OCRWM DESIGN CALCULATION OR ANALYSIS COVER SHEET

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3. System				4. Documen	t Identifier			
S	ite Specific Car	nister			000-00C-HAC	0-00100-	000-00A	
5. Title								
Normal Load Bearing by S	ite Specific Ca	nister						
6. Group								i
Waste Package and Compo		ral	·					
7. Document Status Designati	on							
	⊠ Pre	eliminary	☐ Final	☐ Cance	lled			
8. Notes/Comments								
A LP-2.14Q-BSC review is not required for this document because no other organization is affected by this document.								
		Atta	achments				Total Numbe	r of Pages
See Section 10							<u> </u>	_ -
Attachment 1							3	
Attachment 2							1	
			RECORD OF RE	VISIONS				
9. 10.	11.	12.	13.	14.	15.		16.	17
9. 10. No. Reason For Revisi	on Total # of Pgs.	Last Pg. #	Originator (Print/Sign/Date)	Checker (Print/Sign/Date)	QER (Print/Sign/Date)		ed/Accepted int/Sign)	17. Date
00A Initial Issue	28	Att 2 Sht. 1	Mohan Durani Marani 3/22/05	Tim Schmitt Tanghand	Daniel J. Tunney Daniel J. Tunney 3 23 2052	Michael	J. Anderson	Yespos

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1. PURPOSE AND INTENDED USE:

The over all purpose of this calculation is to perform a preliminary analysis of the Site Specific Canister/Basket, subject to static gravity loads that include the self weight of the Canister Shell, the Basket, the Spent Nuclear Fuel, the Shield Plug and the related hardware, so that the loads are approximately known for sizing purposes. Based on these loads the stress levels in various components of the Site Specific Canister/Basket are evaluated.

This calculation is performed by the Waste Package and Components Group in accordance with AP-3.12Q, *Design Calculations and Analyses* (Reference 3).

2. METHOD:

This calculation for the Site Specific Canister/Basket is based on the details of the geometry per following sketches:

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000-M0K-HAC0-00101-000 Sheet 1 of 3 (Attachment 1)
000-M0K-HCA0-00102-000 Sheet 2 of 3 (Attachment 1)
000-M0K-HCA0-00102-000 Sheet 3 of 3 (Attachment 1)
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The Site Specific Canister/Basket is analyzed for loading imposed by the self weight of various components of the assembly. A static analysis is performed to evaluate the structural integrity of the Canister Shell and the Basket. The Site Specific Canister/Basket assembly can be stored in either a vertical position or a horizontal position. The assembly can be lifted by an attachment provided in the shield plug and hence will be in a vertical position during the lifting operation. Based on the above, the following loading conditions have been considered in evaluating structural integrity of the Site Specific Canister/Basket:

• Loading cases considered in the analysis:

- 1. Load on top of the Canister Shell assembly, imposed by dead weight of the Shield Plug assembly, causing compressive stress in the Canister Shell walls.
- 2. Load on the Bottom Plate of the Canister Shell, imposed by the Basket and the Spent Nuclear Fuel assembly dead weight, including self weight of the Bottom Plate, during lifting operation of the Site Specific

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Canister/Basket assembly, causing tensile stress in the Canister Shell walls.

- 3. Load on the Bottom Plate of the Canister Shell caused by the Basket, and the Spent Nuclear Fuel assembly dead weight, and self weight of the Bottom Plate, during a lifting operation of the Site Specific Canister/Basket assembly, causing stresses in the Bottom Plate.
- 4. Load on the Shear Ring caused by weight of the Canister Shell, the Basket and the Spent Nuclear Fuel assembly, during the Site Specific Canister/Basket lifting operation, causing shear stress in the Shear Ring.
- 5. Load on the Basket End Side Guide and or the Basket Corner Guide, imposed by self weight of the Basket and the Spent Nuclear Fuel assembly with the Site Specific Canister/Basket placed in a horizontal position, while the Basket and the Spent Nuclear Fuel assembly are stored inside the Site Specific Canister/Basket.

For all loading conditions described above (1 through 5), the Canister Shell is assumed to be loaded concentrically. Compressive and tensile stresses, and elongation in the Canister Shell wall for loading cases 1 and 2, stresses in the Bottom Plate for loading case 3, shear stress in the Shear Ring for loading case 4, and stress in the Basket Side Guide and or Basket Corner Guide, for loading case 5 are calculated based on following formulas extracted from: *Roark's Formulas for Stress & Strain*, 6th Edition (Reference 1) p. 76:

Formulas:

Let:

P = applied load

t = Bottom Plate thickness

a = Bottom Plate outer radius

q = uniformly distributed load on the Bottom Plate of the Canister Shell

 r_0 = start of the uniformly distributed load (r_0 = a, load starts at the Bottom Plate center line)

A = cross-sectional area of the Canister Shell (before loading)

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L = length of the Canister Shell (before loading)

E = modulus of elasticity of the Canister Shell material

 \mathbf{v} = Poisson's ratio of the Canister Shell material

Then:

σ = uniform stress in the Canister Shell wall (tensile or compressive)

 $\sigma = P / A$

e = elongation in the Canister Shell wall

$$e = (P * L) / (A * E)$$

The outside edge of the 3.5 in thick Bottom Plate is continuously attached to 1 in thick wall of the Canister Shell. The weld between the Bottom Plate assembly including short segment of the Canister Shell wall and main segment of the Canister Shell wall is significantly away from the corner joint at the outside edge the Bottom Plate, hence away from effects of joint geometry. Based on the difference in thickness between the Bottom Plate (3.5 in) and the Canister Shell wall (1 in), boundary condition of the outer edge of the Bottom Plate can be considered partially "Fixed". The reason for this is, because of relative stiffness of the Bottom Plate and the Canister Shell wall, there will be some rotation in the joint, when the Bottom Plate is loaded. To account for this partial "fixity" of the joint at the outside edge of the Bottom Plate, it is evaluated for two separate boundary conditions: Simply Supported and Fixed. The actual behavior of the joint is somewhere between the two extremes. These analysis conditions have been addressed under Loading case 3.

Under Loading case 3, the Bottom Plate of the Canister Shell is evaluated, based on the formula's extracted from *Roark's Formulas for Stress and Strain*, 6th Edition (Reference 1) Table 24, "Formulas for flat circular plates of constant thickness," solid circular plate with uniformly distributed load from "r₀ to a," Load Case 10a, "Simply Supported" and Load Case 10b, "Fixed" outside boundary conditions, as described on p. 428 and p. 429.

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• Formulas for Plate with Simply supported outer edge:

Plate Constant D = E *
$$t^3 / 12 * (1 - v^2)$$

Page 398 (Reference 1)

Since plate is loaded with uniformly distributed load $r_0 = a$,

Maximum deflection at plate center:

$$y_c = -(q*a^4 / 64D) * {(5 + v) / (1 + v)}$$

Page 393 (Reference 1)

Maximum Moment at plate center:

$$M_c = (q*a^2 / 16) * (3 + \mathbf{v})$$

Page 393 (Reference 1)

Maximum Stress at plate center:

Max
$$\sigma = (6 * M_c) / t^2$$

Page 393 (Reference 1)

• Formulas for Plate with Fixed outer edge:

Maximum deflection at plate center:

$$y_c = -(q*a^4 / 64*D)$$

Page 429 (Reference 1)

Maximum Moment at plate center:

$$M_c = [q*a^2 * (1 + \mathbf{v}) / 16]$$

Page 429 (Reference 1)

Maximum Moment at plate outer edge:

$$M_{ra} = -[(q * a^2) / 8]$$

Page 429 (Reference 1)

Maximum Stress at plate center:

Max
$$\sigma = [6 * M_{max} (Maximum of M_c and M_{ra}) / t^2]$$

Page 398 (Reference 1)

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• Stress Concentration:

At abrupt changes of section in members made of ductile materials subjected to static loads at ordinary temperatures, the localized stresses at abrupt change of section are relieved by localized yielding of the material that occurs across intercrystalline planes. According to *Roark's Formulas for Stress and Strain*, 6th Edition (Reference 1) p. 34, "The plastic yielding that occurs on overstressing greatly mitigates stress concentration even in relatively brittle materials and causes it to have much less influence on breaking strength than might be expected from consideration of elastic stresses only. The practical significance of stress concentration therefore depends on circumstances. For ductile metal under static loading it is usually (though not always) of little or no importance;....."

This calculation considers only the static loading due to self weight on the Site Specific Canister/Basket assembly at normal temperature. All stresses are shown to be well within elastic limits. Therefore no stress concentration factors have been considered in the calculation.

3. QUALITY ASSURANCE:

The Site Specific Canister/Basket is not yet classified in the *Q-List*, (Reference 8, Table A-1, p. A-8). However, this document is subject to the requirements of *Quality Assurance Requirements and Description* (Reference 2).

4. USE OF COMPUTER SOFTWARE:

All calculations are performed using a hand held calculator. Hence no software qualification is required.

5. INPUTS:

All calculations performed in this document for the Site Specific Canister/Basket are based on the following drawings:

•	000-M0K-HAC0-00101-000	Sheet 1 of 3	Rev 00A
•	000-M0K-HAC0-00102-000	Sheet 2 of 3	Rev 00A
•	000-M0K-HAC0-00103-000	Sheet 3 of 3	Rev 00A

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6. ASSUMPTIONS:

In the course of developing this document, following assumptions are made regarding the calculations:

6.1 ASSUMPTIONS NOT REQUIRING VERIFICATION

- 6.1.1 The Poisson's ratio and density at elevated temperatures are not available for SA-240 S31603 (316L SS). The room temperature (RT) (= 20 °C) Poisson's ratio and density are assumed for this material. Impact of using RT Poisson's ratio and density is anticipated to be small. Rationale for this assumption is that these material properties do not have significant impact on the calculation results. Therefore this assumption does not require verification. This assumption is used in the Section 7 and corresponds to paragraph 5.2.8.6 of Reference 4.
- 6.1.2 The Poisson's ratio of 316L SS is not available in literature. Therefore, Poisson's ratio of 316 SS is assumed for 316L SS. Impact of this assumption is anticipated to be negligible. Rationale for this assumption is that the chemical composition of 316L SS and 316SS are similar (Reference 5, Section II, Part A, SA-240, Table 1). This assumption is used in Section 7 and corresponds to paragraph 5.2.8.4 of Reference 4.
- 6.1.3 This calculation for Site Specific Canister/Basket is based on preliminary sketches (see Attachment 1). The design, including the masses provided in Section 7 do not require verification at this phase of the design.
- 6.1.4 Dimensions for the Shear Ring for the Site Specific Canister/Basket have been obtained from drawing No.: 6254E32, Naval Spent Fuel Canister Shear Ring Detail, Rev. 00A, (see Attachment 2). The details for the Shear Ring are anticipated to be same for the Site Specific Canister/Basket. These dimensions are used in Section 7, and do not require verification in this phase of the design.

6.2 ASSUMPTIONS REQUIRING VERIFICATION

Not applicable.

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7. CALCULATIONS:

7.1 Site Specific Canister/Basket component weights: (see Assumption 6.1.3)

• BASKET ASSEMBLY:

	COMPONENT		MATERIAL	OTY.	MASS
				REQD.	(\underline{Lb})
1.	Basket Side Guide		SA-516 K02700	16	1500
2.	Basket Side Guide Stiffener		SA-516 K02700	32	142
3.	Basket End Side Guide		SA-516 K02700	32	2290
4.	Basket End Side Guide Stiffe:	ner	SA-516 K02700	64	141
5.	Basket Corner Guide		SA-516 K02700	16	1800
6.	Basket Corner Guide Stiffene	r	SA-516 K02700	32	208
7.	Fuel Basket A-Plate	Ni-Gd	Alloy (UNS N06464)	8	3160
8.	Fuel Basket B-Plate	Ni-Gd	Alloy (UNS N06464)	8	3160
9.	Fuel Basket C-Plate	Ni-Gd	Alloy (UNS N06464)	16	3330
10.	Fuel Basket D-Plate		SB-209 A96061 T4	8	720
11.	Fuel Basket E-Plate		SB-209 A96061 T4	8	720
12.	Fuel Basket Tube		SA-516 K02700	21	13,400
	Basket total weight				30,571
	Spent Nuclear Fuel (SNF)			21	35,300
	Basket and SNF total weight				65,871

• Weight on top of Canister Shell (including Shield Plug assembly):

1.	Outer Seal Plate	SA-240	31603	1	102
				2	
2.	Outer Seal Plug	SA-240		2	0.6
3.	Shear Ring	SA-240	31603	1	95
4.	Shear Ring Filler Segment	SA-240	31603	1	2.25
5.	Shield Plug	SA-240	31603	1	12,200
6.	Inner Seal Plug	SA-240	31603	2	0.6
	01:11:01				4.00
	Shield Plug assembly Total Weight				12,400

• Canister Shell:

4	Canister Shell	SA-240_316031	16.100
	(anister Shall	CA 2/111 3 16113 1	16 1181
1.	Calling Offeri	3/1-240 31003 1	10.100

Calculation

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7.2 MATERIAL PROPERTIES

The material properties used in this calculation are listed as follows. Some of the temperature dependent material properties are not available for 316L SS. Therefore, RT values for Poisson's ratio and density are used for 316L SS (see Assumption 6.1.1).

Value of each material property is required at $300 \, \text{C}$ (572 F). The material properties at $300 \, \text{C}$ are obtained by linear interpolation of the corresponding material properties by using the formula:

$$p = p(T) = p_l + \left(\frac{T - T_l}{T_u - T_l}\right) \cdot \left(p_u - p_l\right)$$

Subscripts u and l denote the upper and lower bounding values of generic material property p at the corresponding bounding temperatures.

SA-240 S31603 (316L SS):

•	Density	= 7980 kg/m ³ (0.29 Lb/in^3) (Reference 6, Table X1.1, p. 7)
•	Yield strength Yield strength	= 113 MPa (16.4 ksi) (at 500 °F = 260 °C) (Reference 5, Section II, Part D, Table Y-1) = 108 MPa (15.6 ksi) (at 600 °F = 316 °C) (Reference 5, Section II, Part D, Table Y-1)
	Yield strength	= 109 MPa (15.82 ksi) (at 572 °F = 300 °C)
•	Elongation	= 0.40 (at RT) (Reference 5, Section II, Part A, SA-240, Table 2)
•	Poisson's ratio	= 0.3 (at RT) (Reference 7, Figure 15, p. 755, see Assumption 6.1.2)
•	Modulus of elasticity	= 178 GPa (25.8 $10^6 psi$) (at 500 °F = 260 °C) (Reference 5, Section II, Part D, Table TM-1)
	Modulus of elasticity	= 174 GPa (25.3 10 ⁶ psi) (at 600 °F = 316 °C) (Reference 5, Section II, Part D, Table TM-1)
	Modulus of elasticity	= 175 GPa (25.43 $10^6 psi$) (at 572 °F = 300 °C)

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7.3 Site Specific Canister/Basket Analysis:

The Site Specific Canister/Basket is analyzed for loading conditions as described in Section 2 of this report.

• Loading case 1:

Load on top of the Canister Shell assembly, imposed by dead weight of the Shield Plug assembly, causing compressive stress in the Canister Shell walls:

Outside diameter of the Canister Shell (OD canister shell) = 66 in

Inside diameter of the Canister Shell (ID $_{canister shell}$) = 64 in

Area of the Canister Shell (wall) (A canister shell) = $\pi/4$ (OD² canister shell-ID² canister shell)

 $= \pi/4 (66^2 - 64^2) in^2$

 $= 204.2 in^2$

Weight of the Shield Plug assembly ($W_{\text{shield plug}}$) = 12,400 Lb

Stress (Compressive) in the Canister Shell

due to dead weight of the Shield Plug assembly = (W_{shield plug}) / (A_{canister shell})

 $= (12400 / 204.2) Lb / in^2$

 $= 61 Lb / in^2$

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• Loading case 2:

Load on the Bottom Plate of the Canister Shell, imposed by the Basket and the Spent Nuclear Fuel assembly dead weight, including the self weight of the Bottom Plate, during lifting operation of the Site Specific Canister/Basket assembly, causing tensile stress in the Canister Shell walls:

Outside diameter of the Canister Shell (OD canister shell) = 66 in

Inside diameter of the Canister Shell (ID canister shell) = 64 in

Area of the Canister Shell wall (A canister shell) $=\pi/4(OD^2 \text{ canister shell}) - ID^2 \text{ canister shell})$

 $= \pi/4 (66^2 - 64^2) in^2$

 $= 204.2 in^2$

Weight of the Basket assembly (W $_{basket}$) = 30,571 Lb

Weight of the SNF assembly (W $_{SNF}$) = 35,300 Lb

Outside edge diameter of the Bottom Plate (OD $_{PL}$) = 66 in

Thickness of the Bottom Plate (t $_{PL}$) = 3.5 in

Metal Area of the Bottom Plate (A _{PL}) = $\pi/4$ (OD²_{PL})

 $= \pi /4 (66^2) in^2$

 $= 3421 in^2$

Self weight of the Bottom Plate = $(Volume_{PL}) * (material density_{PL})$

= (3421*3.5)*(0.29) Lb

= 3473 Lb

Total weight on the Bottom Plate (W tot) = Weight of (Basket + SNF + Bottom Plate)

=(30,571+35,300+3473) Lb

= 69,344 *Lb*

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Stress (Tensile) in the Canister Shell due to weight of (Basket + SNF + Bottom Plate)

$$= (W_{tot}) / (A_{canister shell})$$

$$= (69,344 / 204.2) Lb / in^2$$

$$= 340 \ Lb/in^2$$

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• Loading case 3:

Load on the Bottom Plate of the Canister Shell caused by the Basket, and the Spent Nuclear Fuel assembly dead weight, and self weight of the Bottom Plate, during lifting operation of the Site Specific Canister/Basket assembly, causing stresses in the Bottom Plate.

The actual outside edge restraint condition of the Bottom Plate is realistically partially fixed, as explained in Section 2. Therefore the simply supported outside edge boundary condition of the Bottom Plate will yield slightly conservative results. Stresses with both the outside edge restraint conditions of the Bottom Plate, fixed and simply supported, will be calculated, to assure structural integrity of the Bottom Plate under the imposed loading.

The two separate outside edge boundary conditions of the Canister Bottom Plate shall be considered under Case A and Case B for this loading case evaluation of the Site Specific Canister/Basket:

- Case A: Circular Bottom Plate with outside edge restraint condition considered 'Simply Supported'.
- Case B: Circular Bottom Plate with outside edge restraint condition considered 'Fixed'.

The analysis for both the above specified outside edge boundary conditions of the Bottom Plate is performed using *Roark's Formulas for Stress & Strain* 6th Edition (Reference 1), Table 24, Formulas for flat circular plates of constant thickness, solid circular plate with uniformly distributed load from "r₀ to a," Cases 10a simply supported, and 10b fixed, described on p. 428 and p. 429 of the quoted reference.

Note: Calculations are performed based on Material properties @ 300 °C

Bottom Plate data:

Diameter of outside edge of the Bottom Plate (OD $_{PL}$) = 66 in

Thickness of the Bottom Plate (t PL) = 3.5 in

Self weight of the Bottom Plate = 3473 Lb

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Total weight on the Bottom Plate (W PL) = Weight of (Basket + SNF + Bottom Plate)

=(30,571+35300+3473) Lb

=69,344 *Lb*

Metal Area of the Bottom Plate (A PL)

 $= 3421 in^2$

Uniformly distributed load on the Bottom Plate = $(W_{PL})/(A_{PL})$

(Load per unit area of the Bottom Plate, q PL) = $69,344 / 3421 Lb / in^2$

 $= 20.27 Lb/in^2$

Modulus of Elasticity of the Bottom Plate material (E _{PL}) = 25.43*E6 Lb/in²

Poisson's ratio of the Bottom Plate material (v_{PL}) = 0.3

• Case A: Circular Bottom Plate with outside edge restraint condition considered Simply Supported.

Note:

Using equations from *Roark's Formulas for Stress & Strain* p. 393, 6th Edition (Reference 1)

The Plate constant 'D'

=
$$(E_{PL}) * (t_{PL})^3 / 12*(1- v_{PL}^2)$$

= $(25.43*E6)*(3.5)^3 / 12*(1-0.3^2)$
= $9985*10^4$

Radius of the outside edge of the Plate (a $_{PL}$) = 33 in

Plate constant (r_{o PL})

= 0.0

(radial location of start of the UDL)
(UDL starts from the center of the Plate and extends radially to the outer edge)

Since $r_{o PL} = 0$,

Maximum deflection y_{c PL} (at the center of the Bottom Plate)

=
$$-[(q_{PL})*(a_{PL}^4)*(5+v_{PL})]/(64*D*(1+v_{PL})$$

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=-
$$[(20.27*33^4)*(5+0.3)]/(64*9985*10^4)*(1+0.3)$$
 in
= -0.0153 in (approximately = 1/64 in)

Maximum Moment (M_{PL}) (at the center of the Bottom Plate)

$$= [(q_{PL})^*(a_{PL})^2)^*(3+\mathbf{v}_{PL})]/16$$

$$= [\{(20.27)^*(33^2)^*(3+0.3)\}/16] \text{ in } Lb / in$$

$$= 4553 \text{ in } Lb / in$$

$$= 6^*(M_{PL}) / t_{PL}^2$$

$$= 6^*4553 / 3.5^2 \text{ } Lb / in^2$$

$$= 2230 \text{ } Lb / in^2$$

• Case B: Circular Bottom Plate with outside edge restraint condition considered Fixed.

Note:

Using equations from *Roark's Formulas for Stress & Strain*, p. 428 and p. 429, 6th Edition (Reference 1)

The Plate constant 'D'

=
$$(E_{PL}) * (t_{PL})^3 / 12*(1-\mathbf{v}_{PL}^2)$$

= $(25.43*E6)*(3.5)^3 / 12*(1-0.3^2)$
= $9985*10^4$

Maximum deflection y_{c PL} (at the center of the Bottom Plate)

= -[
$$(q_{PL})*(a_{PL}^4) / 64D$$
]
= -[$(20.27*33^4)/(64*9985*10^4)$] in
= -0.0038 in

(approximately = 1/256 in) (< y_{c PL} with Simply Supported outside edge of the Plate)

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Maximum moment at the Bottom Plate center (M_{c PL})

$$= -[(q_{PL}) * (a_{PL}^2) * (1 + \mathbf{v}_{PL}) / 16]$$

$$= -[(20.27) * (33^2) * (1 + 0.3) / 16] in Lb / in$$

$$= 1794 in Lb / in$$

(< 4553 in Lb / in M_{c PL} with Simply Supported outside edge of the Plate)

Maximum stress in the Plate (
$$\sigma_{PL}$$
) = 6 * (M $_{PL}$) / t $_{PL}$ ²
= 6 * 1794 / 3.5² Lb / in²
= 879 Lb / in²
(< 2230 Lb / in² σ_{PL} with Simply Supported Plate edges)

Maximum moment at the Bottom Plate outside edge (M_{ra PL})

$$= -[(q_{PL} * a_{PL}^{2}) / 8]$$

$$= -[(20.27 * 33^{2}) / 8] in Lb / in$$

$$= 2759 in Lb / in$$

Maximum stress in the Bottom Plate (
$$\sigma_{PL}$$
) = 6 * (M $_{PL}$) / t $_{PL}$ ² = 6*2750 / 3.5² Lb / in² = 1351 Lb / in²

(< 2230 $Lb/in^2 \sigma_{PL}$ with Simply Supported Plate edges)

• Maximum elongation in the Canister Shell:

Maximum elongation in the Canister Shell occurs during the lifting operation of the Site Specific Canister/Basket, due to the Basket and the Spent Nuclear Fuel weight resting on the Bottom Plate and the self weight of the Canister shell, including the Bottom Plate.

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The maximum vertical deflection in the Canister Shell assembly will comprise of sum of the individual deflections, elongation in the Canister Shell and deflection in the Bottom Plate due to vertical loading.

Maximum vertical deflection in the Bottom Plate:

CaseA:

The Bottom Plate with outside edge restraint condition considered Simply

Supported.

= -0.0153 in

Case B:

The Bottom Plate with outside edge restraint condition considered Fixed.

= -0.0038 in

Elongation in the Canister Shell

= $(P*L_{canister shell}) / (A_{canister shell}*E_{canister shell})$

Dead weight causing elongation in the Canister Shell during lifting operation:

P canister shell

= Dead weight (Basket + Spent Nuclear Fuel +Canister Shell)

P canister shell

$$= (30,571 + 35,300 + 16,100)$$
 Lb

$$=(81,971)$$
 Lb

A canister shell

=
$$\pi$$
 /4 (OD² canister shell - ID² canister shell)

$$=\pi/4(66^2-64^2)$$
 in²

$$= 204.2 in^2$$

L canister shell

$$= 210.5$$
 in

Elongation canister shell

$$= (81,971 * 210.5) / (204.2 * 25.43*E6) in$$

$$= 0.0033$$
 in

Total maximum vertical deflection

= (Canister Shell elongation + maximum

Bottom Plate vertical deflection)

$$= (0.0153 + 0.0033)$$
 in

$$= 0.0186$$
 in

(approximately = 1/64 in)

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• Loading case 4:

Load on the Shear Ring caused by the weight of the Canister Shell, the Basket, and the Spent Nuclear Fuel assembly, during the Site Specific Canister/Basket lifting operation, causing shear stress in the Shear Ring.

Note: Dimensions for the Shear Ring have been obtained from the following drawing: (see Assumption 6.1.4)

Drawing Title:

Naval Spent Fuel Canister Shear Ring Detail

Drawing No.

6254E32

Rev. E

(Attachment 2)

Note: Secondary references on this Drawing are not relevant to this calculation

Plane of vertical shear in the Shear Ring is considered along the inside face of the Shear Ring. Actual radius of the shear plane will be greater than the assumed value, yielding slightly higher shear area and consequently reduced shear stress. Hence results of this calculation for Load case 4 are conservative.

Outside diameter of the Shear Ring (OD $_{SR}$) = 64.0 in

Inside diameter of the Shear Ring (ID $_{SR}$) = 61.0 in

Inside length of the Shear Ring (IDL _{SR}) = π (ID _{SR})

 $=\pi$ (61) in

= 191.64 in

Height of the Shear Ring (Ht $_{SR}$) = 1.23 in

Shear Area of the Shear Ring (A $_{SR}$) = (IDL $_{SR}$ * Ht $_{SR}$) in

= (191.64 * 1.23) in

 $= 235.71 in^2$

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Load on the Shear Ring from the Basket assembly = 30,571 Lb

Load on the Shear Ring from the SNF assembly = 35,300 Lb

Load on the Shear Ring from the Canister Shell = 16,100 Lb

Total Load on the Shear Ring (V $_{SR}$) = (30,571 + 35,300 + 16,100) *Lb*

= 81,971 *Lb*

Average Shear Stress in the Shear Ring $(\tau_{avSR}) = (V_{SR}) / (A_{SR})$

 $= (81,971 / 235.71) Lb / in^2$

 $=348 Lb/in^2$

Moment of Inertia of the Shear Ring (MI _{SR}) = $\{\pi * (ID_{SR}) * (Ht_{SR})^3 \} / 12$

 $= [\pi * (61) * (1.23)^3] / 12 in^4$

 $= 29.72 in^4$

Maximum Shear Stress in the Shear Ring (τ_{maxSR}) = (V _{SR}) * (Ht _{SR})² / 8 * (MI _{SR})

 $= (81,971 * 1.23^{2}) / (8 * 29.72) Lb / in^{2}$

 $= 522 Lb / in^2$

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• Loading case 5:

Load on the Basket End Side Guide and or the Basket Corner Guide, imposed by self weight of the Basket and the Spent Nuclear Fuel assembly with the Site Specific Canister/Basket placed in horizontal position, while the Basket and the Spent Nuclear Fuel assembly are stored inside the Site Specific Canister/Basket.

In this position the weight of the Basket and the Spent Nuclear Fuel assembly is transferred to the Canister shell through the Basket Side Guide plates and or the Basket Corner Guide plates. Minimum of 2 edges of 3/8 in wide plate of the Basket Side Guide or the Basket Corner Guide would be in contact with Canister Shell inside face, along the entire length of the Basket Side Guide or Corner Guide, at any one time.

Load on the Basket Side Guide = Weight of (Basket + SNF) = (30,571 + 35,300) Lb= (65,871) Lb

Area of the face (edge) of the Basket Side Guide plate or the Corner Guide plate in contact

with the Canister Shell inside face = $(2 * 191 * 0.375) in^2$ = $143.25 in^2$

Stress (Compressive) in Basket Side Guide (or Corner Guide) plate

$$= (65,871 / 143.25) Lb/in2$$
$$= 460 Lb/in2$$

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8. RESULTS:

The following results obtained from the analysis are reasonable compared to the inputs and are suitable for intended use.

Results of this calculation are tabulated according to the Loading Cases described in Section 2 of this calculation, and are as follows:

Loading Case 1:

Maximum Stress (Compressive)

in the Canister Shell

= 61 Lb/in^2 < yield strength (=15.82 ksi)

Loading Case 2:

Maximum Stress (Tensile)

in the Canister Shell

= 340 Lb/in^2 < yield strength (=15.82 ksi)

Loading Case 3:

Maximum Stress (Bending)

in the Canister Bottom Plate

= 2230 Lb/in^2 < yield strength (=15.82 ksi)

Maximum displacement (vertical)

in the Canister Shell assembly

= 0.0186 in (approximately 1/64 in)

Loading Case 4:

Maximum Stress (Shear)

in the Shear Ring

= $522 Lb / in^2$ < yield strength (= 0.42*15.82 ksi) = 6.64 ksi

Loading Case 5:

Maximum Stress (Compressive)

in the Basket Side Guide plate

= $460 Lb/in^2$ < yield strength (=15.82 ksi)

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9. REFERENCES:

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10. ATTACHMENTS:

Attachment 1:

000-M0K-HAC0-00101-000

Sheet 1 of 3

Rev. 00A

Site Specific Canister / Basket

000-M0K-HAC0-00102-000

Sheet 2 of 3

Rev. 00A

Site Specific Canister / Basket

000-M0K-HAC0-00103-000

Sheet 3 of 3

Rev. 00A

Site Specific Canister / Basket

Attachment 2:

Drawing No.: 6254E32

Rev. E

Naval Spent Fuel Canister Shear Ring Detail





