

Volume Change in Tool Steel on Hardening and Tempering

Relative volume of water hardened tool steel rods of four diameters, measured before hardening, dead hard, and after tempering to yellow, blue and grey, from tests by Fromme published in 1918.

Reference only. The values on this sheet are reproduced from the source named at the foot of it. They are a published reference rather than a specification of ours, and the sheet carries no tolerances. The unhardened volume is taken as unity, so every other figure is a ratio to it. Values below unity are a net contraction against the annealed rod. Results vary with the grade, the quenching medium and the section, and the source table covers one steel only.

Relative volume, unhardened rod taken as unity

Source, the relative volume table by Fromme on printed page 39 of The Heat Treatment of Tool Steel (Harry Brearley), which is PDF page 57 of the copy consulted. Every figure was read from the 500 dpi page image, not from the OCR text layer.

Condition of rod	7 mm rod	4.2 mm rod	2.65 mm rod	2.55 mm rod
Unhardened	1.00000	1.00000	1.00000	1.00000
Dead hard	1.00772	1.01000	1.01285	1.01210
Tempered, yellow	1.00347	1.00495	1.00660	1.00620
Tempered, blue	1.00217	1.00425	1.00370	1.00205
Tempered, grey	0.99957	1.00060	1.00055	0.99930

Volume of the unhardened rod is taken as unity, so 1.00772 means a rise of 0.772 per cent. The rods were hardened under the same conditions and then tempered. Values below 1.00000 are a net contraction against the annealed rod. Rods are round bar of the diameter named; the source gives no length, so the figures are for the volume of the piece as a whole.

Quenching grows the piece, and the thin rod grows most. The 7 mm rod comes out of a dead hard quench 0.772 per cent larger than it went in. The 2.65 mm rod comes out 1.285 per cent larger, roughly two thirds more movement for a section a third of the diameter. The numbers are the whole volume of the piece, so a block three inches thick will move less than a slender insert of the same steel, which is the opposite of what a shop usually allows for.

Tempering gives part of the growth back. On the 7 mm rod a yellow temper drops the figure to 1.00347, a blue temper to 1.00217, and a grey temper to 0.99957, which is finer than the annealed rod it started from. The same sequence runs on the other three diameters. The recovery is not complete and not even: the thin rods stop further short of their original volume than the thick one, so a thin section is left larger than a thick one after the same temper.

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, O1, O2, A2, S7, H13, H11, H10, H21, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Compiled from The Heat Treatment of Tool Steel (Harry Brearley), the Fromme relative volume table on printed page 39, with the surrounding discussion of critical density changes on printed pages 38 and 39. The figures are reproduced from the published table and are a reference summary rather than an Aobo Steel specification.

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