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Subject Calibration of Control Drums in
a Sub-Critical Assembly

SUMMARY

A method of calibrating control drums in a subcritical assembly with a source is given here as an addenda^{um} to WANL-TMI-458 which discusses the measurement of shutdown reactivity in a subcritical core.

INTRODUCTION

WANL-TMI-458 illustrated a method of measuring the shutdown reactivity in a sub-critical core by using a source jerk technique together with a pulsed neutron measurement of α . If instead of yanking the source, we drive in a control element, interpretation of the kinetics equations on a core of known reactivity allows us to measure the control drum worth.

THEORY

The Laplace transform of the neutron density in a core with a constant extraneous source is given by:

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$$n(s) = \frac{n(o) \left[1 + \sum_i \frac{\beta_i \gamma_i k_{eff}}{l^* (s + \lambda_i)} \right] + \frac{S_o}{s}}{\left[s \left(1 + \sum_i \frac{\beta_i \gamma_i k_{eff}}{l^* (s + \lambda_i)} \right) - \frac{\Delta k_{eff}}{l^*} \right]} \quad (1)$$

If we assume that the core was originally at the steady state level Δk_{effo} with neutron density $n(o)$ whereby:

$$S_o = - \frac{\Delta k_{eff}}{l^*} n(o)$$

and that the source was kept in the assembly and a drum driven in so that the new core reactivity would be Δk_{eff} , Equation 1 becomes:

$$\frac{\tilde{n}(s)}{n(o)} = \frac{1 + \sum_i \frac{\beta_i \gamma_i k_{eff}}{l^* (s + \lambda_i)}}{s \left(1 + \sum_i \frac{\beta_i \gamma_i k_{eff}}{l^* (s + \lambda_i)} \right) - \frac{\Delta k_{eff}}{l^*}} - \frac{\frac{\Delta k_{effo}}{l^* s}}{s \left(1 + \sum_i \frac{\beta_i \gamma_i k_{eff}}{l^* (s + \lambda_i)} \right) - \frac{k_{eff}}{l^*}} \quad (2)$$

The inverse transform of the first term on the right represents a time decay of neutron density after addition of reactivity, where the transform of the second term on the right represents both a decay as well as a steady state level with a pole at $s = 0$. The residue of $n(s)/n(o)$ for the pole at $s = 0$ is $\Delta k_{effo}/\Delta k_{eff}$, so that the expression for the final steady state level, $n(f)$ is:

$$\frac{n(f)}{n(o)} = \frac{\Delta k_{effo}}{\Delta k_{eff}} \quad (3)$$

For small changes in k_{eff} , $\beta\lambda$ is constant and $k_{\text{eff}} = k_{\text{effo}}$, so that Eq. 3 becomes:

$$\frac{n(f)}{n(o)} = \frac{(\Delta k_{\text{effo}} / k_{\text{effo}} \beta\lambda)}{(\Delta k_{\text{eff}} / k_{\text{eff}} \beta\lambda)} \quad (4)$$

EXPERIMENTAL APPROACH

WANL-TMI-458 shows how to determine $(\Delta k_{\text{effo}} / k_{\text{effo}} \beta\lambda)$ for a subcritical core. After the core reactivity has been determined that way, one would restore the source, record the resulting steady state neutron density, and then drive in a drum allowing the core to reach a new steady state level. From Eq. 4, the ratio of neutron densities gives the drum calibration.

SIGNED

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