Fuel Reproduction Factor and Thermal Utilisation

Reproduction factor eta of enriched uranium and the thermal utilisation f of a homogeneous fuel-moderator mixture from enrichment, cross-sections and atom ratio.

Method: One-group thermal factors for a homogeneous fuel-moderator mixture

Input parameters

Unit system: SI

Parameter	Value	Unit
Enrichment (U-235 atom fraction)	3.0000	%
Neutrons per fission (U-235 thermal 2.43)	2.4300	
U-235 fission cross-section	585.00	b
U-235 absorption cross-section	681.00	b
U-238 absorption cross-section	2.6800	b
Moderator molecules per uranium atom	4.0000	
Moderator absorption cross-section per molecule (H_2O 0.664 b)	0.66400	b

Calculated results

Parameter	Value	Unit
Reproduction factor	1.8518	
Thermal utilisation	89.660	%
Product ηf	1.6603	
Absorption cross-section per uranium atom	23.030	b

Notes for this case

• η = νσ_f,5 e/[eσ_a,5 + (1 − e)σ_a,8] and f = Σ_a,U/(Σ_a,U + Σ_a,M) for a homogeneous mixture. Cross-sections are at 0.0253 eV by default; for a hot core use spectrum-averaged values (the non-1/v factors matter for U-235). Cladding and structure absorption lower f further.

Formula and method

$$\eta = \frac{\nu e \sigma_{f,5}}{e\sigma_{a,5} + (1-e)\sigma_{a,8}}, \quad f = \frac{\sigma_{a,U}}{\sigma_{a,U} + (N_M/N_U)\sigma_{a,M}}$$

Variables

e	Enrichment (U-235 atom fraction)	-
ν	Neutrons per fission (U-235 thermal 2.43)	-
$\sigma_{f,5}$	U-235 fission cross-section	m²
$\sigma_{a,5}$	U-235 absorption cross-section	m²
$\sigma_{a,8}$	U-238 absorption cross-section	m²
N_M/N_U	Moderator molecules per uranium atom	-
$\sigma_{a,M}$	Moderator absorption cross-section per molecule (H_2O 0.664 b)	m²
η	Reproduction factor	-
f	Thermal utilisation	-
ηf	Product ηf	-
$\sigma_{a,U}$	Absorption cross-section per uranium atom	m²

Method and standards

Homogeneous one-group factors.

Assumptions and limits

- Homogeneous mixture; no self-shielding or disadvantage factor.

References

One-group thermal factors for a homogeneous fuel-moderator mixture

Report details

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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/fuel-eta-thermal-utilisation

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Reopens the calculator with the inputs of this report.