FOUR FACTOR FORMULA

Multiplication Factor, k

$$k = \frac{number\ of\ neutrons\ in\ current\ generation}{number\ of\ neutrons\ in\ previous\ generation}$$

$$k_{eff} = k_\infty\ £_{th}\ £_{fast} \qquad k_\infty = \eta\ f\ \varepsilon\ \wp$$

$k < 1$	$(\rho < 0)$	subcritical	$B_m^2 < B_g^2$
$k = 1$	$(\rho = 0)$	critical	$B_m^2 = B_g^2$
$k > 1$	$(\rho > 0)$	supercritical	$B_m^2 > B_g^2$

Reproduction Factor, η

$$\eta = \frac{Number\ of\ neutrons\ produced\ by\ fission}{Number\ of\ neutrons\ absorbed\ by\ fuel} = \nu \frac{\sigma_f^{Fuel}}{\sigma_a^{Fuel}} = \frac{\nu}{1+\alpha}$$

where ν is the number of neutrons produced per fission, and α is the capture-to-fission ratio, $\alpha \equiv \sigma_c/\sigma_f$.

Thermal Utilization, f

$$f = \frac{thermal\ neutrons\ absorbed\ by\ fuel}{total\ thermal\ neutrons\ absorbed} = \frac{\sum_a^{Fuel}}{\sum_a^{Total}} = \frac{\sum_a^{Fuel}}{\sum_a^{Fuel} + \sum_a^{H_2O} + \sum_a^{Steel} + \cdots}$$

Fast Fission Factor, ε

$$\varepsilon = \frac{total\ fission\ neutrons\ from\ thermal\ and\ fast\ fission}{fission\ neutrons\ from\ thermal\ fission}$$

Resonance Escape Probability, $\wp$

$$\wp = \frac{number\ of\ neutrons\ slowing\ to\ thermal\ energy}{total\ number\ of\ fast\ neutrons\ available\ for\ slowing}$$

Non-leakage Probabilities, £

$$£_{NL} = \frac{absorption}{production} = \frac{absorption}{absorption + leakage} = £_{th}\ £_{fast}$$

$$£_{fast} = e^{-B_g^2 \tau} \qquad £_{th} = \frac{\sum_a}{\sum_a + D\, B_g^2} = \frac{1}{1 + L_{th}^2\, B_g^2}$$

where D is the diffusion coefficient, B_g^2 is the geometric buckling, and L is the diffusion length.

Conversion Ratio (Breeding Ratio)

$$CR = \frac{Average\ rate\ of\ fissile\ atom\ (Pu-239)\ production}{Average\ rate\ of\ fissile\ atom\ (U-235)\ consumption}$$

$$= \frac{No.\ of\ neutrons\ absorbed\ in\ U-238}{No.\ of\ neutrons\ absorbed\ in\ U-235} \approx \frac{\Sigma_a^{U-238}}{\Sigma_a^{U-235}}$$

$$= \eta_{U-235}\ \varepsilon\ (1-\wp)\ £_{fast} + \frac{\Sigma_a^{U-238}}{\Sigma_a^{U-235}}$$