Control Rod Integral and Differential Worth (Sine-Squared Law)

Integral and differential reactivity worth of a control rod at a given withdrawal in a bare core with a cosine axial flux, from its total worth.

Method: Control rod worth by perturbation theory in a cosine flux

Input parameters

Unit system: SI

Parameter	Value	Unit
Total rod worth (pcm)	1,500.0	
Core height	3.6600	m
Rod withdrawal from the bottom (fully inserted = 0)	1.2000	m

Calculated results

Parameter	Value	Unit
Worth withdrawn so far (pcm)	281.08	
Worth still inserted (pcm)	1,218.9	
Differential worth (pcm per cm)	6.0245	
Fraction of total worth withdrawn	18.739	%

Notes for this case

• First-order perturbation in a cosine flux: worth ∝ ∫φ² over the withdrawn length, giving ρ(z)/ρ_T = z/H − sin(2πz/H)/(2π) and the largest differential worth at mid-height. Real rods show shadowing and flux tilts; use measured S-curves for operation.

Formula and method

$$\frac{\rho(z)}{\rho_T} = \frac{z}{H} - \frac{1}{2\pi}\sin\frac{2\pi z}{H}, \quad \frac{d\rho}{dz} = \frac{\rho_T}{H}\left(1 - \cos\frac{2\pi z}{H}\right)$$

Variables

ρ_T	Total rod worth (pcm)	-
H	Core height	m
z	Rod withdrawal from the bottom (fully inserted = 0)	m
$\rho(z)$	Worth withdrawn so far (pcm)	-
$\rho_T - \rho(z)$	Worth still inserted (pcm)	-
$d\rho/dz$	Differential worth (pcm per cm)	-
$\rho(z)/\rho_T$	Fraction of total worth withdrawn	-

Method and standards

Rod worth curve.

Assumptions and limits

- Bare core, cosine axial flux, small perturbation.

References

Control rod worth by perturbation theory in a cosine flux

Report details

Report reference	FCC-K55V-BF12 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/nuclear-power/control-rod-worth-sin2

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.