NRC Question

Please provide the current Departure from Nucleate Boiling Ratio (DNBR) probability distribution function (pdf) being used at SONGS Units 2 and 3 to determine fuel failure for UFSAR Chapter 15 events. Specifically, provide the table in the format of CENPD-183-A, Table 2.

SCE Response

The NRC requested table is provided with a short chronology of the DNBR pdf evolution since the approval of CENPD-183-A [Reference 1]. The DNBR pdf documented in Table 2 of CENPD-183-A is based on a DNBR Specified Acceptable Fuel Design Limit (SAFDL) of 1.19 and does not include system parameters uncertainties, which were applied deterministically in the thermal-hydraulics (T-H) model used to calculate DNBR. As described in the Statistical Combination of Uncertainties (SCU) document (CEN-283(S)-P) [Reference 2], the DNBR pdf subsequently evolved to include system parameter uncertainties statistically. The components of the DNBR pdf based on the methodology provided in CEN-283(S)-P are:

Mean of distribution (μ) =1.097945
Standard deviation of distribution (σ) = 0.1291
K = 1.645 at 95/95 probability/confidence level
DNBR SAFDL = $\mu + K\sigma$ = 1.31

In the 1990's, SONGS Units 2 and 3 adopted the Modified SCU methodology of CEN-356(V)-P-A [Reference 3]. The use of the Modified SCU methodology is described in the NRC approved SCE Reload Analysis Methodology Topical Report [Reference 4]. The Modified SCU methodology reorganized some of the individual components of the DNBR pdf, resulting in a slight variant of the previously described SCU DNBR pdf. The Modified SCU DNBR pdf fuel damage table, based on the methodology provided in CEN-356(V)-P-A, is enclosed as Table 1. This pdf fuel damage table resulted in the DNBR limit of 1.305 (which rounds up to the same 1.31 DNBR SAFDL). As expected, at the DNBR value of 1.305 the DNBR pdf of Table 1 shows a fuel failure probability of approximately 5%. The DNBR pdf in Table 1 along with a DNBR SAFDL of 1.31 is currently used in SONGS Units 2 and 3 for UFSAR chapter 15 fuel failure calculations.

References:

1) CENPD-183-A, "Loss of Flow – CE Methods for Loss of Flow Analysis," June 1984 (Westinghouse/CE Proprietary information)

2) CEN-283(S)-P, "Statistical Combination of Uncertainties, Part 1, Combination of System Parameter Uncertainties in Thermal Margin Analyses for SONGS Units 2 and 3," June 1984 (Westinghouse/CE Proprietary information)

3) CEN-356(V)-P-A, Revision 01-P-A, "Modified Statistical Combination of Uncertainties", May 1988 (Westinghouse/CE Proprietary information)

4) SCE-9801-P-A, Reload Analysis Methodology for the San Onofre Nuclear Generating Station Units 2 and 3, June 1999 (Westinghouse/CE Proprietary information)

TABLE 1
DNBR PROBABILITY DISTRIBUTION FUNCTION BASED ON MSCU CEN-356(V)-P-A, REVISION 01-P-A
(CURRENTLY IN USE AT SONGS UNITS 2 & 3)

DNBR	Probability of fuel Damage		DNBR	Probability of fuel Damage
1.53	0.001		1.26	0.095
1.49	0.002		1.25	0.111
1.46	0.003		1.24	0.119
1.45	0.004		1.23	0.138
1.43	0.006		1.22	0.158
1.42	0.007		1.21	0.168
1.41	0.008		1.20	0.190
1.40	0.011		1.19	0.213
1.39	0.012		1.18	0.238
1.38	0.015		1.17	0.250
1.37	0.017		1.16	0.277
1.36	0.021		1.15	0.305
1.35	0.026		1.14	0.335
1.34	0.029		1.13	0.350
1.33	0.036		1.12	0.381
1.32	0.039		1.11	0.412
1.31	0.047		1.10	0.444
1.30	0.057		1.09	0.461
1.29	0.062		1.08	0.493
1.28	0.074		1.07	0.537
1.27	0.080		1.06	0.583
			1.05	0.606

Mean of distribution (μ) =1.07596
Standard deviation of distribution (σ) = 0.13913
K = 1.645 at 95/95 probability/confidence level
DNBR SAFDL = $\mu + K\sigma$ = 1.305 (rounded up to 1.31)