ENCLOSURE 4

Non-Proprietary - NUH32PHB-0201, Revision 0

Calvert Cliffs Nuclear Power Plant, LLC
June 19, 2012

Non-Proprietary Version

AREVA TRANSNUCLEAR INC.	**Form 3.2-1 Calculation Cover Sheet** TIP 3.2 (Revision 4)	Calculation No.:	NUH32PHB-0201
		Revision No.:	0
		Page: 1 of 36	

DCR NO (if applicable) : NA	PROJECT NAME: NUHOMS® 32PHB System
PROJECT NO: 10955	CLIENT: CENG - Calvert Cliff Nuclear Power Plant (CCNPP)

CALCULATION TITLE:

NUHOMS® 32PHB Weight Calculation of DSC/TC System

SUMMARY DESCRIPTION:

1) Calculation Summary

The nominal weight of the NUHOMS® 32PHB storage package is calculated. The primary difference between the 32PHB and 32P DSC designs is the replacement of the steel/aluminum frame basket rails with solid aluminum rails. Also the transfer cask is modified to include forced air cooling, which has bolted wedges at the bottom and cut outs in the cask lid.

2) Storage Media Description

Secure network server initially, then redundant tape backup

If original issue, is licensing review per TIP 3.5 required?

Yes ☐ No ☒ (explain below) Licensing Review No.: _____

This calculation is prepared to support a Site Specific License Application by CCNPP that will be reviewed and approved by the NRC. Therefore, a 10CFR72.48 licensing review per TIP 3.5 is not applicable.

Software Utilized (subject to test requirements of TIP 3.3):	**Version:**
None	N/A

Calculation is complete:	
Originator Name and Signature: Abhijit Honrao	Date: 04/06/10
Calculation has been checked for consistency, completeness and correctness:	
Checker Name and Signature: Veeresh Sayagavi	Date: 04-06-2010
Calculation is approved for use:	
Project Engineer Name and Signature: Kamran Tavassoli	Date: 04/06/10

REVISIONS

REV.	DESCRIPTION OF CHANGES	AFFECTED PAGES	AFFECTED Computational I/O
0	Initial Issue	All	All

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1.0 Purpose

The purpose of this calculation is to calculate nominal weight of the NUHOMS® 32PHB storage package. The primary distinction between the 32PHB and 32P designs is the replacement of the steel/aluminum basket rails with solid aluminum rails and forced air cooling option in the Cask.

2.0 References

2.1 BGE Calculation No. CA03988, Rev. 2, "Final Weight Calculation of NUHOMS-24P DSC/TC System".

2.2 TN Calculation No.1095-1, Rev. 1, "NUHOMS 32P – Weight Calculation of DSC / TC System" or CCNPP Calculation No. CA06319, Rev.0, "NUHOMS 32P – Weight Calculation of DSC / TC System".

2.3 TN Sketches for 32PHB DSC and Transfer Cask (Included as Appendix).

2.4 TN Design Criteria Document, NUH32PHB.0101, Rev. 0, "Design Criteria Document (DCD) for the NUHOMS® 32PHB System for Storage".

2.5 R. E. Taylor, H. Root and J. Larimore, "Thermal Conductivity of Aluminum –Boron Alloy", Properties Research Laboratory, May 1989, West Lafayette, Indiana.

3.0 Assumptions

1. The thickness of aluminum/poison plate thickness for 32PHB DSC is different as compared to the 32P DSC, but the total thickness remains same. The density of poison is assumed to be same as aluminum [2.5] hence weight is not affected.
2. The difference in the density of pure water and borated water is negligible. The density of water used in the calculations is that of pure water.
3. Bounding fuel assembly weight of 1,375 lbs is used per Ref. [2.4], Table 4-2.
4. The component weights rounding off to the nearest integer is considered having insignificant effect on the overall weight of the NUHOMS® 32PHB storage package.

4.0 Methodology

The 32PHB DSC is identical to 32P DSC, except the following changes; a) 32PHB basket has solid Aluminum rails compared to Stainless Steel rails for 32P basket, b) Different thickness of aluminum/poison plates are used within the basket. For the 32PHB DSC only the solid Aluminum rails mass properties are calculated and rest of DSC components are referred to Ref. [2.2]. The other minor design changes are the top lead shielding thickness, lead plug top casing plate, top plug assembly lifting lug, basket key and DSC lifting lug.

The 32PHB transfer cask is identical to 24P transfer cask; the only changes made to the cask are the bolted wedges, the cutouts in the cask lid for the forced air cooling option and the lid plate thickness.

Material Densities

Aluminum (6061) 0.098 lb/in^3 [2.1]

Water	0.0361 lb/in^3 [2.1]
Steel	0.286 lb/in^3 [2.1]

5.0 Computation

5.1 *32PHB Canister Assembly*

32PHB DSC is identical to 24P DSC Ref. [2.1] except a few design modifications. The top lead shielding thickness is changed from 4.38" to 4.0 inches and the top shield plug casing plate thickness is to 0.75" from 0.38". 24P DSC has a 6" long basket key, for the 32PHB DSC 151.63" long key is used.

Due to these changes the components affected are

a. Lead Shielding:

Lead Shielding 24P DSC weight = 5944 lb Ref. [2.1]

Lead Shielding 32PHB DSC weight = 5944 x 4.0 / 4.38 **= 5,428 lb**

b. Lead Plug Top Casing Plate:

Weight from 24P DSC = 359 lb Ref. [2.1]

Weight for 32PHB DSC = 359 x 0.75 / 0.38 **= 709 lb**

c. Top Plug Assembly Lifting Lug:

Weight from 24P DSC = 9 lb Ref. [2.1]

Weight for 32PHB DSC = 9 x 4.0 / 4.38 **= 8 lb**

d. Basket Key:

Weight from 24P DSC = 2 lb Ref. [2.1]

Weight for 32PHB DSC = 0.5 x 0.75 x 151.63 x 0.286 **= 16 lb**

e. Lifting Lug: (Section 9.0, NUH32PHB-30-3, Sheet 1)

Volume of Lifting Lug = 4 x 4.25 x 5.5 x 1.25 = 116.9 in^3 (Assuming plate)

Weight of Lifting Lug = 116.9 x 0.286 **= 33 lbs**

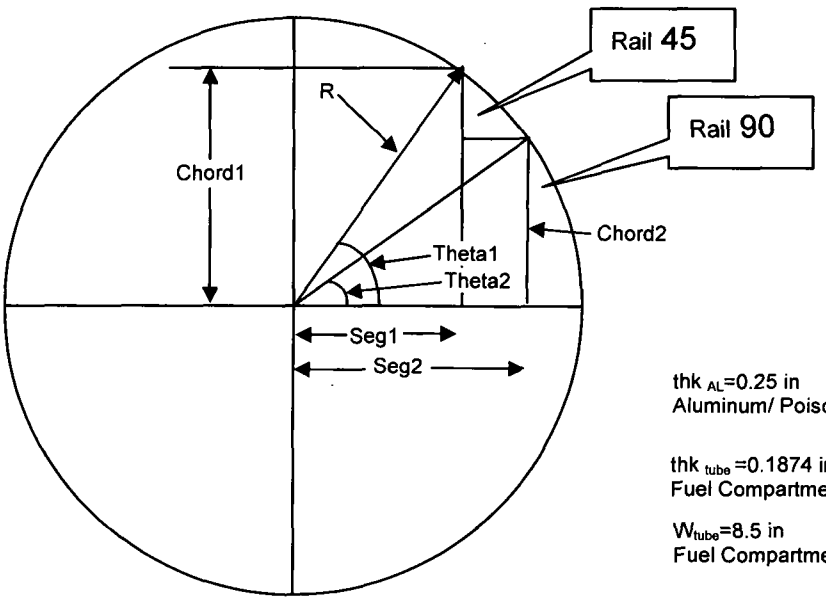
All other component weights are taken from Ref. [2.1]. Table 1 summarizes the DSC component weights.

5.2 *32PHB Basket*

32PHB basket assembly is identical to 32P basket assembly except the Stainless Steel rails are changed to solid Aluminum rails and the thickness of aluminum/poison plate thicknesses are different.

The total thickness of the aluminum and poison is identical to the 32P basket. Since the density of aluminum and poison is same, there is no change in the weight of the aluminum/poison plates when compared to the 32P basket.

Solid Aluminum Rails:



thk_{AL}=0.25 in
Aluminum/ Poison Plate thk

thk_{tube}=0.1874 in
Fuel Compartment Tube thk

W_{tube}=8.5 in
Fuel Compartment Width

$Seg_1 = 2.thk_{AL} + 4.thk_{tube} + 2.W_{tube} = 18.2496$ in

$Seg_2 = 3.thk_{AL} + 6.thk_{tube} + 3.W_{tube} = 27.3744$ in

$Chord_1 = sqrt\{ R^2 - Seg_1^2 \}$

$= sqrt\{ 32.75^2 - 18.2496^2 \}$

$= 27.1940$ in

$Chord_2 = sqrt\{ R^2 - Seg_2^2 \}$

$= sqrt\{ 32.75^2 - 27.3744^2 \}$

$= 17.9779$ in

$Theta_1 = Cos^{-1}(Seg_1 / R)$

$= 0.9797$ rad

$Theta_2 = Cos^{-1}(Seg_2 / R)$

= 0.5811 rad

Sector $_1$ = R^2 x Theta$_1$ /2

= 32.75^2 x 0.9797 / 2 = 525.3947 in^2

Sector $_2$ = R^2 x Theta$_2$ /2

= 32.75^2 x 0.5811 / 2 = 311.6330 in^2

Area R90 = Sector $_2$ – ½ Seg $_2$ Chord $_2$

= 311.6330 – ½ x 27.3744 x 17.9779

= 65.5659 in^2

Area R45 = Sector $_1$ – ½ Seg $_1$ x Chord$_1$ – Chord $_2$ x (Seg $_2$ –Seg $_1$) – Area90

= 525.3947 – ½ x 18.2496 x 27.194– 17.9779 x (27.3744-18.2496) -65.5659

= 47.6442 in^2

Total Volume R90 = 8 x Area R90 x Length

= 8 x 65.5659 x 158 = 82,875 in^3

Total Weight R90 = 82,875 x 0.098

= 8,122 lb

Total Volume R45 = 4 x Area R45 x Length

= 4 x 47.6442 x 158 = 30,111 in^3

Total Weight R45 = 30,111 x 0.098

= 2,951 lb

All other basket components are identical to 32P Basket Ref. [2.2]. Table 1 summarizes the Basket component weights.

Table 1 DSC Component Weights Summary

Component	Volume (in^3)	Weight (lbs)	Ref.
Canister Shell	**21,864**	**6,253**	[2.1] Pg. 15
Bottom Cover Plate	6,216	1,778	[2.1] Pg. 15
Lead Shielding	14,650	6,021	
Lead Casing Plate	1,623	464	
Grapple Ring Assembly Plate	124	35	
Grapple Ring Plate	123	35	
Lead Casing Shell	498	142	
Grapple Ring Shell	269	77	
Bottom Plug Post	30	9	
Total Bottom End Assembly	**23,533**	**8,561**	
Inner Cover Plate	5,107	1,461	[2.1] Pg. 18
Lead Shielding	13,208	5,428	Sec. 5.1
Lead Plug top Casing Plate	2,477	709	
Top Plug Assembly Lifting Lug	28	8	
Drain and Fill Cover Plate	1	0	[2.1] Pg. 18
Top Cover Plate	4,245	1,214	
Lead Plug Side Casing Plate	491	140	
Top Plug Post	Included	Included	
Backing Bar	51	14	
Total Top End Assembly	**25,608**	**8,974**	
Support Ring	307	88	[2.1] Pg. 17
Tubing and Connectors		4	
Lifting Lug	117	33	Sec. 5.1
Drain and Fill Port	504	144	[2.1] Pg. 17
Basket Key	57	16	Sec.5.1
Total Miscellaneous	**985**	**285**	
TOTAL CANISTER ASSEMBLY	**71,990**	**24,073**	
Basket Components			
Fuel Compartment Tubes	32,925	9,548	[2.2] Pg. 2
Steel Plates	5,572	1,616	
Aluminum/Poison Plates	21,347	2,092	
BASKET COMPONENTS	59,844	13,256	
Basket Rails			
Rail 90	82,875	8,122	Sec. 5.2
Rail 45	30,111	2,951	Sec. 5.2
TOTAL -- BASKET RAILS	112,986	11,073	
TOTAL BASKET ASSEMBLY	**172,830**	**24,329**	
DSC TOTAL-- EMPTY	**244,820**	**48,402**	
Fuel Assembly	134,080	44,000	
TOTAL-- LOADED DSC	**378,900**	**92,402**	

5.3 *Transfer Cask*

The 32PHB transfer cask is identical to 24P transfer cask except a few design modifications.

a. Bolted wedges used at the cask bottom.

b. The lid has 8" x 7" x 1.5" cutouts in the lid for the forced air option (Pg. 34, Sketches).

c. The inner top cover plate of the transfer cask lid thickness is reduced from 1" to 0.5" and the outer top cover plate is increased from 2.5" to 3".

All other component weights are taken from Ref. [2.1] except the modified component weights.

5.3.1. Bolted Wedges

(Refer Sketches on Pg. 33 for dimensions and quantity)

No. of bolted wedges	= 10	
Width at the top	= 11.57"	
Thickness	= 0.5"	
Outer Diameter	= 65.75"	
Inner Diameter	= 28"	
Height of Triangle	= (65.75-28)/2 – 1 = 17.875	[Pg. 33, Sketches]
Area of Triangle	= 0.5 x 17.875 x 11.57 = 103.41 in^2	
Total Volume	= 103.41 x 10 x 0.5 = 517.1 in^3	
Total Weight	= 103.41 x 10 x 0.5 x 0.286 = 148 lbs	

5.3.2. Lid Cutouts

(Refer Sketches on Pg. 34 for dimensions and quantity)

No. of cutouts	= 16
Cutout	= 8.0" x 7.0" x 1.5"
Cutout Height (Bottom half)	= [69.95 – (80.0 – 2x7.0)]/2 = 1.975"
Cutout Height (Top half)	= 7.0 – 1.975 = 5.025"
Width	= 8.0"
Depth	= 1.5" (1.0" in top half outer cover plate and 1.5" in bottom half outer cover plate)
Total Volume	= 16 x 8 x (5.025 x 1 + 1.975 x 1.5) = 1022 in^3
Total Weight	= 1022 x 0.286 = 292 lbs

5.3.3. Outer Top Cover Plate

The weight of Outer Top Cover Plate is calculated in Ref. [2.1]. The top outer cover plate design in modified per Sketches provided in Appendix.

Top Cover Plate Bottom Half (volume) = 3816 x 0.5 / 1.0 = 1,908 in^3

Top Cover Plate Bottom Half (Weight) = 1,909 x 0.286 = 546 lbs

Top Cover Plate Top Half (volume) = 10,053 x 2.5 / 2.0 = 12,566 in^3

Top Cover Plate Top Half (Weight) = 12,566 x 0.286 = 3,594 lbs

Table 2 summarizes all the inner and outer shell assembly weights. Table 3 summarizes the transfer cask component weights.

Table 2 Inner and Outer Shell Assembly Weights Summary

Component	Volume (in^3)	Weight (lbs)	
Top Flange	10,624	3,039	[2.1] Pg.19
Structural Shell, 1.5in	43,419	12,288	
Bottom Support Ring	12,216	3,494	
Bottom Cover Plate	5,806	1,660	
Ram Access Penetration Ring	995	285	
Upper Trunnion Sleeve	1,082	309	
Structural Shell, 2in	21,344	6,040	
Lower Trunnion Sleeve	519	148	
Structural Shell Assembly	**96,005**	**27,263**	
Inner and Outer Shell Assembly			
Structural Shell Assembly	96,005	27,263	
Inner Shell	27,093	7,748	[2.1] Pg.22
NSP Support Ring	849	243	
NSP Support Angle	4,524	1,294	
Lead Shielding	152,860	62,826	
Neutron Shield Panel	11,104	3,176	
Relief Valve	Included		
NSP Support Ring Bottom Plate	849	243	
Rails	121	34	
Lower Trunnion	531	152	
Upper Trunnion	970	277	
Inner and Outer Shell Assembly	**294,906**	**103,256**	

Table 3 Transfer Cask Component Weights Summary

Cask Main Assembly	Volume (in^3)	Weight (lbs)	
Inner and Outer Shell Assembly	294,906	103,256	Table 2
Castable Neutron Sheilding (A)	14,981	953	[2.1] Pg.24
Castable Neutron Sheilding (B)	13,271	844	
Castable Neutron Sheilding (C)	174,548	11,101	
Castable Neutron Sheilding (D)	176	11	
Trunnion Cover Plate	79	22	
Top Cover Plate (Bottom Half)	1,908	546	Sec. 5.3.3
Top Cover Plate (Top Half)	12,566	3,594	
Forced Air Lid Cut-out	-1,022	-292	Sec. 5.3.2
Bolted Wedges	517	148	Sec. 5.3.1
Plater for Top Cover (Item # 5)	900	257	[2.1] Pg. 24
Plater for Top Cover (Item # 6)	128	37	
Stand Off Rod	99	28	[2.1] Pg. 25
Plate for Top Cover	155	44	
Eyebolt		4	
Bottom Cover Plate (Ram access)	363	104	
Plate for Bottom Cover (1")	64	18	
Plate for Bottom Cover (0.5")	47	13	
Bottom End Plate	2,781	795	
Trunnion Cover Plate	2	0	
Cover Plate	Included		
Plug Plate	Included		
Eyebolt		1	
Bolt with Washer	Included		
Eyebolt		1	
Accessories	4,045	570	[2.1] Pg. 26
Cask Main Assembly	**520,514**	**122,055**	

5.4 *Water in Cavity*

Inside DSC Shell Assy.	543,115 cu in	[2.2]
DSC Total	613,610 cu in.	[2.2]
Basket Volume	172,830 cu in.	Table 1
Fuel Assy. Vol.	134,080 cu in.	[2.2]

Note: Using lower fuel assembly volume would result in more water inside the cask. Thus using a lower volume for the fuel assembly is bounding for weight calculation.

Transfer Cask inside Vol. = Transfer Cask Cavity – Wedges Volume

$$= \frac{\pi}{4} x 68.0^2 x 173.5 - 517$$

Transfer Cask inside Vol. = 629,580 cu in.

Weight of annulus water = (629,580 – 613,610) x 0.0361 = 577 lb.

Weight of water in DSC = (543,115 – 172,843 – 134,080) x 0.0361 = 8,527 lb

Weight of water to fill space of DSC Cover plate = 153 lb Ref. [2.1]

Weight of water to fill space of Cask Top

= (Top cover plate Vol. – Forced air cutouts Vol.) x 0.0361

= (1,909 + 12,566 – 1,022) x 0.0361 = 486 lb

Weight of water to fill Grapple Ring Annulus Space = 33 lb Ref. [2.1]

Total Weight of Water = 577 + 8,527 + 153 + 486 + 33 = 9,776 lb.

6.0 Weight Summary

Table 4 summarizes the NUHOMS® 32PHB DSC weight for storage and transfer configuration.

Table 4 NUHOMS® 32PHB DSC/TC Weight Summary

	Component	Weight (lbs)
1	Cask without Head or Ram Access Cover	115,874
2	Cask Lid	5,464
3	DSC without Top Cover Plate/ Basket/ Fuel	22,859
4	DSC Top Cover Plate	1,214
5	Basket	24,329
6	Fuel	44,000
7	Water (Remaining Space of Loaded DSC and Cask)	9,776
8	Ram Access Plugs	570
9	Ram Access Cover Plate	147
	Cask Lifting With Water and Loaded DSC (1+3+5+6+7+9)	**216,985**
	Cask Lifting With Sealed DSC Transport (1+2+3+4+5+6+9)	**213,887**
	Loaded DSC With Water (3+5+6+7)	**100,964**
	Sealed DSC (3+4+5+6)	**92,402**
	Cask Docked at HSM With Sealed DSC (1+2+3+4+5+6+8)	**214,310**
	CASK (EMPTY)	122,055
	32PHB DSC (EMPTY)	48,402
	Fuel Assembly	44,000
	32PHB DSC (LOADED), DRY	**214,457**

7.0 List of Files

Below is listing of computer file used for computing the weights of NUHOMS®32PHB DSC/TC System.

File Name	Time	Description
NUH32PHB-0201_rev0.xls	1/22/2010 9:57:50	Component weight calculation using excel spread sheet.

Note: The date & time are reported by the OS on the report issue date; these values may be changed by windows depending on time of the year (e.g., daylight savings time) and time zones.

8.0 Conclusions

The nominal weight of the NUHOMS® 32PHB storage package is calculated. The sketches for the DSC and the transfer cask are provided in the Appendix.

9.0 APPENDIX – SKETCHES

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD PURSUANT TO 10 CFR 2.390

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