Parent-Daughter Decay: Daughter Activity and Equilibrium

Daughter activity grown from a decaying parent (Bateman solution), the time of maximum daughter activity and the transient or secular equilibrium ratio.

Method: Bateman solution for a two-member decay chain

Input parameters

Unit system: SI

Parameter	Value	Unit
Initial parent activity	10.000	GBq
Parent half-life	65.940	h
Daughter half-life	6.0067	h
Branching fraction to this daughter	87.600	%
Time since the daughter was zero (e.g. last elution)	24.000	h

Calculated results

Parameter	Value	Unit
Parent activity	7.7702	GBq
Daughter activity	6.8847	GBq
Daughter-to-parent activity ratio	0.88603	
Time of maximum daughter activity	22.843	h
Maximum daughter activity	6.8900	GBq
Equilibrium ratio bλ₂/(λ₂ − λ₁) (parent longer-lived)	0.96380	

Notes for this case

- Bateman solution for a parent and its daughter with no daughter at t = 0.
- Parent longer-lived: transient equilibrium after several daughter half-lives.

Formula and method

$$A_2(t) = bA_1(0)\frac{\lambda_2}{\lambda_2-\lambda_1}\left(e^{-\lambda_1 t}-e^{-\lambda_2 t}\right), \quad t_{max}=\frac{\ln(\lambda_2/\lambda_1)}{\lambda_2-\lambda_1}$$

Variables

$A_1(0)$	Initial parent activity	Bq
T_1	Parent half-life	s
T_2	Daughter half-life	s
b	Branching fraction to this daughter	-
t	Time since the daughter was zero (e.g. last elution)	s
$A_1(t)$	Parent activity	Bq
$A_2(t)$	Daughter activity	Bq
A_2/A_1	Daughter-to-parent activity ratio	-
t_{max}	Time of maximum daughter activity	s
$A_{2,max}$	Maximum daughter activity	Bq
$(A_2/A_1)_{eq}$	Equilibrium ratio bλ₂/(λ₂ − λ₁) (parent longer-lived)	-

Method and standards

Bateman equations for a parent and daughter.

Assumptions and limits

- Two members only; the daughter's own daughter is not tracked.

References

Bateman solution for a two-member decay chain

Report details

Report reference	FCC-V282-4M4Y (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/parent-daughter-decay-chain

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.