Steel Critical Temperatures Ac1 and Ac3 (Andrews)

Lower and upper critical temperatures Ac1 and Ac3 of a low-alloy steel from its composition by Andrews' empirical formulas.

Method: Andrews (1965); JISI 203: 721 (empirical formulae for transformation temperatures)

Input parameters

Unit system: SI

Parameter	Value	Unit
Carbon (wt %)	0.40000	%
Manganese (wt %)	0.70000	%
Silicon (wt %)	0.25000	%
Nickel (wt %)	0	%
Chromium (wt %)	1.0000	%
Molybdenum (wt %)	0.20000	%
Vanadium (wt %)	0	%
Tungsten (wt %)	0	%
Copper (wt %)	0	%

Calculated results

Parameter	Value	Unit
Lower critical temperature	739.68	°C
Upper critical temperature	767.09	°C
Intercritical range	27.402	K

Notes for this case

• Andrews' regressions for steels below 0.6 % C (As, P, Al and Ti taken as zero). Heating rates above equilibrium raise the actual critical points; austenitise about 30–50 K above Ac3 for hardening hypoeutectoid steels.

Formula and method

$$Ac_1 = 723 - 10.7Mn - 16.9Ni + 29.1Si + 16.9Cr + 6.38W$$

$$Ac_3 = 910 - 203\sqrt{C} - 15.2Ni + 44.7Si + 104V + 31.5Mo + 13.1W - 30Mn - 11Cr - 20Cu$$

Variables

C	Carbon (wt %)	-
Mn	Manganese (wt %)	-
Si	Silicon (wt %)	-
Ni	Nickel (wt %)	-
Cr	Chromium (wt %)	-
Mo	Molybdenum (wt %)	-
V	Vanadium (wt %)	-
W	Tungsten (wt %)	-
Cu	Copper (wt %)	-
Ac_1	Lower critical temperature	K
Ac_3	Upper critical temperature	K
$Ac_3 - Ac_1$	Intercritical range	K

Method and standards

Andrews' formulas (°C, wt %).

Assumptions and limits

- Low-alloy steels, C < 0.6 %.
- With high alloy contents the two regressions can cross (Ac3 at or below Ac1); a note then says the result is outside their range.

References

• Andrews (1965)
• JISI 203: 721 (empirical formulae for transformation temperatures)

Report details

Report reference	FCC-4P2R-5DPW (the same inputs always give the same reference)
Generated	17 November 2026, 19:36 UTC
Calculator	Steel Critical Temperatures Ac1 and Ac3 (Andrews)
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	2 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/critical-temperatures-andrews

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.