Pilling–Bedworth Ratio of an Oxide

Pilling–Bedworth ratio of an oxide (oxide volume per volume of metal consumed) from molar masses and densities, indicating whether the scale is protective.

Method: Pilling and Bedworth (1923); J. Inst. Metals 29: 529

Input parameters

Unit system: SI

Parameter	Value	Unit
Oxide molar mass	101.96	kg/kmol
Oxide density	3,950.0	kg/m³
Metal molar mass	26.980	kg/kmol
Metal density	2,700.0	kg/m³
Metal atoms per oxide formula	2.0000	

Calculated results

Parameter	Value	Unit
Pilling–Bedworth ratio	1.2916	
Scale class (0 porous, 1 protective, 2 spalling)	1.0000	

Notes for this case

• Below 1 the oxide cannot cover the metal (porous, e.g. Mg); 1–2 tends to be protective (Al, Cr, Ni); above 2 compressive stresses crack and spall the scale (Fe_2O_3 about 2.1). Diffusion through the scale matters as much as PBR.

Formula and method

$$PBR = \frac{M_{ox}\rho_m}{nM_m\rho_{ox}}$$

Variables

M_{ox}	Oxide molar mass	kg/kmol
ρ_{ox}	Oxide density	kg/m³
M_m	Metal molar mass	kg/kmol
ρ_m	Metal density	kg/m³
n	Metal atoms per oxide formula	-
PBR	Pilling–Bedworth ratio	-
class	Scale class (0 porous, 1 protective, 2 spalling)	-

Method and standards

Volume ratio.

Assumptions and limits

- Dense oxide; no porosity.

References

• Pilling and Bedworth (1923)
• J. Inst. Metals 29: 529

Report details

Report reference	FCC-6R2R-WG6R (the same inputs always give the same reference)
Generated	17 November 2026, 19:49 UTC
Calculator	Pilling–Bedworth Ratio of an Oxide
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 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/corrosion/pilling-bedworth-ratio

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.