One-Group Critical Radius and Mass of a Bare Fissile Sphere

Critical radius and mass of a bare sphere of fissile metal from one-group fast cross-sections, neutrons per fission and density, by one-group diffusion theory.

Method: One-group diffusion criticality of a bare fast sphere

Input parameters

Unit system: SI

Parameter	Value	Unit
Neutrons per fission (fast)	2.6000	
Fission cross-section (one group)	1.4000	b
Absorption cross-section (one group)	1.6500	b
Transport cross-section (one group)	6.8000	b
Metal density	18,900	kg/m³
Molar mass	235.04	kg/kmol

Calculated results

Parameter	Value	Unit
Infinite multiplication νσ_f/σ_a	2.2061	
Diffusion coefficient	1.0123	cm
Material buckling (per cm²)	0.095197	
Critical radius (with extrapolation distance)	8.0260	cm
Critical mass	40.930	kg

Notes for this case

• One-group fast diffusion: B² = (νΣ_f − Σ_a)/D, D = 1/(3Σ_tr), R = π/B − 2.13D. One-group theory gives the right order of magnitude (about 50 kg for bare U-235) but transport and multigroup methods are needed for accuracy; reflectors cut the mass several-fold. Teaching use only.

Formula and method

$$B^2 = \frac{\nu\Sigma_f - \Sigma_a}{D}, \quad D = \frac{1}{3\Sigma_{tr}}, \quad R = \frac{\pi}{B} - 2.13D, \quad m_c = \frac{4}{3}\pi R^3 \rho$$

Variables

ν	Neutrons per fission (fast)	-
σ_f	Fission cross-section (one group)	m²
σ_a	Absorption cross-section (one group)	m²
σ_{tr}	Transport cross-section (one group)	m²
ρ	Metal density	kg/m³
M	Molar mass	kg/kmol
k_∞	Infinite multiplication νσ_f/σ_a	-
D	Diffusion coefficient	m
B^2	Material buckling (per cm²)	-
R	Critical radius (with extrapolation distance)	m
m_c	Critical mass	kg

Method and standards

One-group criticality.

Assumptions and limits

- Bare homogeneous sphere; one energy group.

References

One-group diffusion criticality of a bare fast sphere

Report details

Report reference	FCC-7FGE-21ZG (the same inputs always give the same reference)
Generated	23 November 2026, 17:35 UTC
Calculator	One-Group Critical Radius and Mass of a Bare Fissile Sphere
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
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/critical-mass-bare-sphere

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.