Furnace Heating Time to Temperature and Soak (One-Term Solution)

Time for the centre of a plate or bar in a furnace to come within a set margin of furnace temperature, with radiation and convection, plus the soak time.

Method: One-term transient conduction with linearised radiation

Input parameters

Unit system: SI

Parameter	Value	Unit
Section shape	Long round bar	
Half-thickness or radius	50.000	mm
Thermal conductivity	30.000	W/(m·K)
Density	7,850.0	kg/m³
Specific heat (mean)	0.60000	kJ/(kg·K)
Initial temperature	30.000	°C
Furnace temperature	850.00	°C
Allowed centre lag behind furnace	10.000	K
Convective coefficient	15.000	W/(m²·K)
Surface emissivity	80.000	%
Metallurgical soak time at temperature	30.000	min

Calculated results

Parameter	Value	Unit
Combined surface coefficient	270.37	W/(m²·K)
Biot number	0.45062	
Fourier number at the end of heating	5.5825	
Heating time	36.519	min
Heating plus soak	66.519	min

Notes for this case

• h = h_c + εσ(T_f² + T_s²)(T_f + T_s) with T_s midway between furnace and target. One-term solution: centre θ = C₁e^(−λ₁²Fo); accurate for Fo above about 0.2. Real heating is faster at first (radiation scales with T⁴) and properties vary; furnace load and spacing matter as much as section size. Soak time is the metallurgical hold, from the procedure.

Formula and method

$$\frac{T_f - T_c}{T_f - T_i} = C_1 e^{-\lambda_1^2 Fo}, \quad t_h = \frac{Fo\, L^2 \rho c_p}{k}, \quad h = h_c + \varepsilon\sigma(T_f^2 + T_s^2)(T_f + T_s)$$

Variables

shape	Section shape	-
L	Half-thickness or radius	m
k	Thermal conductivity	W/(m·K)
ρ	Density	kg/m³
c_p	Specific heat (mean)	J/(kg·K)

T_i	Initial temperature	K
T_f	Furnace temperature	K
ΔT_c	Allowed centre lag behind furnace	K
h_c	Convective coefficient	W/(m²·K)
ε	Surface emissivity	-
t_s	Metallurgical soak time at temperature	s
h	Combined surface coefficient	W/(m²·K)
Bi	Biot number	-
Fo	Fourier number at the end of heating	-
t_h	Heating time	s
t	Heating plus soak	s

Method and standards

Heating time.

Assumptions and limits

- Constant properties and h; isolated part; one-term solution.

References

One-term transient conduction with linearised radiation

Report details

Report reference	FCC-RXGX-A1NZ (the same inputs always give the same reference)
Generated	23 November 2026, 18:00 UTC
Calculator	Furnace Heating Time to Temperature and Soak (One-Term Solution)
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/materials/heat-treatment/furnace-heating-soak-time

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.