

Hot Work Tool Steel Tensile Strength at Elevated Temperature

Hot work tool steels are chosen for the strength they keep while they are hot, and the figures that answer that question are tensile and yield strength measured at the working temperature rather than at room temperature. Three chromium hot work grades are collected here. H11 and H13 are the two steels most aluminum die casting and hot forging tooling is made from, and H12 is the more highly alloyed grade used where the tool has to survive heavier shock.

Reference only. This is a reference summary of published practice and not a specification of ours. Each set of figures belongs to the exact heat treatment named in the caption above it, on one heat of each condition, and a tool run at a different austenitizing or tempering temperature will sit somewhere else on these scales. Confirm the working values for a particular die against the material test certificate of the heat you buy before ordering.

Tensile properties of H11 tool steel at temperature

Air cooled from 1010 °C and double tempered 2.5 h at 570 °C

Testing temperature, °C (°F)	Tensile strength, MPa	Tensile strength, ksi	Yield strength (0.2% offset), MPa	Yield strength (0.2% offset), ksi	Elongation in 50 mm (2 in.), %	Reduction of area, %	Hardness before testing, HRC	Hardness after testing, HRC
Room	1806	262	1482	215	10.0	35.8	50	50
150 (300)	1689	245	1358	197	10.1	36.1	50	50
260 (500)	1600	232	1345	195	9.8	34.5	50	50
345 (650)	1579	229	1317	191	10.0	35.2	50	50
425 (800)	1510	219	1289	187	11.4	38.7	50	50
480 (900)	1427	207	1145	166	12.2	38.9	50	50
540 (1000)	1241	180	965	140	11.0	35.4	50	50
595 (1100)	979	142	724	105	12.8	46.2	50	47
650 (1200)	586	85	434	63	18.9	66.6	50	41

Source, Table 13-4, Tensile properties of chromium-molybdenum hot-work tool steels at elevated temperatures, H11, printed page 230 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 223 of the copy consulted. Composition 0.40% C, 0.92% Si, 5.09% Cr, 1.34% Mo, 0.52% V; austenitized at 1010 °C (1850 °F) and air cooled, then double tempered 2.5 h at 570 °C (1060 °F). The room temperature row is printed as Room in the source and carries no separate degree figure.

Tensile properties of H13 tool steel at temperature

Oil quenched from 1010 °C and tempered 2 h at 565 °C

Testing temperature, °C (°F)	Tensile strength, MPa	Tensile strength, ksi	Yield strength (0.2% offset), MPa	Yield strength (0.2% offset), ksi	Elongation in 50 mm (2 in.), %	Reduction of area, %	Hardness before testing, HRC	Hardness after testing, HRC
480 (900)	1531	222	Not reported	Not reported	9	37	52	Not reported
540 (1000)	1413	205	Not reported	Not reported	11	43	52	Not reported
595 (1100)	1193	173	Not reported	Not reported	15	49	52	Not reported
650 (1200)	814	118	Not reported	Not reported	22	59	52	Not reported

Source, Table 13-4, H13, printed page 230 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 223 of the copy consulted. Composition 0.40% C, 1.00% Si, 5.25% Cr, 1.15% Mo, 1.00% V; austenitized at 1010 °C (1850 °F) and oil quenched, then tempered 2 h at 565 °C (1050 °F). The source reports no yield strength and no hardness after testing for this condition.

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Tensile properties of H12 tool steel at temperature

Oil quenched from 1050 °C and tempered 2 h at 565 °C

Testing temperature, °C (°F)	Tensile strength, MPa	Tensile strength, ksi	Yield strength (0.2% offset), MPa	Yield strength (0.2% offset), ksi	Elongation in 50 mm (2 in.), %	Reduction of area, %	Hardness before testing, HRC	Hardness after testing, HRC
400 (750)	1703	247	Not reported	Not reported	12	36	53	Not reported
540 (1000)	1482	215	Not reported	Not reported	12	41	53	Not reported
650 (1200)	531	77	Not reported	Not reported	32	83	53	Not reported
760 (1400)	124	18	Not reported	Not reported	71	97	53	Not reported

Source, Table 13-4, H12 oil quenched from 1050 °C, printed page 230 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 223 of the copy consulted. Composition 0.33% C, 0.85% Si, 5.00% Cr, 1.25% W, 1.45% Mo, 0.23% V; austenitized at 1050 °C (1925 °F) and oil quenched, then tempered 2 h at 565 °C (1050 °F). The source reports no yield strength and no hardness after testing for this condition.

Tensile properties of H12 tool steel at temperature (continued)

Air cooled from 980 °C and tempered 1.5 h at 565 °C

Testing temperature, °C (°F)	Tensile strength, MPa	Tensile strength, ksi	Yield strength (0.2% offset), MPa	Yield strength (0.2% offset), ksi	Elongation in 50 mm (2 in.), %	Reduction of area, %	Hardness before testing, HRC	Hardness after testing, HRC
540 (1000)	1358	197	1086.7	157.6	10	55	50	Not reported
620 (1150)	593.7	86.1	396.5	57.5	24	71	49.5	Not reported

Source, Table 13-4, H12 air cooled from 980 °C, printed page 230 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 223 of the copy consulted. The steel was austenitized at 980 °C (1800 °F), air cooled, then tempered 1.5 h at 565 °C (1050 °F). The source reports no hardness after testing for this condition.

Reading the four sets of figures together

Read the four sets at the temperature the tool actually runs at. H11 holds 1289 MPa yield strength at 425 °C, which is the range aluminum die casting works in, and falls to 965 MPa at 540 °C and 434 MPa at 650 °C. H13 keeps 52 HRC before testing at every temperature and falls from 1531 MPa at 480 °C to 814 MPa at 650 °C. H12 oil quenched from 1050 °C is the strongest of the three below 600 °C, at 1703 MPa at 400 °C, and the air cooled condition is softer at 1358 MPa at 540 °C. Elongation rises as strength falls in every case, so an overheated tool goes soft and distorts rather than becoming brittle.

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, P20+Ni and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates. Compiled from Tool Steels (G. A. Roberts and G. Krauss), Table 13-4, Tensile properties of chromium-molybdenum hot-work tool steels at elevated temperatures, printed page 230, the chapter on chromium hot work tool steels.

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