MISSISSIPPI POWER & LIGHT COMPANY
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P. O. BOX 1640, JACKSON, MISSISSIPPI 39215-1640

February 26, 1986

O. D. KINGSLEY, JR.
VICE PRESIDENT NUCLEAR OPERATIONS

U. S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation
Washington, D. C. 20555

Attention: Mr. Harold R. Denton, Director

Dear Mr. Denton:

SUBJECT: Grand Gulf Nuclear Station
Unit 1
Docket No. 50-416
License No. NPF-29
Additional Information
Requested at 1/9/86
Turbine Disc Meeting
AECM-86/0055

Following the January 9, 1986 meeting between the Nuclear Regulatory Commission (NRC) and Mississippi Power and Light (MP&L), the staff requested that MP&L provide an example calculation illustrating the usage of the equations provided in Engineering Report ER-8503. This report was used as the basis for justifying the inspection interval of 50,000 hours and was provided as Attachment IV to AECM-85/0033, dated November 1, 1985.

An example calculation illustrating each step of the calculations performed in ER-8503 is provided as an attachment to this letter.

If additional information is required, please contact us.

Yours truly,

ODK:bms
Attachment

cc: (See Next Page)

A001
1/1

cc: Mr. T. H. Cloninger (w/a)
Mr. R. B. McGehee (w/a)
Mr. N. S. Reynolds (w/a)
Mr. H. L. Thomas (w/o)
Mr. R. C. Butcher (w/a)

Mr. James M. Taylor, Director (w/a)
Office of Inspection & Enforcement
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dr. J. Nelson Grace, Regional Administrator (w/a)
U. S. Nuclear Regulatory Commission
Region II
101 Marietta St., N. W., Suite 2900
Atlanta, Georgia 30323

Example for Calculation of P_i (t)

LP Rotor 3, Disk 2 TS ; Grand Gulf Unit 1

Tangential Stress :	84 Ksi
Fracture Toughness :	178 Ksi $\sqrt{in}$
Metal Temp., T	220 °F ≙ 220 + 460 = 680 °R
Yield strength, $Rp_{0,2}$	139 Ksi
Service Time, t	50,000 hours

1. Crack growth rate

mean value :

$$R_m = e^{\left(-4.968 - \frac{7302}{T} + 0.0278 \cdot Rp_{0.2}\right)}$$

$$R_m = e^{\left(-4.968 - \frac{7302}{680} + 0.0278 \cdot 139\right)} = e^{-11.842}$$

$$R_m = 7.196 \cdot 10^{-6} \text{ in/hr}$$

Density function with standard deviation s = 0.587

$$f(\ln R) = \frac{1}{s \cdot \sqrt{2\pi}} \cdot e^{-\frac{1}{2s^2}(\ln R - \ln R_m)^2}$$

(normal distribution for ln R)

Crack depth after 50,000 hours

$$a_{0i}(t) = R \cdot t = R \cdot 50\,000$$

$$f_t(a_{0i}) = \frac{f(\ln R)}{R \cdot t}$$ (Log-normal distribution for $a_{0i}(t)$)

$$f_t(a_{0i}) = \frac{1}{R \cdot t \cdot s \cdot \sqrt{2\pi}} \cdot e^{-\frac{1}{2s^2}(\ln R - \ln R_m)^2}$$

$$f_t(a_{0_i}) = \frac{1}{R \cdot 5 \cdot 10^4 \cdot 0.587 \cdot \sqrt{2\pi}} \cdot e^{-\frac{1}{2 \cdot 0.587^2}(\ln R - \ln 7.196 \cdot 10^{-6})^2}$$

$$f_t(a_{0_i}) = \frac{1.359 \cdot 10^{-5}}{R} \cdot e^{-1.451(\ln R + 11.842)^2}$$

e.g.:

$$f_t(a_{0_i}{=}1) = \frac{1.359 \cdot 10^{-5}}{1/50{,}000} \cdot e^{-1.451(\ln(1/50000) + 11.842)^2} = 0.149\ \frac{1}{\text{in}}$$

2. Density Function for a_{c_i}

$$a_c = \frac{Q}{1.21 \cdot \pi} \left(\frac{K_{IC}}{k/K \cdot \sigma} \right)^2 - \frac{d}{2}$$

$$a_c = \frac{Q}{1.21 \cdot \pi} \left(\frac{178}{k/K \cdot 84} \right)^2 - 0.394$$

$$a_c = 1.181 \ \frac{Q}{(k/K)^2} - 0.394$$

Q = uniformly distributed from 0.77 to 2.2

k/K = normal distributed with mean value 0.65
and standard deviation s = 0.175

$$\varphi(k/K) = \frac{1}{0.175 \cdot \sqrt{2\pi}} \cdot e^{-\frac{1}{2 \cdot 0.175^2}(k/K - 0.65)^2}$$

$$\varphi(k/K) = 2.280 \cdot e^{-16.327(k/K - 0.65)^2}$$

min Value of a_c is given for $Q = 0.77$ and $k/K = 1$

$$a_{c_{min}} = 1.181 \frac{0.77}{1^2} - 0.394 = 0.515 \text{ in}$$

Density function $g(a_{c_i})$ is given by numerical calculation with variation of Q and k/K and begins at $a_{c_{min}}$.

e.g.:

$$\Delta Q = \frac{2.2 - 0.77}{10} = 0.143, \text{ Frequency of } Q_1 = \frac{1}{10}$$

$$Q_1 = 0.77 + \frac{0.143}{2} = 0.842$$

$$\Delta (k/K) = 0.01$$

$$(k/K)_1 = 1 - 0.01 = 0.99$$

$$\varphi(k/K)_1 = 2.280 \cdot e^{-16.327 (0.99 - 0.65)^2} = 0.345$$

$$\text{Frequency of } (k/K)_1 = 0.345 \cdot 0.01 = 3.45 \cdot 10^{-3}$$

$$a_{c_1} = 1.181 \cdot \frac{0.842}{(0.99)^2} - 0.394 = 0.621 \text{ in}$$

Frequency of a_{c_1} (calculated by Q_1 and $(k/K)_1$)

$$= \frac{1}{10} \cdot 3.45 \cdot 10^{-3} = \underline{\underline{3.45 \cdot 10^{-4}}}$$

3. Probability of disk rupture $P_i(t)$

$$P_i(t) = \text{Probability}\left[a_{0i}\ (t) \geq a_{ci}\right]$$

It can be evaluated through the density functions $f\ (a_{0i})$ and $g(a_{ci})$ with the known convolution integral

$$P_i(t) = \int_0^{\infty} f_t\,(a_{0i}) \cdot \int_0^{a_{0i}} g(a_{ci}) \cdot da_{0i} \cdot da_{ci}$$

by numerical integration.

a_{0i}	$f_t(a_{0i})$	$\int_0^{a_{0i}} g(a_{ci}) \cdot da_{ci}$	da_{0i}	$f_t(a_{0i}) \cdot da_{0i} \int_0^{a_{0i}} g(a_{ci}) \cdot da_{ci}$
0.515	1.095	0		0
0.6	0.775	$\approx 5.5 \cdot 10^{-4}$	0.085	$\approx 3.62 \cdot 10^{-5}$
0.7	0.510	$\approx 2.87 \cdot 10^{-3}$	0.1	$\approx 1.46 \cdot 10^{-4}$
0.8	0.336	$\approx 5.76 \cdot 10^{-3}$	0.1	$\approx 1.94 \cdot 10^{-4}$
0.9	0.222	$\approx 1.04 \cdot 10^{-2}$	0.1	$\approx 2.31 \cdot 10^{-4}$
1.0	0.149	$\approx 1.8 \cdot 10^{-2}$	0.1	$\approx 2.68 \cdot 10^{-4}$
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
				$\Sigma\, 2.35 \cdot 10^{-3}$