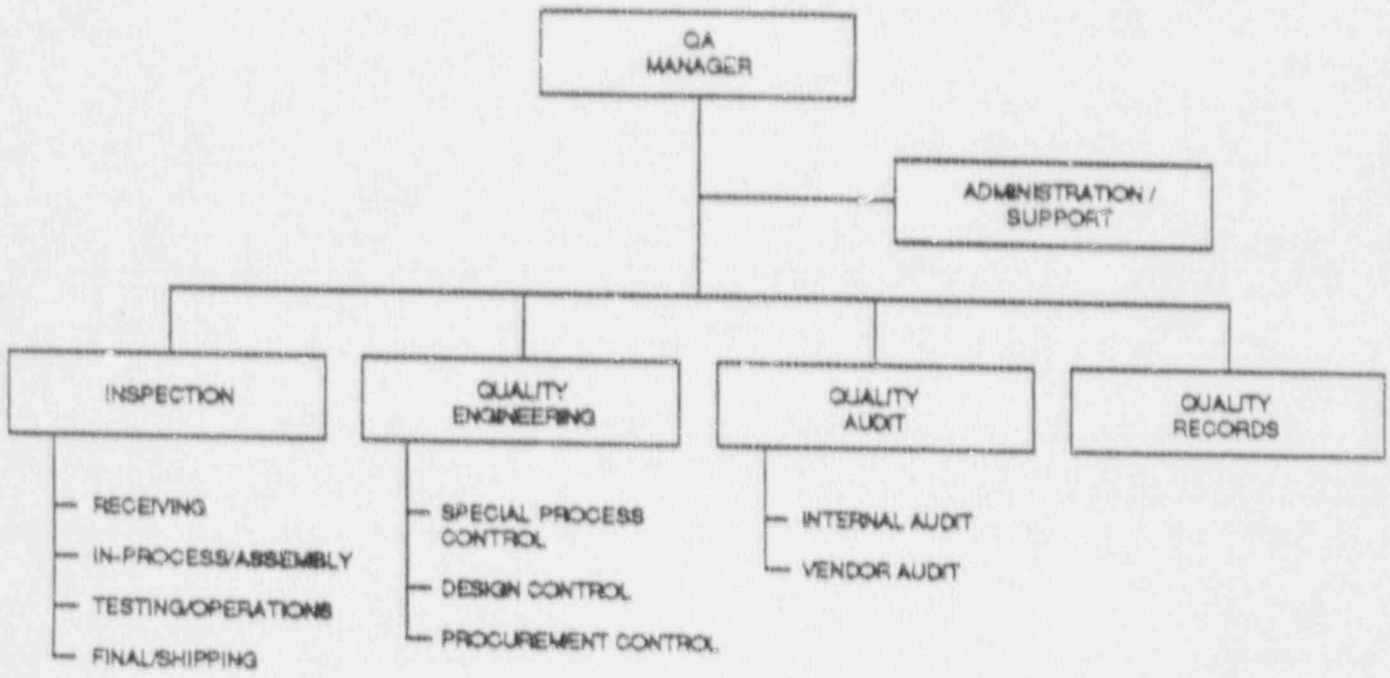


Figure 1-3

TYPICAL ORGANIZATION CHART
QA DEPARTMENT



2.0 SCOPE

The PNSI Quality Assurance Program complies with NRC Regulations, Regulatory Guides, ANSI/ASME Standards, and PNSI Quality Assurance policies as specifically defined herein. The PNSI Quality Assurance Program defines the policies, assigns the responsibilities, and summarizes the procedures governing the design, procurement, construction, testing and operational activities of quality-related components, systems, and structures for nuclear applications. The PNSI Quality Assurance Program is also applicable to energy research and development, military, aeronautical, and space projects to the extent specified by contract.

2.1 General

2.1.1 The PNSI Quality Assurance Program described herein addresses the requirements of the quality assurance criteria documents identified in this section and applies to the design, procurement, construction, testing and operational activities (at PNSI, its subsidiaries and in field locations) affecting the quality of radioactive material transport/storage packages and nuclear power plant structures, systems, and components that prevent or mitigate the consequences of postulated accidents that could cause undue risk to the health and safety of the public. The project team, including personnel of supporting departments whose activities affect quality, shall comply with the provisions of this quality assurance program.

2.1.2 The PNSI Quality Assurance Program conforms to quality assurance criteria documents listed below, including other quality assurance criteria not specifically identified. Applicable quality requirements are specified by the customer contract or appropriate regulatory criteria for licensing projects.

This is not intended to be an all inclusive list of quality assurance programmatic documents applicable to PNSI, but rather a general list of standards for the reviewer to measure the depth and breadth of the PNSI Quality Assurance Program.

a. Title 10, Code of Federal Regulations, Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants".

b. Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material", Subpart H, "Quality Assurance".

c. Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)", Subpart G, "Quality Assurance."

d. ANSI/ASME NQA-1-1986, (including latest ASME Code accepted addenda) "Quality Assurance Program Requirements for Nuclear Power Plants and Fuel Reprocessing Plants."

e. The ASME Boiler and Pressure Vessel Code, Sections III and XI, 1986 Edition.

f. ANSI/ASME N45.2-1977, "Quality Assurance Program Requirements for Nuclear Facilities."

g. ANSI/ASME N45.2.6-1978, "Qualifications of Inspection, Examination, and Testing Personnel for Nuclear Power Plants."

h. ANSI/ASME N45.2.9-1979, "Requirements for Collection, Storage, and Maintenance of Quality Assurance Records for Nuclear Power Plants."

i. ANSI N45.2.11-1974, "Quality Assurance Requirements for the Design of Nuclear Power Plants."

j. ANSI/ASME N45.2.12-1977, "Requirements for Auditing of Quality Assurance Programs for Nuclear Power Plants."

k. ANSI/ASME N45.2.23-1978, "Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants."

l. ANSI/ASME N626.3-1979, "Qualifications and Duties of Personnel Engaged in ASME Boiler and Pressure Vessel Code, Section III, Division 1 and 2, Certifying Activities."

m. Regulatory Guide 1.28, "Quality Assurance Program Requirements (Design and Construction)."

n. Regulatory Guide 1.58, "Qualification of Nuclear Power Plant Inspection, Examination, and Testing Personnel."

o. Regulatory Guide 1.64, "Quality Assurance Requirements for the Design of Nuclear Power Plants."

p. Regulatory Guide 1.88, "Collection, Storage, and Maintenance of Nuclear Power Plant Quality Assurance Records."

q. Regulatory Guide 1.144, "Auditing of Quality Assurance Programs for Nuclear Power Plants."

r. Regulatory Guide 1.146, "Qualification of Quality Assurance Program Audit Personnel for Nuclear Power Plants."

s. Regulatory Guide 7.10, "Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Materials".

t. Military Specification, MIL-Q-9858A, "Quality Program Requirements."

u. Military Specification, MIL-I-45208A, "Inspection System Requirements."

v. Military Specification, MIL-C-45662A, "Calibration System Requirements."

w. NASA Quality Publication, NHB 5300.4(1B), "Quality Program Provisions for Aeronautical and Space System Contractors."

x. U.S. Energy Research and Development Administration, Division of Reactor Development and Demonstration, RDT F 2-2, August 1973, "Quality Assurance Program Requirements."

y. Office of Civilian Radioactive Waste Management (OCRWM), "Quality Assurance Management Policies and Requirements," OCRWM-DOE/RW-0032, October 1985.

z. American Society for Nondestructive Testing, Recommended Practice, SNT-TC-1A, June 1975 and August 1984 Editions.

2.1.3 The PNSI Quality Assurance Program provides a basis of commitment and placement of responsibility for the duration of the contract or licensing effort. The procedural methods for implementing the requirements of the PNSI Quality Assurance Manual are contained in the Quality Procedures (QP's). Applicability of other quality standards, business mix, unique customer requirements, or other considerations may dictate the need for a subsidiary, regional, or branch office to utilize Quality Procedures specific to that location. Therefore, each PNSI subsidiary, regional, or branch office has the authority to develop, in accordance with Section 5.0 of this QA Manual, Quality Procedures unique to that location. Project Instructions (PI's) are utilized to address unique project requirements which are not specifically covered by the Quality Procedures. A further description for the review, approval, and control of QP's and PI's is contained in Section 5.0 of this manual.

2.1.4 The project planning document (Exhibit 2-1) is the key controlling feature utilized by PNSI to specify the appropriate regulatory licensing or contractual quality assurance program requirements. The applicable quality assurance program criteria, or parts thereof, are identified in the Project Plan to assure adequate quality assurance coverage. Project planning shall be performed in accordance with applicable Quality Procedures and shall provide, as a minimum, for the following activities:

a. Establishing project team responsibilities.

b. Determining quality assurance program applicability.

c. Defining project scope and special technical and quality requirements for the project.

Preparation and approval of project plans for quality related projects involves both project and quality assurance personnel. All project plans for quality related projects are reviewed by the QA Manager to assure that QA controls are commensurate with the specific activity, item complexity, importance to safety, and customer-imposed contractual or appropriate regulatory licensing requirements.

2.1.5 The PNSI Quality Assurance Program provides for accomplishing activities affecting quality under suitably controlled conditions with consideration given to the following:

a. Use of appropriate equipment.

b. Suitable environmental conditions for accomplishing the activity.

c. Assurance that prerequisites for the given activity have been satisfied.

2.1.6 The PNSI Quality Assurance Program takes into account the need for special controls, processes, test equipment, tools, and skills to attain the required quality.

2.1.7 The PNSI Quality Assurance Program recognizes the need for verification of quality by inspection, monitoring and test.

2.2 <u>Material Review Board</u>

The PNSI Quality Assurance Program provides for the use of a Material Review Board (MRB) to disposition hardware or operational related discrepancies in accordance with an approved quality procedure. The MRB is convened when determined necessary by the Quality Assurance Manager and consists of representatives from engineering, licensing, production, procurement and quality assurance as applicable to the scope of the discrepancy.

2.3 <u>Quality Assurance Manual Review, Approval and Control</u>

2.3.1 The PNSI Quality Assurance Manual sections shall be reviewed by the Director, Corporate Quality Assurance and approved by the President.

2.3.2 The Director, Corporate Quality Assurance is responsible for the maintenance and distribution of the Quality Assurance Manual.

2.3.3 Revisions to the PNSI Quality Assurance Manual shall be indicated by a vertical line in the right hand margin unless a complete new edition of the manual is issued. In the case of a new edition, the manual shall be clearly identified as a new edition and each section shall be issued as revision zero.

2.3.4 The Director, Corporate Quality Assurance will issue controlled copies of the PNSI Quality Assurance Manual when requested. Only controlled copies of the PNSI Quality Assurance Manual shall be issued internal to the corporation. All controlled copies of the manual will be assigned a sequential number which shall appear on the title page of each controlled copy. The Director, Corporate Quality Assurance will ensure that current revisions are sent to all controlled manual holders. It is, however, the responsibility of the manual holders to keep the manuals up-to-date.

Quality Assurance Manual holders within the Corporation shall be placed on controlled distribution for a complete set of Quality Procedures (QP's) by the subsidiary Quality Assurance Manager or the Director, Corporate Quality Assurance. Controlled distribution of QP's to external recipients (other than PNSI employees) is accomplished by request from the manual holder.

Controlled distribution shall include a transmittal acknowledgement (Exhibit 2-2) which is to be signed by the document recipient and returned to the document distributor. If the document recipient fails to return the transmittal acknowledgement to the document distributor within the time frame designated on the transmittal, verbal acknowledgement may be obtained and documented to verify that the document was received. The document distributor will maintain a file of acknowledgements for each Quality Assurance Manual/QP set and has the option of removing an externally distributed document from the controlled distribution list at any time if receipt acknowledgement is not obtained. Receipt acknowledgement for overdue internally distributed documents shall be obtained by contacting the individual or his supervisor, if necessary.

2.3.5 The Director, Corporate Quality Assurance (or, for Quality Procedures, the Quality Assurance Manager) may authorize issuance of uncontrolled copies of the PNSI Quality Assurance Manual and Quality Procedures for information only. Uncontrolled copies of the Quality Assurance Manual and Quality Procedures will be up-to-date at the time of issuance and will be stamped "UNCONTROLLED" indicating that no future revisions will be issued to the document holder.

2.4 Management Review of Quality Assurance Program

2.4.1 The Director, Corporate Quality Assurance shall inform PNSI Corporate Management of the status and adequacy of the PNSI Quality Assurance Program. Quality Assurance Management Audits shall be conducted on each division, regional, and branch office annually by the Director, Corporate Quality Assurance.

These audit reports shall be transmitted to the applicable Quality Assurance Manager for action as required and distributed to Management of the affected organization as well as the President.

2.4.2 The Director, Corporate Quality Assurance shall prepare a semi-annual summary report of the quality assurance program which shall be distributed to the President for review. This report shall include the status of Corrective Action Reports (CARs), Audit Finding Reports (AFRs), Nonconformance Reports, Quality Discrepancy Reports, and shall identify any trends adverse to quality. The report shall also include a review of the Quality Assurance Manual to ensure its consistency with the quality assurance criteria documents identified in this Section.

2.5 Indoctrination and Training

2.5.1 The Quality Assurance Manager will conduct quality assurance program indoctrination sessions for new employees for his subsidiary, regional, or branch office.

2.5.2 Training for personnel who participate in the quality assurance program will be conducted by the Quality Assurance Manager for his subsidiary, regional, or branch office.

2.5.3 When necessary, training in project unique quality requirements will be provided by the appropriate Project Manager.

2.5.4 When required by applicable codes and standards, qualified personnel shall be appropriately certified in accordance with approved Quality Procedures.

2.5.5 Proficiency of personnel performing quality-affecting activities is maintained by continuing execution of their assigned responsibilities, retraining, reexamining, and/or recertifying as appropriate.

2.5.6 Records of Quality Assurance training and retraining shall be maintained by the Quality Assurance Manager to demonstrate implementation of the training program. Project unique training records shall be maintained by the Project Manager.

TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE	DATE
DESIGN CONTROL	[signature]	1-14-91
	PRESIDENT [signature]	DATE 14 Jan 1991

3.0 SCOPE

This section defines the requirements and assigns the responsibilities to assure that design and engineering activities are properly planned, documented and controlled.

3.1 General

3.1.1 Quality Procedures (QP's) shall be established and implemented to assure applicable technical requirements such as design bases, regulatory requirements, codes, standards and customer-specified requirements are correctly translated into calculations (Exhibits 3-1 and 3-2), specifications, design drawings, procedures, instructions, and design, topical and safety analysis reports. The Quality Procedures shall also ensure that appropriate quality standards are specified and included in technical documents.

3.1.2 Changes or deviations from specified technical requirements or quality standards shall be identified, documented and controlled.

3.1.3 Records of design control measures shall be identified, documented and controlled in accordance with applicable Quality Procedures and shall be available for review.

3.1.4 As appropriate for the type of project and the contracted scope of work, Quality Procedures shall provide measures for the following activities:

a. Controlling items such as physics, stress, thermal, hydraulic and accident analyses.

b. Compatibility of materials.

c. Accessibility for inservice inspection, maintenance and repair.

d. Delineation of acceptance criteria for inspections and tests.

e. Selection and review for suitability of application of materials, parts, equipment and processes that are essential to the function of the structure, system or component.

f. The identification of items and characteristics designated as important to safety are included in the details of "Topical and Safety Analysis Reports" when these documents are required. When required, these reports are produced in accordance with regulatory requirements.

3.1.5 Design documents shall be checked for both computational accuracy and appropriate design criteria by competent design personnel other than those who performed the original design.

3.1.6 Quality Procedures shall be established and implemented to identify and control design interfaces and for coordination among participating organizations. Such procedures shall describe the review, approval, release, distribution and revision of documents involving interfaces.

3.1.7 Verification of design adequacy, such as performance of design reviews, alternate calculations or qualification testing shall be in accordance with applicable Quality Procedures. The particular design verification method(s) utilized shall be identified and shall be based on regulatory and contractual requirements, the design complexity, the degree of standardization and the state-of-the-art considerations applicable to material, fabrication processes and operating conditions.

Where testing is used to verify the accuracy of the design in lieu of design review or alternate calculations, it shall include qualification testing under the most adverse design conditions.

3.1.8 Design verification shall be performed by competent individuals or groups other than those who performed the original design but who may be from the same organization or the same project team. Regardless of their title, individuals performing design verification shall not have immediate supervisory responsibility (except as allowed by Paragraph 3.1.9) and shall not have specified a singular design approach or ruled out certain design considerations or established the design inputs used in the design. The design verification shall include a review to ensure that design characteristics can be controlled, inspected, tested, and that inspection and test criteria are identified.

3.1.9 Design verification may be performed by the design originator's supervisor provided the supervisor is the only individual in the organization competent to perform the verification. In this case the following provisions apply:

a. The necessity for the supervisor to perform the verification shall be documented and approved in advance by the supervisor's management, and;

b. Effectiveness of the supervisor's design verification and the frequency of use of this verification method shall be periodically assessed by performance of comprehensive internal audits.

3.1.10 Changes to approved design documents, including field changes, are subject to design control measures commensurate with those applied to the original design, based on the importance to safety of the change under consideration. Design changes are reviewed and approved by the person or organization that performed the review and approval of the initial issue of the design document or by other equally qualified personnel or organizations as determined by the Project Manager. The personnel or organization(s) designated to perform the review and approval of changes shall be competent in the specific area of interest and have access to the background information and data related to the document being changed.

Changes to approved design documents, including field changes and defective or nonconforming items that are repaired or accepted as-is, are subject to the design control requirements described above. Design changes are reflected by applicable changes to drawings, reports and specifications when required to provide accurate as-built information. The verification records for specific items provide the basic as-built data and information.

3.2 **Responsibilities**

3.2.1 The Project Engineer is responsible for assuring that technical documents such as drawings, specifications, reports and calculations have been properly prepared and checked.

3.2.2 The Engineering Manager is responsible for verifying design adequacy through independent design verification.

3.2.3 The Project Manager is responsible for coordination of design interfaces among participating organizations and for maintaining records of activities related to design.

4.0 SCOPE

This section defines the requirements and assigns the responsibilities for the preparation, review, approval and control of procurement documents for items and services.

4.1 General

4.1.1 Procurement activities are performed in accordance with approved Quality Procedures to implement the policies defined in this QA Manual section.

Procurement documents shall identify the scope of work, technical requirements, quality assurance program requirements, rights of access, inspection and test requirements, special process requirements, documentation requirements and requirements for reporting and dispositioning of nonconformances, as applicable, to the item or service being procured. A typical Purchase Order is shown as Exhibit 4-1.

4.1.2 Procurement documents shall be reviewed prior to release by qualified QA personnel to assure that quality requirements are correctly stated, inspectable, and controllable; there are adequate acceptance and rejection criteria; and the procurement document has been prepared, reviewed and approved in accordance with applicable Quality Procedures.

4.1.3 Procurement documents shall also require documentation that identifies any procurement requirements which have not been met, together with a description or listing of those nonconformances dispositioned "use as is" or "repair".

4.1.4 Changes to procurement documents shall be subject to the same review and approval as the original procurement document.

4.1.5 Selection of procurement sources shall be in accordance with Section 7.0 of this Quality Assurance Manual.

4.2 **Responsibilities**

4.2.1 The Project Engineer is responsible for establishing the technical requirements of the procurement.

4.2.2 The Project Manager is responsible for documenting the technical and other requirements of the procurement in the procurement documents.

4.2.3 The Project Manager is responsible for assuring that all applicable customer and Quality Assurance requirements have been adequately included in procurement documents and for assuring that procurement documents have been properly controlled.

4.2.4 The Quality Assurance Manager is responsible for reviewing procurement documents to verify that they include or reference the requirements of this section. The Field Quality Assurance Supervisor is delegated this responsibility when procurement documents are prepared and issued at the field site.

5.0 SCOPE

This section defines the requirements and assigns the responsibilities for the preparation, revision, review and approval of procedures, instructions and drawings which prescribe activities affecting quality.

5.1 General

5.1.1 Activities that affect quality shall be accomplished in accordance with written procedures, instructions and/or drawings as appropriate to the activity being performed.

5.1.2 Procedures, instructions and drawings shall include the appropriate quantitative or qualitative acceptance criteria for determining that important activities have been satisfactorily accomplished.

5.1.3 Quality Procedures (Exhibit 5-1) define the methods for implementation of the PNSI Quality Assurance Manual requirements for both office and field activities.

5.1.4 Quality Procedures, signed by the President and Director, Corporate Quality Assurance, are generic to PNSI subsidiaries, regional and branch offices, unless otherwise identified.

5.1.5 Each PNSI subsidiary, regional and branch office is authorized to develop Quality Procedures that are suitable to their method of operation, In no case shall Quality Procedure deviate from the quality criteria specified by the PNSI Quality Assurance Manual.

5.1.6 Project Instructions will be written, as necessary, to implement special requirements determined by customer contracts or project needs, and will be applicable only to that project or customer for both office and field activities or as defined in the project instruction.

5.1.7 All revisions to procedures, instructions and drawings shall be prepared, reviewed and approved in the same manner as the original document.

5.2 <u>Responsibilities</u>

5.2.1 The Quality Assurance Manager is responsible for the preparation of Quality Procedures to implement the requirements of the PNSI Quality Assurance Manual.

5.2.2 The Director, Corporate Quality Assurance is responsible for review, control and distribution of Quality Procedures.

5.2.3 The PNSI President is responsible for the approval of the Quality Procedures.

5.2.4 When a subsidiary, regional or branch office develops separate Quality Procedures specific to their location, the authority for review, approval, maintenance, distribution and control is delegated to the respective subsidiary, regional or branch office General Manager and the Quality Assurance Manager. All Quality Procedures shall be reviewed by the Director, Corporate Quality Assurance prior to issuance.

5.2.5 The individuals responsible for preparation, review and approval of procedures, instructions and drawings that prescribe activities affecting quality are identified by the Quality Procedure that generates the document.

TITLE

DOCUMENT CONTROL

DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91

PRESIDENT DATE 14 Jan 1991

6.0 SCOPE

This section defines the requirements and assigns the responsibilities to control the review, issuance and distribution of documents which prescribe activities affecting quality. These requirements pertain to corporate, subsidiary, regional and branch office activities as well as activities performed by PNSI at the field sites.

6.1 General

6.1.1 Documents which require control in accordance with this section are finalized technical documents, procedures and instructions.

6.1.2 Documents that prescribe activities affecting quality shall be reviewed and approved for technical adequacy and inclusion of appropriate quality requirements prior to approval and issuance. The Quality Procedure (QP) that generates the document describes the requirements for the review and approval functions.

6.1.3 Changes to documents which prescribe activities affecting quality shall be reviewed and approved by the same organization that performed the initial review and approval, or by equally qualified responsible organizations as determined by the Project Manager. However, such review and approval is not required when the changes are inconsequential, such as the correction of minor typographical errors. Such changes shall be made by the appropriate division, regional or branch office personnel by lining out the incorrect data, adding the new information, initialing and dating the correction.

6.1.4 Documents which prescribe activities affecting quality shall be distributed to, and used at, the location where the activity will be performed prior to implementation of work. The internal and external distribution of technical documents to responsible personnel are predetermined and established for each project. Distribution to individuals at the customer's facility is as specified by the customer.

6.1.5 Obsolete or superseded documents shall be either removed from the work area and destroyed or appropriately marked to identify that they have been replaced by a later revision.

6.1.6 A master list may be used to identify the latest revision of each document. When used, the master list shall be distributed to predetermined, responsible personnel. The master list shall be updated as required to remain accurate.

6.1.7 Controlled distribution of documents which prescribe activities affecting quality shall be accomplished by the use of distribution logs (Exhibit 6-1) and transmittal forms (Exhibit 6-2) or other means of positive receipt acknowledgement.

6.2 Responsibilities

6.2.1 The Project Manager is responsible for the receipt, issuance and distribution of controlled documents within the scope of the project. The Project Manager is also responsible, through customer direction, for identifying responsible personnel at the customer's facility who are to receive and use quality-related documents generated by PNSI.

6.2.2 The Director, Corporate Quality Assurance or Quality Assurance Manager is responsible for the issuance and distribution of controlled documents within the scope of quality assurance activities.

6.2.3 The applicable department manager, generating quality-related procedures or instructions for his department, is responsible for the issuance and distribution of those documents.

6.2.4 Individuals who utilize documents which prescribe activities affecting quality are responsible for using the latest revision, as identified in the appropriate distribution records, or obtaining controlled distribution for those documents.

7.0 SCOPE

This section defines the requirements and assigns the responsibilities to assure that purchased items and services, including special processes, whether purchased directly or through subcontractors, conform to specified procurement document requirements. Such measures include, as appropriate, provisions to properly plan, document, monitor and control the quality of purchased items and services.

7.1 General

7.1.1 Control of purchased items and services shall be performed in accordance with approved Quality Procedures (QP's).

7.1.2 Prior to award of contract, suppliers shall be subjected to a documented technical and quality assurance evaluation (Exhibit 7-1) for their capability to provide items or services and related records in accordance with the requirements of approved procurement documents.

7.1.3 The technical and quality assurance evaluations are not required for any one of the following conditions:

a. The supplier is currently on PNSI's Approved Suppliers List (ASL) for similar items or services.

b. The supplier is currently on the customers approved suppliers list or has been specifically selected by the customer and documentation attesting to this approval has been supplied from the customer to PNSI.

c. The supplier holds a valid Certificate of Authorization or Quality System Certificate from the American Society of Mechanical Engineers (ASME) for the activities described in the procurement documents.

7.1.4 Items and services shall be controlled, monitored (surveillance) and verified upon receipt by qualified personnel to assure conformance with procurement documents. Surveillance of the suppliers activities shall be performed when determined necessary by the Quality Assurance Manager. When conducted, surveillance shall be documented on a surveillance report (Exhibit 7-2). The extent or need of surveillance activities by PNSI, at the supplier's location, is dependent on the following conditions:

a. The complexity or uniqueness of the item and its importance to safety.

b. The need for special controls and surveillance over processes and equipment. Surveillance is performed on those items where verification of procurement requirements cannot be determined upon receipt.

c. The degree to which functional compliance can be demonstrated by receipt inspection and test.

d. The availability of quality history or the degree of standardization of identical items.

7.1.5 When purchased items are received, a receiving inspection shall be performed in accordance with the requirements specified by Section 10.0 of this Quality Assurance Manual.

7.1.6 For commercial "off-the-shelf" items, where specific quality assurance controls appropriate for nuclear applications cannot be imposed in a practicable manner, additional quality verification requirements shall be performed to the extent necessary to verify the acceptability and conformance of an item to procurement document requirements.

7.1.7 In addition to the requirements of Regulatory Guide 1.144, quality assurance audits shall be conducted to verify compliance with applicable quality requirements at intervals consistent with the importance, complexity and quantity of items or services provided. However, quality assurance audits of suppliers are not required when any one of the following conditions exist:

a. The supplier holds a valid ASME Quality System Certificate or Certificate of Authorization for the items or services being procured.

b. The supplier has been approved by the customer for the specific procurement and documentation so stating has been provided to PNSI.

c. The supplier is a nationally recognized manufacturer of test equipment and related calibration services and the calibration services are verified by PNSI prior to use of the equipment.

d. The supplier is a regulatory agency or a nationally recognized standards laboratory such as the U.S. National Institute of Standards and Technology.

7.2 **Responsibilities**

7.2.1 The Project Manager is responsible for the following activities in relation to procurement:

a. Planning and executing the procurement process.

b. Evaluating the supplier's technical capability to perform the scope of work specified by the procurement documents.

c. Notifying the Quality Assurance Manager for the performance of scheduled source surveillance.

7.2.2 The Quality Assurance Manager is responsible for performing the following activities in relation to procurement:

a. Evaluating the supplier's quality assurance program to the requirements of the specified procurement documents.

b. Performing supplier surveillance activities.

c. Conducting supplier quality assurance audits to the requirements specified herein.

7.2.3 The supplier is responsible for first-line inspection and verification of items and services, including special processes, within their contractual scope of work.

7.2.4 The Director, Corporate Quality Assurance, or his designee is responsible for maintenance and distribution of the Approved Suppliers List (ASL).

TITLE: IDENTIFICATION AND CONTROL OF MATERIALS, PARTS AND COMPONENTS

DIRECTOR, CORPORATE QUALITY ASSURANCE — DATE 1-14-91

PRESIDENT — DATE 14 Jan 1991

8.0 **SCOPE**

This section defines the requirements and assigns the responsibilities for the identification and control of materials, parts and components, including partially fabricated subassemblies received or constructed by PNSI.

8.1 **General**

8.1.1 Quality Procedures (QP's) shall identify the appropriate criteria and responsibilities to assure that identification is maintained, either on the item or on records traceable to the item, to preclude use of incorrect or defective items.

8.1.2 When required by the applicable specification (procurement, fabrication, construction, erection), the identification of materials and parts shall be traceable to the appropriate documentation such as drawings, specifications, purchase orders, manufacturing and inspection documents, deviation reports and physical and chemical material test reports.

8.1.3 Quality Procedures shall identify the appropriate criteria and responsibilities to assure that the correct identification of material, parts and components is verified and documented as described in Section 10.0 throughout fabrication, operation, assembling, shipping and inspection.

8.1.4 Hardware identification requirements shall be determined during generation of drawings (design and manufacturing) and specifications such that the location and method of identification does not affect the form, fit, function, or quality of the item being identified.

8.2 **Responsibilities**

8.2.1 The Quality Assurance Manager shall be responsible for assuring that items are adequately identified and traceable to the appropriate reference documentation.

8.2.2 The Project Manager shall be responsible for assuring that all documentation identified as a deliverable by the purchase document is received and is acceptable.

TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE	DATE
CONTROL OF SPECIAL PROCESSES	[signature]	1-14-91
	PRESIDENT [signature]	DATE 14 Jan 1991

9.0 SCOPE

This section defines the requirements and assigns the responsibilities to assure that special processes such as nondestructive examination, chemical cleaning, lead pouring, welding, fabrication, weld overlay, heat treating, waste processing and induction heating stress improvement are acceptably performed and to assure that special processes are performed by qualified personnel using qualified procedures and equipment.

9.1 General

9.1.1 A special process is a process in which verifying the results are highly dependant on the control of the process or the skill of the operators, or both, and in which the specified quality cannot be readily determined by inspection or test of the product.

9.1.2 Special processes shall be controlled using special purpose forms such as Travelers (Exhibit 9-1) to define the sequential operations which must occur. These forms include provision to record the procedures, personnel and material identities related to each sequence. They will also provide a vehicle for the establishment of QA Hold/Witness Points.

9.1.3 Special process procedures, equipment and personnel shall be qualified for conformance to applicable Codes, standards and specifications.

9.1.4 Quality Procedures shall be developed to require that special processes be performed using qualified procedures, equipment and personnel.

9.1.5 Qualification records of special process procedures, equipment and personnel shall be established and maintained.

9.1.6 When special processes are subcontracted, PNSI procurement documents shall require the supplier to submit special process procedure qualification data to PNSI for review. Selection and control of special process subcontractors shall be in accordance with Section 7.0 of this Quality Assurance Manual.

9.2 **Responsibilities**

9.2.1 The Project Manager is responsible for the following activities in relation to special processes:

a. Review and approval of PNSI procedures which describe and control special processes for his project.

b. Review of subcontractor special process procedures when applicable.

9.2.2 The Project Manager is responsible for maintenance and turnover of records associated with the execution and acceptability of special processes except for nondestructive examination personnel qualification and certification records for which the Quality Assurance Manager is responsible.

9.2.3 The Quality Assurance Manager is responsible for final approval of special process procedures as well as inspection procedures or data sheets that provide for recording evidence of acceptable use of special process procedures, equipment and personnel.

9.2.4 The Quality Assurance Manager is responsible for maintaining a qualification program and certification records for personnel involved with special process inspection and nondestructive examination.

10.0 SCOPE

This section defines the requirements and assigns the responsibilities to assure that inspection and surveillance activities are performed by appropriately trained and qualified personnel using written, approved procedures.

This section includes inspection of items, upon receipt by PNSI at the designated location, and also includes surveillance and in-process and final inspections of PNSI or PNSI subcontractor fabricated, constructed, operated or erected items, systems, components or structures.

10.1 General

10.1.1 Inspection and surveillance personnel shall have been appropriately trained and shall be qualified to the requirements of ANSI N45.2.6-1978 and Regulatory Guide 1.58 for the level of inspection which they are performing.

10.1.2 Inspection and surveillance personnel shall be individuals other than those who performed or directly supervised the activity being inspected and they shall not report directly to the immediate supervisors who are responsible for the activity being inspected.

10.1.3 Inspection and surveillance personnel shall utilize written, approved procedures, checklists or instructions which delineate the acceptance criteria for the items under inspection.

The approved, written procedures, checklists or instructions shall provide for the following, as required for the inspection or surveillance:

a. Identification of characteristics or activities to be inspected, witnessed or verified, including criteria for acceptance.

b. A description of the method of inspection or surveillance.

c. Identification of required procedures, drawings, specifications or other documentation and revisions necessary to facilitate the inspection.

d. Identification of the inspector or data recorder and recording the results of the inspection or surveillance operation.

e. Specifying necessary measuring and test equipment, referencing accuracy requirements.

10.1.4 Inspection shall be performed to verify the following characteristics, as a minimum:

a. The material, component or equipment is properly identified and corresponds to the requirements of the purchase or fabrication control documents.

b. Material, components, equipment and acceptance records satisfy the inspection instructions prior to acceptance, installation or use.

c. Specified inspection, test and other records (such as certificates of conformance attesting that the material, components and equipment conform to specified requirements) are available and acceptable prior to installation or use. These records are periodically evaluated by audits, surveillances, independent inspections or tests to assure validity.

10.1.5 Procedures shall be established to assure that PNSI hold points, including customer hold points, are identified and work will not proceed until acceptance by authorized personnel.

10.1.6 Inspection and surveillance results shall be documented and evaluated, and a determination of their acceptability shall be made.

10.1.7 Results of surveillances and inspections (receiving, in-process, assembly, final packaging and shipping) shall be documented on an inspection checklist (Exhibit 10-1) or other process control document and shall be maintained as quality records.

10.2 Responsibilities

10.2.1 The Quality Assurance Manager is responsible for maintaining a qualification program for inspection and NDE personnel and for approving procedures, planning, travelers or other documents which establish inspection hold points.

10.2.2 The Quality Assurance Manager is responsible for approving inspection procedures, checklists or instructions or other documents to identify inspection hold points where work is stopped.

10.2.3 Level II or III Certified Inspectors are responsible for evaluating inspection results to determine their acceptability.

10.2.4 The Project Manager is responsible for developing procedures, planning, travelers or other documents to control the fabrication or operations activities, and for assuring that work will not proceed until acceptance by the inspector.

10.2.5 Inspection personnel are responsible for performing the inspection using calibrated inspection, measuring and test equipment as defined in Section 12.0 and for compiling records to document the inspections.

10.2.6 The Project Manager is responsible for maintaining inspection records in accordance with this Quality Assurance Manual.

TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE / DATE	PRESIDENT / DATE
TEST CONTROL	1-14-91	14 Jan 1991

11.0 <u>SCOPE</u>

This section defines the requirements and assigns the responsibilities for the control of testing activities performed by PNSI.

11.1 <u>General Requirements</u>

11.1.1 Test requirements and acceptance criteria shall be provided by the organization requesting the test unless otherwise designated by contract.

11.1.2 Approved, written test procedures or instructions shall be developed that provide the following, as required:

a. The requirements and acceptance limits contained in applicable test specifications or design and procurement documents.

b. Instructions for performing the test.

c. Test prerequisites such as calibrated instrumentation, adequate test equipment and instrumentation (including their accuracy requirements), completeness of item to be tested, suitable and controlled environmental conditions, and provisions for data collection and storage.

d. Mandatory inspection hold points for witness by the customer or the PNSI inspector (as required).

e. Acceptance and rejection criteria.

f. Methods of documenting or recording test data and results.

g. Provisions for assuring test prerequisites have been met.

11.1.3 The test results shall be documented and evaluated to assure the test requirements and acceptance criteria have been satisfied.

11.1.4 Test personnel shall have appropriate training and shall be qualified to the requirements of ANSI N45.2.6-1978 and Regulatory Guide 1.58 for the level of testing which they are performing.

11.1.5 Testing records and records of training shall be maintained as quality records.

11.2 <u>Responsibilities</u>

11.2.1 The organization requesting the test is responsible for issuing documentation that delineates the criteria and requirements of the test unless otherwise specified by contract.

11.2.2 The Project Engineer is responsible for preparing test procedures that are responsive to the test requirements and acceptance criteria.

11.2.3 The Engineering Manager and, when applicable, the organization requesting the test are responsible for reviewing and approving the test procedures.

11.2.4 The Engineering Manager is responsible for properly training test personnel (or assuring that previous training has been accomplished) for the level at which the test personnel are performing.

The Engineering Manager is also responsible for evaluating and approving the test results to assure that the test requirements have been satisfied.

11.2.5 The Quality Assurance Manager is responsible for establishing and maintaining a program for the qualification of test personnel to the requirements specified herein. The Quality Assurance Manager is also responsible for performing audits and/or surveillance of testing activities.

11.2.6 Test personnel are responsible for using calibrated inspection, measuring and test equipment as defined in Section 12.0.

TITLE

CONTROL OF MEASURING AND TEST EQUIPMENT

DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91

PRESIDENT DATE 14 Jan 1991

12.0 SCOPE

This section defines the requirements and assigns the responsibilities for the control of measuring and test equipment used for acceptance of inspections or tests performed by PNSI.

12.1 General Requirements

12.1.1 Measures shall be established and documented to assure that tools, gages, instruments and other inspection, measuring and test equipment used in activities affecting quality are of proper range, type and accuracy to verify conformance to established requirements (Exhibits 12-1 and 12-2).

12.1.2 To assure accuracy, inspection, measuring and test equipment shall be controlled, calibrated, adjusted and maintained at prescribed intervals, or prior to use, against certified equipment having known valid relationships to nationally recognized standards. If no national standards exist, the basis for calibration shall be documented.

12.1.3 Special calibration and control measures on rules, tape measures, levels and other such devices are not required where normal commercial practices provide adequate accuracy.

12.1.4 The method and interval of calibration for each item shall be defined and shall be based on the type of equipment, stability characteristics, required accuracy and other conditions affecting measurement control. Special calibration shall be performed when accuracy of the equipment is suspect.

12.1.5 Unless limited by state-of-the-art, calibrating standards shall have an error requirement of no more than one-quarter (1/4) of the tolerance of the equipment being calibrated.

12.1.6 When inspection, measuring and test equipment are found to be out of calibration, an evaluation shall be made and documented of the validity of previous inspection or test results and of the acceptability of items previously inspected or tested.

12.1.7 If any inspection, measuring or test equipment is consistently found to be out of calibration, it shall be repaired or replaced.

..1.8 Inspection, measuring and test equipment shall be marked to indicate calibration status.

12.1.9 Quality Procedures (QPs) describe the procedural details for the proper execution and documentation for the control of inspection, measuring and test equipment.

12.1.10 Written, approved procedures shall be developed to control the issuance of measuring and test equipment such as instruments, tools, gages, fixtures, reference and transfer standards, and nondestructive test equipment that is used in the acceptance of inspection and test operations.

12.1.11 Records of calibration of measuring and test equipment shall be maintained as quality records.

12.2 **Responsibilities**

12.2.1 The Quality Assurance Manager is responsible for the implementation of the calibration program (including the responsibility for maintaining calibration records of measuring and test equipment).

12.2.2 The Quality Assurance Manager is responsible for implementing procedures to control the issuance and use of measuring and test equipment.

12.2.3 Personnel performing inspections and tests are responsible for using calibrated inspection, measuring and test equipment.

TITLE: HANDLING, STORAGE AND SHIPPING

DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91

PRESIDENT DATE 14 Jan 1991

13.0 SCOPE

This section defines the requirements and assigns the responsibilities for special handling, preservation, storage, cleaning, packaging and shipping of materials, components and systems purchased, fabricated, constructed, operated or erected by PNSI.

13.1 General

13.1.1 Procedures shall be established to describe the control of cleaning, handling, preservation, storage, packaging and shipping of materials, components and systems, when specified by design and procurement specification requirements, to preclude damage, loss or deterioration by environmental conditions such as temperature or humidity.

13.1.2 Special handling, preservation, storage, cleaning, packaging and shipping requirements shall be established by qualified individuals in accordance with predetermined work and inspection instructions.

13.1.3 Special handling tools and equipment shall be inspected and tested in accordance with written, approved procedures, and at specified time intervals, to verify that the tools and equipment are adequately maintained.

13.2 **Responsibilities**

13.2.1 The Project Engineer is responsible for reviewing and approving procedures and instructions which describe the control of cleaning, handling, shipping and storage of materials, components and systems.

13.2.2 The Quality Assurance Manager is responsible for reviewing and approving procedures, instructions and checklists which provide for the inspection of special handling, preservation, storage, cleaning, packaging and shipping requirements of items by PNSI.

13.2.3 The Project Manager is responsible for implementation of receipt, storage, handling and shipping instructions of purchased items and materials. This includes the responsibility for providing special handling special coverings, special equipment, special environments and adequate storage areas as applicable.

TITLE

INSPECTION AND TEST STATUS

DIRECTOR, CORPORATE QUALITY ASSURANCE DATE 1-14-91
PRESIDENT DATE 14 Jan 1991

14.0 SCOPE

This section defines the requirements and assigns the responsibilities for the control of inspection and test status indicators, including the authority for application and removal of inspection and test status indicators.

14.1 General

14.1.1 Procedures shall be established to indicate the inspection and test status of materials, items, structures, systems and components throughout fabrication, installation, operation and test.

14.1.2 Procedures shall be established to control the application and removal of inspection and welding stamps and status indicators such as tags (Exhibit 14-1), markings, labels and stamps.

14.1.3 The status of nonconforming, inoperative or malfunctioning structures, systems and components shall be documented and identified to prevent inadvertent use, in accordance with section 15.0 of this Quality Assurance Manual.

14.1.4 Procedures shall be established to assure that items accepted and released are identified as to their inspection status prior to forwarding them to a controlled storage area or releasing them for installation, operation or further work.

14.2 Responsibilities

14.2.1 The Quality Assurance Manager is responsible for approving procedures that provide for the identification of inspection and test status indicators, including the application and removal of status indicators such as tags and labels.

14.2.2 The Quality Assurance Manager is responsible for assuring that the status of nonconforming, inoperative or malfunctioning structures, systems or components is indicated.

14.2.3 Production, Test and Operations personnel are responsible for compliance with indicated inspection and test status indicators.

15.0 **SCOPE**

This section defines the requirements and assigns the responsibilities for the control, identification, segregation, documentation and close-out of nonconforming items to prevent their inadvertent installation or use in fabrication, construction, operations or erection.

15.1 **General**

15.1.1 Procedures shall be established to describe the identification, documentation, segregation, review, disposition, and notification to affected organizations of nonconforming items, materials, systems, parts and components (Exhibit 15-1).

15.1.2 Nonconforming items shall be dispositioned as "use-as-is", "reject", "repair" or "rework".

15.1.3 Nonconforming items dispositioned "use-as-is" or "repair" shall include technical justification to indicate and assure continued compliance with design, regulatory and contractual requirements.

15.1.4 Items dispositioned as "rework", "repair", or replacement items shall be inspected and tested in accordance with the original inspection and test requirements or acceptable alternatives which are in compliance with the specified acceptance criteria.

15.1.5 Nonconforming items dispositioned "use-as-is" or "repair" shall be reported to the customer unless such reporting is formally waived by the customer.

15.1.6 When determined by the Quality Assurance Manager to be appropriate, he shall convene a Material Review Board (MRB) as described in PNSI's Quality Assurance Manual Section 2.0 to provide a disposition of the discrepancy. MRB activities are as described in an approved Quality Procedure and are in addition to the responsibilities defined in this Quality Assurance Manual Section.

15.2 **Responsibilities**

15.2.1 The Project Engineer is responsible for determining (if not already provided by a Material Review Board) and approving the disposition of nonconforming items.

15.2.2 The Quality Assurance Manager is responsible for reviewing and approving the disposition of nonconforming items and for determining when it is appropriate to convene a Material Review Board to disposition discrepancies.

15.2.3 The Project Manager is responsible for approving the disposition of Nonconformance Reports. The Project Manager is also responsible for segregating nonconforming items when practical, reporting nonconforming items to the customer, and in conjunction with production, operations, test and QA personnel, implementing the approved disposition.

15.2.4 For licensed products, the Manager of Licensing and Analysis is responsible for reviewing Reports of Nonconformances to assess the impact of the discrepancy on the licensing commitments.

15.2.5 All employees are responsible for notifying their supervisor of any potential nonconforming condition affecting hardware, documentation or services.

16.0 **SCOPE**

This section defines the requirements and assigns the responsibilities for identifying and correcting significant conditions adverse to quality, including provisions to prevent recurrence.

16.1 **General**

16.1.1 A condition adverse to quality such as a nonconformance, failure, malfunction, deficiency, deviation, defective material or equipment shall be documented and corrected as soon as practical after the condition has been determined. Sections 15.0 and 18.0 describe the requirements for documenting and correcting these conditions.

16.1.2 Significant conditions adverse to quality including the cause of the condition and the corrective action to preclude repetition shall be documented (Exhibit 16-1) and reported to subsidiary management and the Director, Corporate Quality Assurance. For the purpose of this section, a significant condition adverse to quality is defined as, but not limited to, an unsatisfactory quality trend, bypassing of required inspections, tests, or other critical operations, a significant deficiency as defined by 10 CFR 50.55(e), or a defect or failure as defined by 10 CFR 21.

16.1.3 Timely follow-up action shall be taken to verify proper implementation and close-out of the required corrective action.

16.1.4 A Summary Report of the status of Corrective Action Reports shall be prepared on a semi-annual basis by the Director, Corporate Quality Assurance for distribution to the President for review.

16.2 Responsibilities

16.2.1 All PNSI personnel are responsible for reporting potentially significant conditions adverse to quality to the Quality Assurance

16.2.2 The Quality Assurance Manager is responsible for assuring implementation of the corrective action program, including follow-up and close-out actions. He is also responsible for informing the Director, Corporate Quality Assurance of corrective action activities.

16.2.3 The Director, Corporate Quality Assurance is responsible for reviewing all Corrective Action Reports to determine if the deviation or deficiency documented on the CAR is potentially reportable to the Nuclear Regulatory Commission in accordance with 10 CFR 50.55 (e) or 10 CFR 21.

16.2.4 For licensed products, the Manager of Licensing and Analysis is responsible for reviewing Corrective Action Reports to assess the impact of the discrepancy on the licensing commitments.

16.2.5 Production, Operations, Test and QA personnel, as identified, are responsible for correcting significant conditions adverse to quality.

TITLE	DIRECTOR CORPORATE QUALITY ASSURANCE	DATE
RECORDS	[signature]	1-14-91
	PRESIDENT [signature]	DATE 14 Jan 1991

17.0 SCOPE

This section defines the requirements and assigns the responsibilities for establishing the control and disposition of quality records generated by PNSI.

17.1 General Requirements

17.1.1 Quality Procedures (Qps) shall be developed identifying documents ge rated by PNSI which are considered quality records. Typically, quality assurance records include operating logs and results of reviews, inspections, tests, audits and material analyses, monitoring of work performance, qualification of personnel, procedures and equipmen ; drawings; specifications; procurement documents; calibration procedures and reports; design review reports; and inspection and test records which contain the following when applicable:

a. a description of the type of observation,
b. the date and results of the inspection or test,
c. information related to conditions adverse to quality,
d. inspector or data recorder information,
e. evidence as to the acceptability of the results,
f. action taken to resolve any discrepancies noted.

17.1.2 Identified quality records shall be classified as lifetime, product nonpermanent, or programmatic nonpermanent as described by Regulatory Guide 1.28 using an approved procedure.

17.1.3 QA records shall be indexed to provide for identification, records retention period and storage location.

17.1.4 For licensed equipment or shipping/storage containers, lifetime and nonpermanent records generated by PNSI including design related records such as calculations, drawings, design qualification data and material analysis shall be maintained in the QA records system as follows. Lifetime records shall be maintained for the life of the licensed equipment or shipping/storage containers. Programmatic nonpermanent records shall be retained for at least three (3) years and product nonpermanent records shall be retained for at least ten (10) years or the life of the item if less than ten ye- .

17.1.5 Lifetime and product nonpermanent records generated by PNSI for nonlicensed products, which are applicable to a specific scope of work or contract, are generated and may be transmitted to the customer during execution of the work or contract. Upon completion of the scope of work or contract, all records which have not been previously transferred will be offered to the customer for disposition. PNSI does not permanently store product quality records unless specifically requested to do so by the customer or, for licensed products, when PNSI is the licensee.

17.1.6 Nonpermanent programmatic records generated by PNSI, which are generic to the implementation of PNSI's Quality Assurance Program, and not related to a specific project such as QA Management Audits, shall be retained by PNSI for a period of three (3) years from date of generation, unless otherwise stated by customer contractual requirements.

17.1.7 Records shall be indexed, filed and maintained in facilities that provide a suitable environment to minimize deterioration or damage, and to prevent loss subsequent to completion of work, during the specified retention time or until transferred to the customer, as required by applicable Codes, Standards and procurement documents.

17.1.8 Protection for QA records is provided by using one of the following storage methods:

(a) Two sets of identical records are maintained at separate storage locations, or

(b) The official copy of all QA records is maintained in approved fire-proof files or vault, at a single location.

17.2 **Responsibilities**

17.2.1 The Project Manager is responsible for identifying, indexing and storing product related records under his jurisdiction.

17.2.2 The Quality Assurance Manager is responsible for identifying, indexing and storing programmatic records under his jurisdiction for the specified retention period. This includes responsibility for maintenance of training records for testers, inspectors, and auditors.

17.2.3 The Quality Assurance Manager is responsible for performing periodic audits of PNSI's Project QA records.

17.2.4 The Director, Corporate Quality Assurance is responsible for scheduling periodic audits of PNSI's QA records.

18.0 SCOPE

This section defines the requirements and assigns the responsibilities for a comprehensive system of planned and documented audits including audits of suppliers and site activities to verify compliance with all aspects of PNSI's Quality Assurance Program and to determine the effectiveness of the program.

18.1 General

18.1.1 Audits shall be scheduled in a manner to provide coverage and coordination with ongoing Quality Assurance Program activities commensurate with the status and importance of the activity. All elements of PNSI's Quality Assurance Program shall be audited at least once each year at each subsidiary or during the life of the activity, whichever is shorter.

The need for reaudit of deficient areas shall also be considered. Audits shall be planned to assure effective implementation of quality assurance activities during design, procurement, fabrication, construction, operations, erection, inspection and testing.

18.1.2 Audits shall be performed in accordance with preestablished written procedures using checklists (Exhibit 18-1) and conducted by trained and certified personnel (Exhibit 18-2) having no direct responsibilities in the areas being audited. Objective evidence shall be examined for compliance with quality assurance program requirements.

18.1.3 Audit results shall be documented by auditing personnel and shall be distributed to and reviewed by management having responsibility in the area being audited.

18.1.4 Quality Assurance Management Audits shall be performed to determine the effectiveness of functions for which quality assurance personnel are responsible.

18.2 Responsibilities

18.2.1 The Quality Assurance Manager for each PNSI subsidiary is responsible for implementing a quality assurance audit program suitable to the type, scope and complexity of the work for that location. This activity also includes supplier audits and audits of QA related activities at the job site.

18.2.2 The Director, Corporate Quality Assurance is responsible for planning, scheduling and conducting annual Quality Assurance management Audits of each PNSI subsidiary.

18.2.3 Management of the audited organization is responsible for correcting the deficiencies identified by the audit.

TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE	DATE
EXHIBITS	[signature]	1-14-91
	PRESIDENT	DATE
	[signature]	14 Jan 1991

Usage Note

The forms contained in this section are included to demonstrate how the QA Program controls are typically applied and are not intended to limit PNSI subsidiaries to using the forms shown as long as the QA Manual requirements are adhered to.

TITLE	EXHIBIT NO.	REVISION
Stop Work Order	1-1	0
Project Planning Form	2-1	0
QAM/QP Transmittal Form	2-2	0
Standard Calculation Cover	3-1	0
Standard Calculation Page	3-2	0
Purchase Order	4-1	0
Quality Procedure Page	5-1	0
Distribution Log	6-1	0
Transmittal Form	6-2	0
Supplier Certification Summary	7-1	0
Surveillance Report Form	7-2	0
Process Control Traveller	9-1	0
Inspection Checklist	10-1	0
Calibration Log	12-1	0
Calibration Record	12-2	0
Status Tags	14-1	0
Nonconformance Report	15-1	0
Corrective Action Report	16-1	0
Audit Checklist	18-1	0
Lead Auditor Certification	18-2	0

PACIFIC NUCLEAR SYSTEMS

STOP WORK ORDER

DESCRIPTION OF PROBLEM / REQUEST FOR WORK STOPPAGE:

INITIATOR ____________ DATE ________

STOP WORK REQUEST ASSESSMENT:

IS A WORK STOPPAGE REQUIRED? ☐ YES ☐ NO

CAR NO: ____________

QA MANAGER ____________ DATE ________

STOP WORK ORDER ACKNOWLEDGEMENT:

PROJECT MANAGER ____________ DATE ________

PROBLEM CORRECTED, STOP WORK ORDER RESCINDED:

QA MANAGER ____________ DATE ________

PROJECT MANAGER ____________ DATE ________

EXHIBIT 1-1
STOP WORK ORDER

PACIFIC NUCLEAR SYSTEMS

PROJECT PLANNING FORM

File No:

Revision________

Customer________________________

Contract/P.O. No: __________

Work Scope Change? ▯ Yes ▯ No

P.O. Change No:__________

Project No: ____________________

Work Order: __________

Authorized Amount: $________________

Contract/P.O. Date: __________

Invoices To Be Mailed To:

Project Title: __________

T & M ▯ Firm Price ▯

Other ▯ __________

Attachments As Applicable:

- ▯ Budget Information
- ▯ Charge Numbers
- ▯ Special Billing Instructions
- ▯ Special Job Requirements
- ▯ Detailed Work Scope
- ▯ Project Schedule Information
- ▯ Interface Control & Interfaces
- ▯ Detailed QA Requirements
- ▯ Experience Reports
- ▯ Design Input Listing
- ▯ Design Verification Requirements
- ▯ File Numbers
- ▯ Key Project Personnel
- ▯ Graded QA Listing
- ▯ Planning - Form Distribution

Job Description Or Work Scope Change Summary __________

PNSI Quality Assurance Program Is To Be Applied? ▯ Yes ▯ No

Is This A Revision To The Project Plan? ▯ Yes ▯ No

If "YES", Does This Revision Affect The Application Of PNSI QA Program? ▯ Yes ▯ No ▯ N/A

Approvals:

Project Manager	Date	Engineering Manager	Date
Manager Of Licensing And Analysis (For Licensed Product Only)	Date	Quality Assurance Manager	Date

EXHIBIT 2-1
PROJECT PLANNING FORM

PACIFIC NUCLEAR SYSTEMS

TRANSMITTAL FORM

Date: ____________________

File: ____________________

No.: ____________________

To:

Enclosures:

Please acknowledge receipt by signing below and returning original to:

PACIFIC NUCLEAR FUEL SERVICES, INC.
145 Martinvale Lane
San Jose, CA 95119
Phone: (408) 629-9800 Telecopy: (408) 281-6186

Attention:

Received ______________________________ Date: ____________________

White: Original
Yellow: Recipient's Copy
Pink: File Copy

EXHIBIT 2-2
QAM/QP TRANSMITTAL FORM

PACIFIC NUCLEAR SYSTEMS

CALCULATION PACKAGE

FILE NO:
PROJECT NO:
CALC. NO:

PROJECT NAME:

CLIENT:

CALCULATION TITLE:

PROBLEM STATEMENT OR OBJECTIVE OF THE CALCULATION:

DOCUMENT REVISION	AFFECTED PAGES	REVISION DESCRIPTION	PROJECT ENGINEER APPROVAL/DATE	NAME AND INITIALS OF PREPARERS & CHECKERS

PAGE ______ OF ______

EXHIBIT 3-1
STANDARD CALCULATION COVER SHEET

PACIFIC NUCLEAR SYSTEMS

PROJECT ________________ FILE NO. ________________

OWNER ________________

CLIENT ________________

REVISION						PAGE ____
PREPARED BY/DATE						OF ____
CHECKED BY/DATE						

EXHIBIT 3-2

STANDARD CALCULATION PAGE

PACIFIC NUCLEAR SYSTEMS

1010 South 336th Street
Federal Way, Washington
98003
(206) 874-2235
Telex 152667 PNS
Telecopy (206) 874-2401

Nuclear Packaging Division, Inc.

PURCHASE ORDER

The reporting requirements of 10 CFR Part 21 apply to this contract. All pertinent questions and data shall be directed to PNSI/NuPac QA via Provided Supplier Disposition Requests (SDR), form No. NPQ-019.

☐ Applies ☐ Does Not Apply

TO ______________________________

____

____

ATTN: ______________ PHONE: ______________

CONFIRMED BY/DATE
SHIP VIA F.O.B.
DELIVERY DATE TERMS

P.O. NO	CHG. NO	DATE

1. Ship all orders to Nuclear Packaging, Inc. at above address, unless otherwise specified.
2. Purchase order number must appear on all labels, packing lists, and invoices.
3. Invoices must show freight, taxes, and duties as separate items. Send original and 3 copies to Nuclear Packaging, Inc. at above address. If purchase is F.O.B. Seller's plant, add transportation charges to invoice and attached receipted freight bill. Seller will be assessed $35.00 if freight is sent collect.

Quality Related Procurement

☐ Q.A. Related ☐ Non-Q.A. Related

☐ Q.A. Requirements Attached

__________ __________ Quality Representative

PLEASE ENTER THIS ORDER SUBJECT TO CONDITIONS ON FACE AND REVERSE SIDE AND SUPPLEMENTARY TERMS AND CONDITIONS

ITEM	QTY	DESCRIPTION	UNIT PRICE	EXTENSION

TAXABLE YES NO	TAX NO C600151625

NUCLEAR PACKAGING, INC.

WR# ______________ WO# ______________

WBS# ______________ TYPE ________ COMP # ______________

Purchasing: ______________________

Approved: ______________________

1. Seller/Supplier — White 2. Procurement - Canary 3. QA — Pink 4. Accounting — Goldenrod 5. Program Mgr. — Green 6. File

EXHIBIT 4-1

PACIFIC NUCLEAR SYSTEMS	QUALITY PROCEDURE	QP REVISION PAGE ____ OF ____
TITLE	DIRECTOR, CORPORATE QUALITY ASSURANCE / DATE	
	PRESIDENT / DATE	

EXHIBIT 5-1

QUALITY PROCEDURE PAGE

TECHNICAL DOCUMENT DISTRIBUTION LOG

PROJECT NO: ______________________ FILE NO: ______________________

PROJECT NAME: ______________________

DOCUMENT TITLE AND NO: ______________________

RECEIVER OR FILE NUMBER	COPY NUMBER	INITIAL AND DATE FOR REVISIONS RECEIVED OR INDICATE TRANSMITTAL NUMBER AND DATE TRANSMITTED					
		ECN NO OR REV NO	ECN NO OR REV NO	ECN NO OR REV NO	ECN NO OR REV NO	ECN NO OR REV NO	ECN NO OR REV NO
		* / **					

RECEIPT ACKNOWLEDGMENT: * INITIALS ** DATE RECEIVED OR * TRANSMITTAL NO. ** DATE TRANSMITTED

EXHIBIT 6-1

DISTRIBUTION LOG

"Controlled Transmittals"

TRANSMITTAL AND RECEIPT ACKNOWLEDGEMENT FORM

PACIFIC NUCLEAR SYSTEMS

DATE: ____________

TO: ______________________________

____

____

____

ATTN: ______________________________

TRANSMITTED HEREWITH ARE (IS):

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

__ each ____________ Pages ___ Rev.___ Reason ___ S/N ____________

Reason Legend

1. Use in Fabrication
2. Price Quotation
3. Your Approval
4. Revised/Approved
5. Your Files
6. Your Information
8. Your Request

7. Other: ______________________________

The Documents listed in this transmittal are "controlled copies" for your files. "Controlled copies" means you **WILL** be receiving revisions to these documents as they are released through our Document Control System. Any previous revisions to the enclosed documents should be voided and removed from your active files. These documents have been stamped "Controlled" with a serial number. To verify receipt of the above items, immediately countersign the second transmittal sheet within one week, (attached) and return to Document Control:

____
Document Control

Received by: ______________________ W.O.#: ______________________

Title: ______________________

Date: ______________________

NPQ #110, 1-2-89
File: TRANS.CON

EXHIBIT 6-2

TRANSMITTAL FORM

PACIFIC NUCLEAR SYSTEMS

QUALITY DEPARTMENT EVALUATION OF SUPPLIER QUALITY

Supplier Name and Location: ______________________________

____

Supplier's Scope of Activity: ______________________________

____

____

Evaluation Method(s):

Physical Survey ___

Survey Report Number __________ Date ______________

Other ___

Explain ______________________________

____

____

Approved ___ Conditionally Approved* ___ Disapproved* ___

*Conditions of Approval/Disapproval:

____

____

____

____

Add this supplier to the Approved Supplier List: Yes ___ No ___

____

Director Corporate QA/Date

EXHIBIT 7-1

SUPPLIER CERTIFICATION SUMMARY

PACIFIC NUCLEAR SYSTEMS

QUALITY SOURCE SURVEILLANCE CHECKLIST

FILE NO:

PAGE ____ OF ____

PROJECT NO. ______________________

SUPPLIER ______________________

PURCHASE ORDER NO. ______________ REV ______

CHECKLIST APPROVED BY DATE

SOURCE REVIEW BY DATE

ITEM(S) INSPECTED

SPECIFICATIONS, PROCEDURES OR DRAWINGS AND REVISIONS

NO.	ATTRIBUTES	RESULTS			
		REVIEW ACCEPTABLE		N/A	COMMENTS
		(✓) YES	(✓) NO		

EXHIBIT 7-2

SURVEILLANCE REPORT FORM

PACIFIC NUCLEAR SYSTEMS

PROCESS CONTROL TRAVELER

FILE NO.

PAGE ______ OF ______

CLIENT: ____________________

PROJECT NUMBER: ____________________

UNIQUE TRAVELER IDENTIFICATION NO: ____________________

PREPARED BY: ____________ DATE: ____________

APPLICABLE CONSTRUCTION DOCUMENT(S) AND REVISION(S)

SHEET REV.	0					
REVIEWED*						
APPROVED*						
DATE						

STEP NO.	OPERATION	SHEET REV.	RESPONSIBLE ORGANIZATION	COMPLETED BY	NOTIFICATION POINT		REMARKS
				SIGN*/DATE	ORG	SIGN*/DATE	

*OR INITIALS

EXHIBIT 9-1

PROCESS CONTROL TRAVELLER

PACIFIC NUCLEAR SYSTEMS

INSPECTION CHECKLIST

FILE NO

PAGE ____ OF ____

PROJECT NO. ____	APPROVED BY / DATE
SUPPLIER ____	INSPECTED BY / DATE
TRAVELER NO. OR PURCHASE ORDER NO. ____ DATE OR REV ____	
ITEM(S) INSPECTED / QTY	EVALUATED BY (LEVEL II) / DATE

RELATED SPECIFICATIONS, PROCEDURES OR DRAWINGS AND REVISIONS

NO.	ATTRIBUTES TO BE INSPECTED, METHOD OF INSPECTION, AND REQUIRED M & TE, AS APPLICABLE	MEASURING / TEST EQUIPMENT USED (NAME / SERIAL NO.)	INSPECTION RESULTS: ACCEPTABLE (✓) YES	(✓) NO	COMMENTS

EXHIBIT 10-1

INSPECTION CHECKLIST

PACIFIC NUCLEAR SYSTEMS

PG ____ OF____

QA CONTROLLED TOOL LIST				
NOMENCLATURE	QA NO.	CALIB		REMARKS
		Y	N	

EXHIBIT 12-1

CALIBRATION LOG

PACIFIC NUCLEAR SYSTEMS

MEASURING AND TEST EQUIPMENT CALIBRATION RECORD

ITEM: S/N:

OWNED BY: CALIBRATION RESPONSIBILITY: CALIBRATION INTERVAL:

CALIBRATION DATE	BY (FACILITY OR INDIVIDUAL)	RESULTS	CALIBRATION NEXT DUE

EXHIBIT 12-2

CALIBRATION RECORD

ACCEPTED — GREEN CARD

PART NO. ____________ DATE ____________
PART NAME ____________
SERIAL NUMBER ____________
TRAVELER OR P.O. ____________
QTY ACCEPTED ____________
REMARKS ____________
QC INSPECTOR ____________

REJECTED — RED CARD

PART NO. ____________ DATE ____________
PART NAME ____________
SERIAL NUMBER ____________
TRAVELER OR P.O. ____________
NCR NO. ____________ QTY REJECTED ____________
REASON ____________
QC INSPECTOR ____________

CONDITIONAL RELEASE — YELLOW CARD

PART NO. ____________ DATE ____________
PART NAME ____________
SERIAL NUMBER ____________
TRAVELER OR P.O. ____________
NCR NO. ____________ QTY ____________
REASON ____________
QC INSPECTOR ____________

EXHIBIT 14-1

STATUS TAGS

PACIFIC NUCLEAR SYSTEMS	NONCONFORMANCE REPORT (NCR)	NCR NO FILE NO PAGE ____ OF ____

PROJECT TITLE:

PROJECT NO: NCR ISSUE DATE:

PART DESCRIPTION: ISSUED TO:

RESPONSE DUE DATE:

NONCONFORMANCE DESCRIPTION AND APPLICABLE REQUIREMENT:

INSPECTOR DATE

DISPOSITION: ☐ USE AS-IS ☐ REJECT ☐ REPAIR ☐ REWORK

JUSTIFICATION:

LICENSING IMPACT ☐ YES ☐ NO ☐ NA

MANAGER OF LICENSING/ANALYSIS / DATE

APPROVAL:

PROJECT ENGINEER PROJECT MANAGER QUALITY ASSURANCE

DATE DATE DATE

DISPOSITION COMPLETED AND ACCEPTABLE:

PROJECT ENGINEER PROJECT MANAGER QUALITY ASSURANCE

DATE DATE DATE

EXHIBIT 15-1

NONCONFORMANCE REPORT

PACIFIC NUCLEAR SYSTEMS	CORRECTIVE ACTION REPORT	CAR NO: PROJECT NO: FILE NO:

PREPARED BY: ______________________ ISSUE DATE: ______________________

ASSIGNED TO / TITLE: ______________________ RESPONSE DUE DATE: ______________________

REQUIREMENT:

DEFICIENCY DESCRIPTION:

RECOMMENDED CORRECTIVE ACTION:

STOP WORK ORDER REQUIRED? ☐ NO ☐ YES

DATE SENT TO DIR. CORP. QUALITY ASSURANCE __________

NRC REPORTABLE? ☐ YES ☐ NO
DIR. CORP. QUALITY ASSURANCE ______________ / ______ DATE

LICENSING IMPACT? ☐ YES ☐ NO ☐ NA
MANAGER, LICENSING/ANALYSIS ______________ / ______ DATE

TO BE COMPLETED BY RESPONSIBLE ORGANIZATION

SUBMITTED BY: ______________________ DATE: ______________

TO BE COMPLETED BY QUALITY ASSURANCE ORGANIZATION

QUALITY ASSURANCE EVALUATION OF RESPONSE / CORRECTIVE ACTION STATUS

RESPONSE SATISFACTORY: DATE: CORRECTIVE ACTION COMPLETE: DATE:

EXHIBIT 16-1

CORRECTIVE ACTION REPORT

AUDIT CHECKLIST

SUBJECT					AUDIT NO. ____ PAGE ____ of ____ DATE ____
ITEM NUMBER	REQUIREMENTS	COMPLIANCE WITH REQUIREMENTS			REFERENCE & REMARKS
		YES	NO	N/A	

EXHIBIT 18-1

AUDIT CHECKLIST

PACIFIC NUCLEAR SYSTEMS

RECORD OF LEAD AUDITOR QUALIFICATIONS

NAME | DATE

ANNUAL EVALUATION (Signature & Date) ________ ________ ________ ________ ________ ________ ________

QUALIFICATION POINT REQUIREMENTS | CREDITS

EDUCATION (University/Degree/Date) 4 CREDITS (Max)

1. Undergraduate Level
2. Graduate Level

EXPERIENCE (Company/Date) (see resume) 9 CREDITS (Max)

Technical (0-5 Pts) And
Nuclear Industry (0-1 Pt) Or
Quality Assurance (0-2 Pts) Or
Auditing (0-4 Pts)

PROFESSIONAL ACCOMPLISHMENT (Certificate/Date) 2 CREDITS (Max)

1. P.E.
2. Society

MANAGEMENT (Qualification/Evaluator/Date) 2 CREDITS (max)

Explain:

Evaluated By QA Manager: ______________________ Date: ____________

TOTAL CREDITS

AUDIT COMMUNICATIONS SKILLS (Written & Oral)

Evaluated By QA Manager ______________________ Date: ____________

AUDIT TRAINING COURSES

Course Title or Topic | Date

AUDIT PARTICIPATION FOR QUALIFICATION

Location | Audit | Date

1.
2.
3.
4.
5.

WRITTEN EXAMINATION Date Passed: Score:

AUDITOR QUALIFICATION CERTIFIED BY:
QA Manager ______________________ Date Certified ____________

EXHIBIT 18-2
LEAD AUDITOR CERTIFICATION