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Design Calculation or Analysis Cover Sheet

Complete only applicable items.

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2. Page 1

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5. Title

Comparison of WHF Fuel Pool Sloshing for the 2004 Versus 2007 Seismic Input Ground Motions for the Wet Handling Facility (WHF)

6. Group

Civil / Structural / Architectural

7. Document Status Designation

☐ Preliminary ☒ Committed ☐ Confirmed ☐ Cancelled/Superseded

8. Notes/Comments

None

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None	0

RECORD OF REVISIONS

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00A	Initial Issue	15	15	Prithvi R Gandhi JAN 30/08	Paresh D. Patel 01/30/08	James Dockery 1/30/08	Raj Rajagopal 1/30/08

DISCLAIMER

The calculations contained in this document were developed by Bechtel SAIC Company, LLC (BSC) are intended solely for the use of BSC in its work for the Yucca Mountain Project.

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ATTACHMENTS

NONE

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ACRONYMS

BDBGM	Beyond Design Base Ground Motion (10000 Year Return Period)
DBGM-2	Design Basis Ground Motion (2000 Year Return Period)
PDC	Project Design Criteria
Ref.	Reference
WHF	Wet Handling Facility
YMP	Yucca Mountain Project

1. PURPOSE

The purpose of this calculation is to evaluate the sloshing of water due to seismic events in the spent fuel pool of the Waste Handling Facility (WHF), using updated 2007 Seismic Design Spectra and compare its results with those from calculation 050-SYC-WH00-00400-000-00A, which used 2004 Seismic Design Spectra to evaluate the sloshing of water.

2. REFERENCES

2.1 PROJECT PROCEDURES/DIRECTIVES

2.1.1 BSC (Bechtel SAIC Company) 2007. EG-PRO-3DP-G04B-00037, Rev. 10, *Calculations and Analyses*. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071018.0001

2.1.2 BSC (Bechtel SAIC Company) 2007. IT-PRO-0011 Rev.007, *Software Management*. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20070905.0007.

2.2 DESIGN INPUTS

2.2.1 BSC (Bechtel SAIC Company) 2007. *Basis of Design for the TAD Canister-Based Repository Design Concept*. 000-3DR-MGR0-00300-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071002.0042.

2.2.2 MO0706DSDR5E4A.001. *Seismic Design Spectra for the Surface Facilities Area at 5E-4 APE for Multiple Dampings. Submittal date: 06/14/2007 (*DIRS 181422)(TBV-9157).

2.2.3 MO0706DSDR1E4A.001. *Seismic Design Spectra for the Surface Facilities Area at 1E-4 APE for Multiple Dampings. Submittal date: 06/14/2007 (*DIRS 181421)(TBV-9156).

2.2.4 BSC (Bechtel SAIC Company) 2007. *WHF Pool Sloshing Evaluation* 050-SYC-WH00-00400-000-00A, Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070227.0007

2.2.5 BSC (Bechtel SAIC Company) 2007, *Wet Handling Facility General arrangement Pool Plan and Sections D,H,J;* 050-P10-WH00-00107-000-00B, Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071205.0037

2.3 DESIGN CONSTRAINTS

None

2.4 DESIGN OUTPUTS

None

3. ASSUMPTIONS

3.1 ASSUMPTIONS REQUIRING VERIFICATION

3.1.1 The calculation WHF Pool Sloshing Evaluation (Ref. 2.2.4) evaluates the sloshing of water on 48", 72", and 96" feet thick walls during a seismic event. Ref. 2.2.5 shows that there is a 24" thick wall in the spent fuel pool. This calculation does not address the sloshing on the two feet thick wall. It is assumed that the sloshing on a 24" thick wall be evaluated during the detailed design phase.

Rational: This calculation is for a preliminary design phase. A more sophisticated calculation during the detailed design phase will evaluate sloshing on a 24" thick wall. This assumption is being tracked in CalcTrac.

Where used: Section 6

3.2 ASSUMPTIONS NOT REQUIRING VERIFICATION

None

4. METHODOLOGY

4.1 QUALITY ASSURANCE

This calculation was prepared in accordance with EG-PRO-3DP-G04B-00037, *Calculations and Analyses* (Ref. 2.1.1). Section 5.1.2 of the *Basis of Design for the TAD Canister-Based Repository Design Concept* (Ref. 2.2.1) classifies the WHF structure as Important to Safety (ITS). Therefore, the record version of this document is designated as QA: QA.

4.2 USE OF SOFTWARE

MS Excel 2000, part of the Microsoft Office professional version 2000 (Software Tracking number 610236-2000-00) suite of programs and Mathcad version 13 (Software tracking number 611161 – 13 – 00), were used in preparation of this document. Microsoft

Office 2000 is classified as Level 2 software as defined in IT-PRO-0011, Software Management, (Ref. 2.1.2). Microsoft Office 2000 is listed on the current Level 2 Usage Controlled Software Report. There are no inputs or outputs for MS Excel 2000 and Mathcad. The checking of Excel 2000 tabulations and Mathcad computations is performed using visual inspection and hand calculations. Microsoft Office Excel 2000 and Mathcad 13 were executed on a PC (Intel Pentium Dell computer) with Windows 2000 Version 5.0 service pack 4 operating system.

4.3 METHODOLOGY

The analysis method consists of the following steps.

- From the calculation *WHF Pool Sloshing* Evaluation (Ref. 2.2.4), extract natural time periods of the pool with sloshing water for all calculated cases.

- Using Seismic Design Response Spectra from *Seismic Design Spectra for the Surface Facilities Area at 5E-4 APE for Multiple Dampings* (Ref. 2.2.2) and *Seismic Design Spectra for the Surface Facilities Area at 1E-4 APE for Multiple Dampings* (Ref. 2.2.3) determine acceleration values corresponding to the above time periods for DBGM-2 and BDBGM respectively. In Ref. 2.2.4 the time periods are broadened by adjusting them 10% up and down in the ascending acceleration. The determination of acceleration will involve interpolation and broadening of time periods similar to Ref. 2.2.4.

- Present comparison tables for accelerations DBGM-2 and BDBGM seismic events.

- Since the results of sloshing, i.e. hydrodynamic pressures on the pool walls and the freeboard are proportional to the accelerations, make a rational judgment on the results of sloshing using 2007 seismic design spectra and its impact on the WHF pool sloshing evaluation.

5. LIST OF ATTACHMENTS

None

6. Body of Calculation

Water sloshing on 24" thick wall in the spent fuel pool is not evaluated in this calculation. See assumption 3.1.1

Time periods of the impulsive mode: Ref. 2.2.4 page 13

$T_{ins48} := .188$ Time period in the north/south direction with 48" thick wall

$T_{ins72} := .113$ Time period in the north/south direction with 72" thick wall

$T_{ins96} := .08$ Time period in the north/south direction with 96" thick wall

$T_{iew48} := .191$ Time period in the east/west direction with 48" thick wall

$T_{iew72} := .115$ Time period in the east/west direction with 72" thick wall

$T_{iew96} := .081$ Time period in the east/west direction with 96" thick wall

Time periods of the convective mode: Ref. 2.2.4 page 13

$T_{cns} := 4.901$ Time period in the north/south direction

$T_{cew} := 5.492$ Time period in the east/west direction

Time periods for the vertical response spectra: Ref. 2.2.4 page 14

$T_{v48} := .034$ Time period with 48" wall

$T_{v72} := .027$ Time period with 72" wall

$T_{v96} := .023$ Time period with 96" wall

Determination of design accererations are based on the 2007 site specific response spectra and the above periods. The accelerations are interpolated from DTN: MO0706DSDR5E4A.001 (Ref. 2.2.2) for the DBGM-2 event, and DTN: MO0706DSDR1E4A.001 (Ref. 2.2.3) for the BDBGM event. Similar to *WHF Pool Evaluation (*Ref. 2.2.4) the time periods will be broadened by adjusting them 10% up or down in the direction of increasing accelerations to ensure maximum accelerations.

The accelrations are determined by interpolation as follows:

$A_i = A_1 + (A_2 - A_1) \times ((T_1 - \beta T_i) / (T_1 - T_2))$ if the seismic design spectra is descending

$A_i = A_1 - (A_1 - A_2) \times ((T_1 - \beta T_i) / (T_1 - T_2))$ if the seismic design spectra is ascending

Where:

A_i = Acceleration corresponding to time period T_i

A_1 = Acceleration corresponding to time period T_1

A_2 = Acceleration corresponding to time period T_2

T_i = Natural Time period of interest of spent fuel pool

T_1 = First period from the tables of the above referenced DTN's that is greater than $\beta_1 T_i$

T_2 = Period from the tables of the above referenced DTN's that preceeds T_1

β = Broadening Factor = 0.9 if the response spectra curve is descending;
= 1.1 if the response spectra curve is ascending

<u>Impulsive mode accelerations in g's based on 5% damping for the DBGM-2 seismic event using 2007 tables of Ref. 2.2.2:</u>

$$A_{ins48DBGM2} := 1.1201 + (1.1581 - 1.1201)\cdot\frac{0.201 - 0.9\cdot T_{ins48}}{0.201 - 0.167}$$

$A_{ins48DBGM2} = 1.156$ Acceleration in north/south direction with 48" thick wall

$$A_{iew48DBGM2} := 1.1201 + (1.1581 - 1.1201)\cdot\frac{0.201 - 0.9\cdot T_{iew48}}{0.201 - 0.167}$$

$A_{iew48DBGM2} = 1.153$ Acceleration in east/west direction with 48" thick wall

$$A_{ins72DBGM2} := 1.1863 + (1.1863 - 1.1894)\cdot\frac{0.110 - .9\cdot T_{ins72}}{0.110 - 0.100}$$

$A_{ins72DBGM2} = 1.184$ Acceleration in north/south direction with 72" thick wall

$$A_{iew72DBGM2} := 1.1863 + (1.1863 - 1.1894)\cdot\frac{0.110 - .9\cdot T_{iew72}}{0.110 - 0.100}$$

$A_{iew72DBGM2} = 1.184$ Acceleration in east/west direction with 72" thick wall

$$A_{ins96DBGM2} := 1.1894 - (1.1894 - 0.8330)\cdot\frac{0.100 - 1.1\cdot T_{ins96}}{0.100 - 0.050}$$

$A_{ins96DBGM2} = 1.104$ Acceleration in north/south direction with 96" thick wall

$$A_{iew96DBGM2} := 1.1894 - (1.1894 - 0.8330)\cdot\frac{0.100 - 1.1\cdot T_{iew96}}{0.100 - 0.050}$$

$A_{iew96DBGM2} = 1.112$ Acceleration in east/west direction with 96" thick wall

<u>Impulsive mode accelerations in g's based on 5% damping for the BDBGM seismic event using 2007 tables of Ref. 2.2.3:</u>

$$A_{ins48BDBGM} := 2.3200 + (2.3430 - 2.32)\cdot\frac{0.201 - 0.9\cdot T_{ins48}}{0.201 - 0.167}$$

$A_{ins48BDBGM} = 2.342$ Acceleration in north/south direction with 48" thick wall

$$A_{iew48BDBGM} := 2.3200 + (2.3430 - 2.32)\cdot\frac{0.201 - 0.9\cdot T_{iew48}}{0.201 - 0.167}$$

$A_{iew48BDBGM} = 2.34$ Acceleration in east/west direction with 48" thick wall

$$A_{ins72BDBGM} := 2.3954 + (2.4037 - 2.3954)\cdot\frac{0.110 - .9\cdot T_{ins72}}{0.110 - 0.100}$$

$A_{ins72BDBGM} = 2.402$ Acceleration in north/south direction with 72" thick wall

$$A_{iew72BDBGM} := 2.3954 + (2.4037 - 2.3954)\cdot\frac{0.110 - .9\cdot T_{iew72}}{0.110 - 0.100}$$

$A_{iew72BDBGM} = 2.401$ Acceleration in east/west direction with 72" thick wall

$$A_{ins96BDBGM} := 2.4037 - (2.4037 - 1.6421)\cdot\frac{0.100 - 1.1\cdot T_{ins96}}{0.100 - 0.050}$$

$A_{ins96BDBGM} = 2.221$ Acceleration in north/south direction with 96" thick wall

$$A_{iew96BDBGM} := 2.4037 - (2.4037 - 1.6421)\cdot\frac{0.100 - 1.1\cdot T_{iew96}}{0.100 - 0.050}$$

$A_{iew96BDBGM} = 2.238$ Acceleration in east/west direction with 96" thick wall

Convective mode accelerations in g's based on 0.5% damping for the DBGM-2 seismic event using 2007 tables of Ref. 2.2.2:

$$A_{cnsDBGM2} := 0.0556 + (0.1267 - 0.0556)\cdot\frac{4.978 - 0.9\cdot T_{cns}}{4.978 - 3.351}$$

$A_{cnsDBGM2} = 0.08$ Acceleration in north/south

$$A_{cewDBGM2} := 0.0109 + (0.0556 - 0.0109)\cdot\frac{10.000 - 0.9\cdot T_{cew}}{10.000 - 4.978}$$

$A_{cewDBGM2} = 0.056$ Acceleration in east/west

Convective mode accelerations in g's based on 0.5% damping for the BDBGM seismic event using 2007 tables of Ref. 2.2.3:

$$A_{cnsBDBGM} := 0.1158 + (0.2686 - 0.1158)\cdot\frac{4.978 - 0.9\cdot T_{cns}}{4.978 - 3.351}$$

$A_{cnsBDBGM} = 0.169$ Acceleration in north/south

$$A_{cewBDBGM} := 0.1158 + (0.2686 - 0.1153)\cdot\frac{4.978 - 0.9\cdot T_{cew}}{4.978 - 3.351}$$

$A_{cewBDBGM} = 0.119$ Acceleration in east/west

Vertical mode accelerations in g's based on 5% damping for the DBGM-2 seismic event using 2007 tables of Ref. 2.2.2:

$$A_{V48DBGM2} := 0.7660 - (0.7660 - 0.6161)\cdot\frac{0.050 - 1.1\cdot T_{v48}}{0.050 - 0.034}$$

$A_{V48DBGM2} = 0.648$ Vertical acceleration with 48" thick wall

$$A_{V72DBGM2} := 0.6161 - (0.6161 - 0.5235)\cdot\frac{0.034 - 1.1\cdot T_{v72}}{0.034 - 0.025}$$

$A_{V72DBGM2} = 0.572$ Vertical acceleration with 72" thick wall

$$A_{V96DBGM2} := 0.6161 - (0.6161 - 0.5235)\cdot\frac{0.034 - 1.1\cdot T_{v96}}{0.034 - 0.025}$$

$A_{V96DBGM2} = 0.527$ Vertical acceleration with 96" thick wall

Vertical mode accelerations in g's based on 5% damping for the BDBGM seismic event using 2007 tables of Ref. 2.2.3:

$$A_{V48BDBGM} := 1.7859 - (1.7859 - 1.4388)\cdot\frac{0.050 - 1.1\cdot T_{v48}}{0.050 - 0.034}$$

$A_{V48BDBGM} = 1.513$ Vertical acceleration with 48" thick wall

$$A_{V72BDBGM} := 1.4388 - (1.4388 - 1.2086)\cdot\frac{0.034 - 1.1\cdot T_{v72}}{0.034 - 0.025}$$

$A_{V72BDBGM} = 1.329$ Vertical acceleration with 72" thick wall

$$A_{V96BDBGM} := 1.4388 - (1.4388 - 1.2086) \cdot \frac{0.034 - 1.1 \cdot T_{v96}}{0.034 - 0.025}$$

$A_{V96BDBGM} = 1.216$ Vertical acceleration with 96" thick wall

Table 1 Impulsive Mode Accelerations

Impulsive mode acceleration direction	DBGM-2		BDBGM	
	2004*	2007	2004**	2007
	(g)	(g)	(g)	(g)
North/south direction with 48"wall	1.208	1.156	2.497	2.342
North/south direction with 72"wall	1.2404	1.184	2.5531	2.402
North/south direction with 96"wall	1.2124	1.104	2.4872	2.221
East/west direction with 48"wall	1.2059	1.153	2.4955	2.34
East/west direction with 72"wall	1.2415	1.185	2.5512	2.401
East/west direction with 96"wall	1.216	1.112	2.493	2.238

Notes

1 * 2004 DBGM-2 accelerations are extracted from Reference 2.2.4 page 15
** 2004 BDBGM accelerations are extracted from Reference 2.2.4 page 15

Table 2 Convective Mode Accelerations

Convective Mode	DBGM-2		BDBGM	
Acceleration Direction	2004*	2007	2004**	2007
	(g)	(g)	(g)	(g)
North/south direction	0.0823	0.08	0.2367	0.169
East/west direction	0.0617	0.056	0.1823	0.119

Notes

1 * 2004 DBGM-2 accelerations are extracted from Ref. 2.2.4 page 16
** 2004 BDBGM accelerations are extracted from Ref. 2.2.4 page 16

Table 3 Vertical Mode Accelerations

Vertical Mode Acceleration with	DBGM-2		BDBGM	
	2004*	2007	2004**	2007
	(g)	(g)	(g)	(g)
48" Wall	0.898	0.648	2.523	1.513
72" Wall	0.8278	0.572	2.3564	1.329
96" Wall	0.7801	0.527	2.2461	1.216

Notes

1 * 2004 DBGM-2 accelerations are extracted from Ref. 2.2.4 page 16
** 2004 BDBGM accelerations are extracted from Ref. 2.2.4 page 17

7. RESULTS AND CONCLUSIONS

7.1 Results

Tables 1, 2, and 3 list accelerations in impulsive mode, convective mode, and vertical mode respectively for both DBGM-2 and BDBGM events.

These three tables show that all acceleration values using the 2004 seismic design spectra are larger than corresponding accelerations using 2007 seismic design spectra.

Since the hydrodynamic pressures on the pool walls as well as the freeboard are directly proportional to the acceleration values, the accelerations using 2004 seismic design spectra will bound these results.

7.2 Conclusion

WHF spent fuel pool design calculations were based on the 2004 seismic design spectra. Since the accelerations based on 2004 seismic design spectra are larger than those based on 2007 seismic design spectra, the WHF pool sloshing forces, pressures and calculated freeboard are carried out for the bounding conditions and are adequate.

Therefore, no further revisions to the WHF pool sloshing evaluation are required.

BSC

Calculation/Analysis Change Notice

Complete only applicable items.

1. QA: QA
2. Page 1 of 1

3. Document Identifier:	4. Rev.:	5. CACN:
050-SYC-WH00-01500-000	00A	001

6. Title:

Comparison of WHF Fuel Pool Sloshing for the 2004 versus 2007 Seismic Input Ground Motions for the Wet Handling Facility (WHF)

7. Reason for Change:

The design response spectra shown in Ref.2.2.2 and Ref. 2.2.3 of this calculation have been qualified with a caveat indicating that spectral values of points with a period of 3.33 second and above are plotted incorrectly. As a result it has been determined that the highest period at which the spectral values are qualified is 2 seconds. This caveat limits the data in DTNs MO0706DSDR5E4A.001 and MO0706DSDR1E4A.001

DTNs MO0706DSDR5E4A.001 and MO0706DSDR1E4A.001 have been included in the calculation in accordance with Procedure EG-3DP-G04B-00037 Section 3.2.2 F. An assumption is being added to the calculation to document adequate justification to use information that is outside the qualified range of the design spectra.

8. Supersedes Change Notice: ☐ Yes If, Yes, CACN No.: _____ X No

9. Change Impact:

Inputs Changed:	☒ Yes	☐ No	Results Impacted:	☐ Yes	☒ No
Assumptions Changed:	☒ Yes	☐ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change:

Remove from Ref. 2.2.2 the statement "TBV-9157" and from Ref. 2.2.3 the statement "TBV-9156" from the references because of the qualification of the DTN.

Add the following assumption requiring verification:

3.1.2 MO0706DSDR5E4A.001 (Ref.2.2.2) and MO0706DSDR1E4A.001 (Ref. 2.2.3) have been qualified with a caveat that limits the validity of results for SSCs with frequencies greater than 0.5 hertz (below 2 second period). Calculation 050-SYC-WH00-00400-000-00A (Ref. 2.2.4) relies on response acceleration above 2 second period for convective modes of pool sloshing. Use the 2007 response spectra for evaluation of pool sloshing.

Rational: This calculation along with Calculation 050-SYC-WH00-00400-000-00A (Ref. 2.2.4) is for the initial design phase. For a given damping value amplitudes of spectral accelerations generally decrease as the period increase beyond peak spectral acceleration point. Therefore, it is probable that the amplitudes of the spectral accelerations for the convective modes, which have periods at approximately 5 seconds, will be lower than the amplitudes at 2 seconds. Additionally, the amplitudes of the spectral accelerations for the 2007 spectra are generally lower than the amplitudes for the 2004 spectra. Therefore, it is probable that the qualified spectral accelerations will be lower than the 2004 spectral accelerations for all ranges of the period. Assumptions 3.1.1 and 3.1.2 are being tracked in CalcTrac database.

Where used: Section 6

As a result it is reasonable to assume that the spectral accelerations values used in this calculation are acceptable. However revisions to the design response spectra will be made in the future to include updated qualified data for the periods greater than 2 seconds and at that time this assumption will be verified.

11. REVIEWS AND APPROVAL

Printed Name	Signature	Date
11a. Originator: Anant Varkekar	A Varkekar	3/1/2008
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11d. DEM: Raj Rajagopal	Raj Rajagopal	3/4/2008
11e. Design Authority: Barbara Rusinko	B Rusinko	3/4/08