Martensite Fraction on Quenching (Koistinen–Marburger)

Martensite fraction and retained austenite after quenching steel to a temperature below Ms, and the temperatures for 90 % and 99 % martensite.

Method: Koistinen–Marburger relation

Input parameters

Unit system: SI

Parameter	Value	Unit
Martensite start temperature	350.00	°C
Quench (lowest) temperature	20.000	°C
Rate constant (1/K)	0.011000	

Calculated results

Parameter	Value	Unit
Martensite fraction	97.348	%
Retained austenite	2.6516	%
Temperature for 90 % martensite	140.67	°C
Temperature for 99 % martensite	-68.652	°C

Notes for this case

• Martensite forms athermally: the fraction depends on how far below M_s the steel is cooled, not on time. Koistinen and Marburger fitted f_m = 1 − exp[−α(M_s − T_q)] with α = 0.011/K for plain carbon and low-alloy steels (any austenite that does not become bainite or ferrite first). High-carbon and high-alloy steels with low M_s retain austenite at room temperature, which a sub-zero treatment converts. Use M_s from the Andrews calculator.

Formula and method

$$f_m = 1 - e^{-\alpha_m (M_s - T_q)}, \quad T_{90} = M_s - \frac{\ln 10}{\alpha_m}$$

Variables

M_s	Martensite start temperature	K
T_q	Quench (lowest) temperature	K
α_m	Rate constant (1/K)	-
f_m	Martensite fraction	-
f_γ	Retained austenite	-
T_{90}	Temperature for 90 % martensite	K
T_{99}	Temperature for 99 % martensite	K

Method and standards

Martensite fraction.

Assumptions and limits

- Fully austenitised steel; no prior bainite or ferrite; athermal kinetics.

References

Koistinen–Marburger relation

Report details

Report reference	FCC-9PVN-87XK (the same inputs always give the same reference)
Generated	23 November 2026, 18:09 UTC
Calculator	Martensite Fraction on Quenching (Koistinen–Marburger)
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/koistinen-marburger-martensite

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.