ENERCON	CALCULATION COVER SHEET	TXUT-001-FSAR 2.4.7-CALC-029
		REV. 0
		PAGE NO. 1 of 9
Title:	Accumulated Freezing Degree Days and Maximum Potential Ice Sheet Thickness for Comanche Peak Nuclear Power Plant Units 3 and 4	Client: Luminant
		Project: MITS063 – Luminant COLA

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions that require confirmation? (If YES, identify the assumptions)_____		X
2	Does this calculation serve as an "Alternate Calculation"? (If YES, identify the design verified calculation.) Design Verified Calculation No._____		X
3	Does this calculation supersede an existing calculation? (If YES, identify the superseded calculation.) Superseded Calculation No._____		X

Scope of Revision:

Revision Impact on Results:

Study Calculation	☐	Final Calculation	☒
Safety-Related	☒	Non-safety-Related	☐

(Print Name and Sign)

Originator: Anubhav Gaur A Gaur	Date: 08/14/09
Design Verifier: Bryan Cline Bryan A. Cline	Date: August 14, 2009
Approver: Pat Brunette Pat Brunette Joe Mancinelli J P Mancinelli	Date: 8/14/09 8/14/09

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0		Original Calculation

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
All	0		

APPENDIX REVISION STATUS

APPENDIX NO.	PAGE NO.	REVISION NO.	APPENDIX NO.	PAGE NO.	REVISION NO.
N/A					

ENERCON	CALCULATION DESIGN VERIFICATION PLAN AND SUMMARY SHEET	TXUT-001-FSAR 2.4.7-CALC-029 REV. 0 PAGE NO. 3 of 9

Calculation Design Verification Plan:

Apply CSP Number 3.01, Revision 6, Section 4.5.a, Design Review Method and to include at a minimum:

1. Determine if the calculation provides a reasonable estimate of the Accumulated Freezing Degree Days and the Maximum Potential Ice Sheet Thickness.
2. Review the design methodology and determine if it is appropriate and correctly applied and is accurate.

(Print Name and Sign for Approval – mark "N/A" if not required)

Approver:	Pat Brunette Pat Brunette Joe Mancinelli J F Mancinelli	Date: 8/14/09 8/14/09

Calculation Design Verification Summary:

I have reviewed the Comanche Peak site Accumulated Freezing Degree Days and the Maximum Potential Ice Sheet Thickness activity calculation and have made the following conclusions:

1. The guidelines for the ice activity calculation are appropriate and applicable for the determination of the Accumulated Freezing Degree Days and the Maximum Potential Ice Sheet Thickness.
2. The calculation for the Accumulated Freezing Degree Days and the Maximum Potential Ice Sheet Thickness report follows the correct procedures.
3. The Accumulated Freezing Degree Days and the Maximum Potential Ice Sheet Thickness summary tables' calculations have been independently verified.
4. The Originator has addressed the recommendations, which were given during the review process.

Based on the above summary, the calculation is determined to be acceptable.

(Print Name and Sign)

Design Verifier: Bryan Cline Bryan A. Cline	Date: August 14, 2009
Others:	Date:

ENERCON	CALCULATION DESIGN VERIFICATION CHECKLIST	TXUT-001-FSAR 2.4.7-CALC-029 REV. 0 PAGE NO. 4 of 9

Item	Cover Sheet Items	Yes	No	N/A
1	Design Inputs - Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis and incorporated in the calculation?	X		
2	Assumptions – Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	X		
3	Quality Assurance – Were the appropriate QA classification and requirements assigned to the calculation?	X		
4	Codes, Standard and Regulatory Requirements – Were the applicable codes, standards and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?	X		
5	Construction and Operating Experience – Have applicable construction and operating experience been considered?			X
6	Interfaces – Have the design interface requirements been satisfied, including interactions with other calculations?	X		
7	Methods – Was the calculation methodology appropriate and properly applied to satisfy the calculation objective?	X		
8	Design Outputs – Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs?	X		
9	Radiation Exposure – Has the calculation properly considered radiation exposure to the public and plant personnel?			X
10	Acceptance Criteria – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?	X		
11	Computer Software – Is a computer program or software used, and if so, are the requirements of CSP 3.02 met?	X		

COMMENTS:

(Print Name and Sign)

Design Verifier: Bryan Cline Bryan A. Cline	Date: August 14, 2009
Others:	Date:

Table of Contents

1.0 Purpose And Scope

Determine the accumulated freezing degree days (AFDD) and maximum potential thickness of sheet ice (surface ice growth on water bodies) for the Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4.

2.0 Summary Of Results And Conclusions

The average maximum AFDD for the CPNPP Units 3 and 4 is about 100°F days. The resulting maximum potential maximum ice thickness is 7 inches.

3.0 References

1. Jones, K.F., J.E. Friddell, S.F. Daly, and C.M. Vuyovich, "Severe Winter Weather in the Continental U.S. and Global Climate Cycles," U.S. Army Corps of Engineers TR-04-19, October 2004.

2. U.S. Army Corps of Engineers, "Engineering and Design: Ice Engineering," EM 1110-2-1612, September 30, 2006.

3. U.S. Army Corps of Engineers, "Ice Engineering, Method to Estimate River Ice Thickness Based on Meteorological Data," TN-04-3, June 2004.

4. U.S. Geological Survey, Geospatial Data Gateway Website, http://datagateway.nrcs.usda.gov/gatewayhome.html, accessed December 27, 2007.

4.0 Assumptions

None

5.0 Design Inputs

The CPNPP Units 3 and 4 locations from the USGS Hill City, TX Quadrangle NAD83 (Reference 4) are as follows:
32° 18' 10" N
97° 47' 30" W

6.0 Methodology

The ice thickness can be estimated using following simplified equation:

$h = \alpha * (U)^{1/2}$ (Reference 2, Equation 2-10, Page 2-12)

where h = ice thickness

α = coefficient (given by table 2-2 of EM 1110-2-1612 – see below)

U = accumulated freezing degree days (AFDD)

Table 6-1. Typical values of coefficient α

Table 2-2
Typical Values of α (after Michel 1971)

Ice Cover Condition	α *	α †
Windy lake w/no snow	2.7	0.80
Average lake with snow	1.7–2.4	0.50–0.70
Average river with snow	1.4–1.7	0.40–0.50
Sheltered small river	0.7–1.4	0.20–0.40

* AFDD calculated using degrees Celsius. The ice thickness is in centimeters.
† AFDD calculated using degrees Fahrenheit. The ice thickness is in inches.

(Reference 2, Table 2-2 Page 2-13)

The U.S. Army Corps of Engineers equation 2-10 is a simplified version of a more complete differential equation based on the following assumptions:

- That the ice is a homogenous, horizontal layer.
- That the ice is growing only at its horizontal interface with the water.
- That the thermal conditions in the ice are quasi-steady.
- That the heat flux from the water is negligible.
- That the heat fluxes are in the vertical direction only.
- That the heat loss rate from the ice surface to the atmosphere is a linear function of the temperature difference between the ice surface and the air.

U.S. Army Corps of Engineers (USACE) EM 1110-2-1612 (Reference 2) indicates that for natural ice covers, the assumptions may not always hold true. However, USACE EM 1110-2-1612 (Reference 2) also indicates that equation 2-10 still represents a good, practical model of ice growth, and that there has been no indication that applying more extensive data collection would provide a more accurate model.

7.0 Calculations

The USACE guidance "Severe Winter Weather in the Continental U.S. and Global Climate Cycles, TR-04-19 (Reference 1)

$h = \alpha * (U)^{1/2}$

AFDD is estimated based on the location of CPNPP Units 3 and 4 on Figure 1 (Reference 1). The CPNPP Units 3 and 4 is located in north central Texas as shown on Figure 1. The CPNPP Units 3 and 4 is under the division 1-100 Average Maximum AFDD. An AFDD of 100 °F Days is estimated to be more conservative.

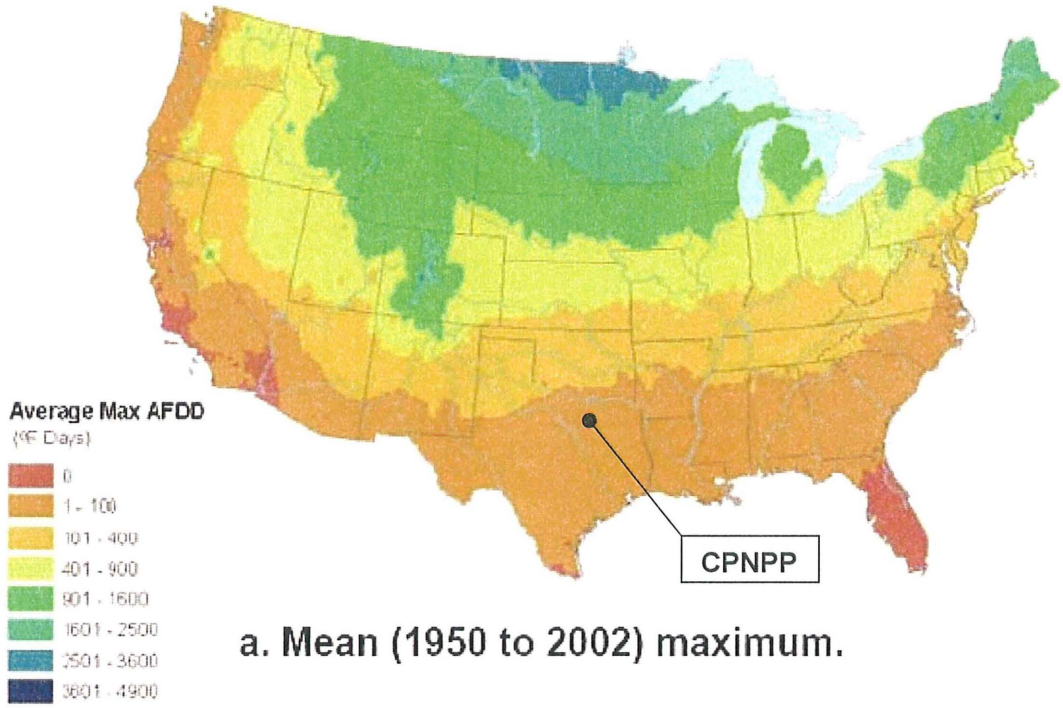

Figure 1. AFDD for the Continental U.S. (Reference 1, Figure 2 Page 7).

CPNPP Units 3 and 4 are located on a peninsula near the Squaw Creek Reservoir (SCR). Based on Table 2-2 of EM 1110-2-1612 (provided in Section 6.0 above), the location would be most appropriately classified as an "average lake with snow". The alpha coefficient ranges from 0.5 to 0.7 for the category "average lake with snow". According to TN-04-3 (Reference 3, page 3), the coefficient usually ranges between 0.3 and 0.6 when using °F. Assuming the worst case scenario, α = 0.7. This value is the maximum of identified range and is judged to be a conservative coefficient.

$h = 0.7 * (100)^{1/2} = 7$ inches

The AFDD and ice thickness are recalculated using metric units to verify the estimates obtained using English units.

As discussed in TN-04-03 (equation 1 page 2) a freezing degree day (FDD) in Fahrenheit is defined as:

$$FDD°F = (32 - T_a)$$

where T_a = average daily air temperature in °F

Therefore, in Celsius the freezing degree day equation becomes:

$$FDD°C = (0 - T_a)$$

where T_a= average daily air temperature in °C

However, if T is in °F, then the equation becomes:

$$FDD°C = (0 - (T_a - 32) \bullet \frac{5}{9})$$

where T_a = average daily air temperature °F

The AFDD in degree Fahrenheit can be estimated using equation shown below as discussed in TR-04-19 (Reference 1)

$$U°F = \sum_{i=0}^{n} (T_m - T_i) \quad \text{for } (T_m - T_i) > 0$$ (Reference 1, Equation 1, Page 3)

$$U°F = \sum_{i=0}^{n} (32 - T_i) = 32 \bullet (n+1) - \sum_{i=0}^{n} T_i = \sum FDD°F$$

Therefore, the accumulated freezing degree days in Celsius equation is defined as:

$$U°C = \sum FDD°C = \sum_{i=0}^{n} (0 - (T_i - 32) \bullet \frac{5}{9}) = 0 \bullet (n+1) - (\sum_{i=0}^{n} T_i - 32 \bullet (n+1)) \bullet \frac{5}{9}$$

$$= \frac{5}{9} \bullet (32 \bullet (n+1) - \sum_{i=0}^{n} T_i)`$$

Substituting the U°F solution into the U°C equation, the equation becomes:

$$U°C = \frac{5}{9} \bullet U°F$$

Therefore given that U°F = 100°F Days from above:

$$U°C = \frac{5}{9} \bullet 100°F = 55.6°C \text{ Days}$$

The metric alpha coefficient is selected from Table 2-2 EM 1110-2-1612 (provided in Section 6.0 above). The selected English coefficient, α = 0.7, is the maximum of the "average lake with snow" category range of 0.5 to 0.7. Therefore, using the metric "average lake with snow" category, the coefficient range is from 1.7 to 2.4. The maximum metric coefficient is α = 2.4. This value is the maximum of identified range and is judged to be a conservative coefficient.

Solving for thickness using metric units:
$h = \alpha * (U)^{1/2} = 2.4 * (55.6)^{1/2} = 17.9$ cm

Checking the result by conversion to English units:
Thickness = 17.9 cm * 1 in / 2.54 cm = 7 inches
This result is equivalent to the English units calculation above.

8.0 Appendices

N/A