Xenon-135 Poisoning: Equilibrium Worth and Post-Shutdown Peak

Equilibrium xenon-135 reactivity worth at a given thermal flux and the xenon build-up after shutdown, with the time and size of the xenon peak.

Method: Iodine-xenon balance equations (one group)

Input parameters

Unit system: SI

Parameter	Value	Unit
Thermal neutron flux at power	3.0000e+13	1/(cm²·s)
Neutrons per fission	2.4300	
Iodine-135 fission yield	6.3900	%
Direct xenon-135 fission yield	0.23700	%
Xenon-135 absorption cross-section	2,650,000	b
Iodine-135 half-life	6.5700	h
Xenon-135 half-life	9.1400	h
Time after shutdown	8.0000	h

Calculated results

Parameter	Value	Unit
Characteristic flux λ_X/σ_X	7.9493e+12	1/(cm²·s)
Equilibrium xenon reactivity	-0.021559	
Equilibrium xenon reactivity (pcm)	-2,155.9	
Xenon relative to equilibrium at t	1.9004	
Approximate xenon reactivity at t (pcm)	-4,097.1	
Time of the xenon peak	8.3797	h
Peak xenon relative to equilibrium	1.9015	

Notes for this case

• One-group equilibrium worth ρ∞ = −(γ_I + γ_X)/ν · φ/(φ + φ_X), assuming the fuel absorbs all thermal neutrons that are not lost to xenon (f ≈ 1); real cores worth about 2.5–3 %. After shutdown iodine keeps decaying to xenon while burn-out stops, so xenon peaks some hours later; reactivity at t is scaled with the concentration.

Formula and method

$$\rho_\infty = -\frac{\gamma_I+\gamma_X}{\nu}\frac{\phi_T}{\phi_T+\phi_X}, \quad \frac{X(t)}{X_\infty} = e^{-\lambda_X t} + \frac{\gamma_I(\lambda_X+\sigma_X\phi_T)}{(\gamma_I+\gamma_X)(\lambda_X-\lambda_I)}\left(e^{-\lambda_I t}-e^{-\lambda_X t}\right)$$

Variables

ϕ_T	Thermal neutron flux at power	1/(m²·s)
ν	Neutrons per fission	-
γ_I	Iodine-135 fission yield	-
γ_X	Direct xenon-135 fission yield	-
σ_X	Xenon-135 absorption cross-section	m²
T_I	Iodine-135 half-life	s
T_X	Xenon-135 half-life	s

t	Time after shutdown	s
ϕ_X	Characteristic flux λ_X/σ_X	1/(m²·s)
ρ_∞	Equilibrium xenon reactivity	-
$X(t)/X_\infty$	Xenon relative to equilibrium at t	-
$\rho(t)$	Approximate xenon reactivity at t (pcm)	-
t_{max}	Time of the xenon peak	s
X_{max}/X_∞	Peak xenon relative to equilibrium	-

Method and standards

Iodine-xenon one-group balance.

Assumptions and limits

- Uniform flux; samarium and spatial xenon oscillations are not included.

References

Iodine-xenon balance equations (one group)

Report details

Report reference	FCC-SB6G-JVAG (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/xenon-135-poisoning

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Reopens the calculator with the inputs of this report.