Steam-Side Oxide Growth and Tube Metal Temperature Rise

Oxide thickness after a service time by the parabolic law from a rate constant, and the metal temperature rise the scale causes at a heat flux.

Method: Parabolic oxidation law $x^2 = x_0^2 + k_p t$; conduction through the scale $\Delta T = q\,x/k$ (rate constant from user data)

Input parameters

Unit system: SI

Parameter	Value	Unit
Oxide thickness now	50.000	µm
Parabolic rate constant at metal temperature (in the units chosen below) From oxide measurements on your tubes or published data for the alloy.	0.25000	
Units of the rate constant	µm²/h	
Further service time	50,000	h
Heat flux through the tube wall	60.000	kW/m²
Oxide thermal conductivity	0.60000	W/(m·K)

Calculated results

Parameter	Value	Unit
Oxide thickness then	122.47	µm
Metal temperature rise now	5.0000	K
Metal temperature rise then	12.247	K

Notes for this case

- A hotter tube oxidises faster: the rate constant rises with temperature, so remaining life can fall quickly.

Formula and method

$$x = \sqrt{x_0^2 + k_p t}, \quad \Delta T = \frac{q x}{k_{ox}}$$

Variables

x_0	Oxide thickness now	m
k_p	Parabolic rate constant at metal temperature, in the units chosen (µm²/h, mm²/h, cm²/s or m²/s)	m²/s
$[k_p]$	Units of the rate constant	-
t	Further service time	s
q	Heat flux through the tube wall	W/m²
k_{ox}	Oxide thermal conductivity	W/(m·K)
x	Oxide thickness then	m
ΔT_0	Metal temperature rise now	K
ΔT	Metal temperature rise then	K

Method and standards

Parabolic oxidation law, $x^2 = x_0^2 + k_p t$, with the rate constant converted to m²/s from the units chosen; the temperature rise is one-dimensional conduction through the oxide at the heat flux entered.

Assumptions and limits

- Constant metal temperature: the rate constant is held fixed although the growing oxide raises the metal temperature and so the rate (the calculation does not iterate). Re-run with a higher k_p as the tube heats up.

- The default oxide conductivity, 0.6 W/(m·K), is a FireCAD starting value, not a sourced figure; use measured or published data for your oxide.

References

- Parabolic oxidation law $x^2 = x_0^2 + k_p t$; conduction through the scale $\Delta T = q\, x/k$ (rate constant from user data)

Report details

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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/boiler-pressure-parts/oxide-scale-growth

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.