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NOTE TO: Jack Duncan, GE

FROM: Glenn Kelly, PRAB, DREP, NRR

SUBJECT: CALCULATION OF SEQUENCE AND PLANT HCLPF FOR THE ABWR

As we discussed in the March 24, 1992 meeting at San Jose, I am documenting how to calculate HCLPF values for the ABWR. Enclosed are instructions on turning fragility curves into HCLPFs. These instructions are the same as those I provided to you verbally at the meeting. Also enclosed is a table of seismic Boolean equations used by BNL and EQE to develop their estimates of the HCLPF for the ABWR.

Enclosures: as stated

To Calculate HCLPF

In many seismic PRAs, the fragility of a component has been represented by a double lognormal model using three parameters: (1) median ground acceleration capacity A_m, logarithmic standard deviations β_R and β_U representing, respectively, (2) randomness in the capacity and (3) uncertainty in the median value. Using the double lognormal model, the fragility curves as shown in Figure 2-1 are developed. The median capacity, β_R and β_U, are estimated using design-analysis information, test data, earthquake experience data, and engineering judgment (Kennedy et al., 1980; Kennedy and Ravindra, 1984). The median capacity can be estimated as a product of an overall median safety factor times the SSE peak ground acceleration for the plant. The overall safety factor is a product

of a number of factors representing the conservatisms at different stages of analysis and design. When the linear scaling of response is not appropriate (e.g., soil sites), the median capacity is evaluated directly using median structural and equipment response parameters, median material properties and ductility factors, median static capacity predictions, and realistic structural modeling and method of analysis.

The HCLPF capacity is calculated using this fragility model as:

$$\text{HCLPF capacity} = A_m \exp[-1.65(\beta_R + \beta_U)]$$

Further details on the development of A_m, β_R, and β_U values for a given component may be obtained from the cited references.

Table 4.4-1 BNL Summary of ABWR Seismic Boolean Equations

Class IA	$SE*K1*LOP*(PW*UR*X1+\overline{PW}*UH*X*(PC+UR)$
Class IB-2	$SE*(K1*\overline{UR}+K2*C)*LOP*PW*(X1+FA)$
Class IC	$SE*\overline{SI}*LOP*C*(\overline{PW}*LPL+\overline{X1}*PW*UR2+K3*(PA+\overline{X2}*UR2)*UH*V)$
Class ID	$SE*K1*LOP*(\overline{X1}*PW*UR*FA+K4*UH*(PC+UR)*(V+HX))$
Class IE	$SE*(SI+LOP*C*UR2*(PW*X1+K3*K5*UH*X2))$
Class II	$SE*\overline{SI}*LOP*(K6*PW+K7*(HX+W1)+K8*(PC+UR)*W1*UH+(K9+K10*PA)*C*W2)$
Class IV	$SE*\overline{SI}*\overline{UR2}*LOP*PW*C*FCTR$
Class IV-1	$SE*\overline{SI}*\overline{FCTR}*K3*K5*K11*LOP*C*C4*W2$
Class IV-2,3,5	$SE*K12*LOP*C*(C42*(\overline{PC2}+K13*\overline{PA})+PC2*FCTR*(K14*UR2*UH+K11*PA*C4+K13*PA))$

where

$K1 = \overline{SI}*\overline{C}$ $\qquad$ $K2 = \overline{SI}*\overline{UR2}*\overline{FCTR}$

$K3 = \overline{PW}*\overline{PC2}$ $\qquad$ $K4 = \overline{PW}*\overline{X}$

$K5 = \overline{PA}*\overline{LPL}$ $\qquad$ $K6 = \overline{X1}*\overline{FA}*(\overline{C}+\overline{UR2}*\overline{FCTR})$

$K7 = \overline{PW}*\overline{C}*(\overline{PC}*\overline{UR}+\overline{UH})$

$K8 = \overline{PW}*\overline{C}*\overline{X}*\overline{V}*\overline{HX}$

$K9 = \overline{PW}*\overline{LPL}*\overline{PC2}*\overline{PA}*\overline{C4}*(\overline{UR2*UH}+\overline{X2}*\overline{V}*\overline{FCTR})$

$K10 = \overline{PW}*\overline{LPL}*\overline{PC2}*\overline{C42}*\overline{FCTR}*K13$

$K11 = \overline{UR2}*\overline{UH}+\overline{X2}*\overline{V}$

$K12 = \overline{SI}*\overline{PW}*\overline{LPL}$

$K13 = \overline{UH*V}$ $\qquad$ $K14 = \overline{PA}*\overline{X2}*\overline{V}$