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ALPHA CORRELATION

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March 24, 1960

ALPHA CORRELATION

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PURPOSE

This study was developed to provide a correlation for the evaluation of the pile $C_{RI}/\text{Tube } C_{RI}$ ratio (alpha value) for each of the Hanford reactors.

INTRODUCTION

In the past, alpha values for all of the reactors have been estimated from a single correlation involving ECT/AT . This relationship, first proposed by Bloomstrand⁽¹⁾,

- (1) Current C_R Values for Tubes and Methods to Calculate Pile C_R , Bloomstrand, RR, (Undocumented).

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has an advantage in being simple, but it lacks the precision afforded by some refinements. Among other possible refinements is the correlation of alpha versus some other parameter than ECT/AT, and the correlation on an individual reactor basis.

SUMMARY AND CONCLUSIONS

By some transformations of the basic rupture equation (see discussion), an IBM program was written involving alpha as a function of individual tube powers and exposures. This program, in conjunction with factor distribution tapes, allowed the machine calculation of alpha values for all reactors. The alpha values were computed on a monthly basis for eight months out of 1959.

Jaech⁽²⁾ was able to secure a very good correlation of the data by plotting alpha against $\bar{P}/P_{Max}$. Instead of plotting alpha vs $\bar{P}/P_{Max}$ individually for each reactor, he was able to group certain reactors together to generate only four curves instead of eight. The reactors were grouped on the basis of similarity in distribution of their I & E natural power factors. Thus, in the accompanying plots, F and C Reactors are plotted individually while B, D, DR, and H, KE, KW are plotted as groups. Since it can be shown that $\bar{P}/P_{Max}$ is identical to $(ECT)(\frac{I}{N})$, the alpha for each reactor can be evaluated with good precision. Because $(\frac{I}{N})$ is relatively constant at any given reactor, the knowledge of ECT and the use of the appropriate plot will give the alpha value. The product of alpha and tube C_{RI} will then yield the appropriate pile C_{RI} value for use in the rupture equation.

DISCUSSION

The underlying premise in the development of the machine program is that the rupture rate of the pile is equal to the summation of the individual tube rupture rates.

$$\text{By definition, } \left[\text{Pile } C_{RI} P_{Max}^{12} M_{Avg}^5 I \left(\frac{P_{Max} ECT}{M_{Avg}} \right) \right] = \left[\text{Tube } C_{RI} \sum P_1^{12} M_1^5 \left(\frac{P_1}{M_1} \right) \right]$$

$$\text{But, } I(P_{Max})(ECT) = \sum P_1$$

$$\text{Therefore, } \left[\text{Pile } C_{RI} P_{Max}^{12} M_{Avg}^5 \left(\sum \frac{P_1}{M_{Avg}} \right) \right] = \left[\text{Tube } C_{RI} \sum P_1^{12} M_1^5 \left(\frac{P_1}{M_1} \right) \right]$$

$$\text{Rearranging } \frac{\text{Pile } C_{RI}}{\text{Tube } C_{RI}} = \alpha = \frac{\sum P_1^{12} M_1^5 \left(\frac{P_1}{M_1} \right)}{P_{Max}^{12} M_{Avg}^5 \sum \frac{P_1}{M_{Avg}}} = \frac{\sum P_1^{13} M_1^4}{P_{Max}^{12} \sum P_1 M_{Avg}^4}$$

(2) J. L. Jaech, Operations Research and Synthesis, HLO.

But, $M_{Avg} = \frac{\sum M_i \left(\frac{P_i}{M_i} \right)}{\sum \left(\frac{P_i}{M_i} \right)} = \frac{\sum P_i}{\sum \left(\frac{P_i}{M_i} \right)}$

Thus, $M_{Avg}^4 = \left[\frac{\sum P_i}{\sum \left(\frac{P_i}{M_i} \right)} \right]^4$

Substituting $\frac{\text{Pile CRI}}{\text{Tube CRI}} = \alpha = \frac{\sum P_i^{1/3} M_i^4}{P_{Max}^{1/2} \left[\frac{\sum P_i}{\sum \left(\frac{P_i}{M_i} \right)} \right]^4} \sum P_i$

Substituting Factors for Powers,

(A) $\alpha = \frac{\sum (f_i^{1/3}) M_i^4}{f_{Max}^{1/2} \sum (f_i) \left[\frac{\sum f_i}{\sum \left(\frac{f_i}{M_i} \right)} \right]^4}$

Equation (A) was then used for the IBM run.

While $\bar{P}/P_{Max}$ was easily evaluated from the factor distribution tapes, it is not a convenient quantity to evaluate directly in normal practice. However, by definition $\bar{P} = \frac{(P_{Max})(ECT)(I)}{N}$. Therefore, $\bar{P}/P_{Max} = \frac{(ECT)(I)}{(N)}$. Thus $\bar{P}/P_{Max}$ is related

to quantities which are easily measurable at each reactor.

NOMENCLATURE

$\bar{P}$ = average power of I & E natural tubes.
 P_{Max} = average power of ten highest power tubes in pile.
 N = number of I & E natural tubes in pile.
 ECT = effective central tubes.
 I = percent of pile power generated by I & E natural metal.
 CRI = metal performance index for I & E natural metal.
 M_{Avg} = average exposure of I & E natural metal in pile.
 M_i = exposure of I & E natural metal in an individual tube.
 AT = active tubes in pile.
 TP = metal throughput.
 P_i = power of an individual tube.
 f_i = power factor of an individual tube = $\frac{P_i}{\bar{P}}$

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