

Mechanical Properties of Mold Steels P4, P20 and P21

A mold steel is chosen for the cavity it has to hold, and the figures that decide whether a grade suits the job are the strength, the ductility and the hardness its heat treatment leaves behind. Three mold steels are collected here. P4 is the deepest hardening of the low carbon carburizing grades, P20 is the pre-hardened grade that most machined cavities are cut from, and P21 is the nickel aluminium grade that hardens by precipitation rather than by quenching.

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 grade, and a mold run at a different tempering or aging temperature will sit somewhere else on these scales. Confirm the working values for a particular mold against the material test certificate of the heat you buy before ordering.

Mechanical properties of P4 mold steel

Core properties after air cooling from 955 °C and tempering at 425 °C

Property	Value
Tensile strength, MPa (ksi)	1289 (187)
Yield strength, MPa (ksi)	1034 (150)
Elongation in 50 mm (2 in.), %	15
Reduction of area, %	53
CVN impact, J (ft-lbf)	43 (32)
Hardness, HB	390

Source, Table 15-3, Core mechanical properties of P4 mold steel air cooled from 955 °C (1750 °F) and tempered at 425 °C (800 °F), printed page 296 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 289 of the copy consulted.

Mechanical properties of P20 mold steel

Figures after oil quenching from 845 °C and tempering 2 h at 205 °C

Property	Value
Tensile strength, MPa (ksi)	1310 (190)
Yield strength, MPa (ksi)	1172 (170)
Elongation in 50 mm (2 in.), %	13
Reduction of area, %	51
Hardness, HRC	36-38

Source, Table 15-5, Mechanical properties of P20 mold steel after oil quenching from 845 °C (1550 °F) and tempering 2 h at 205 °C (400 °F), printed page 297 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 290 of the copy consulted.

Mechanical Properties of Mold Steels P4, P20 and P21

Mechanical properties of P21 mold steel

The solution treated and the aged condition

Property	Solution treated	Aged
Tensile strength, MPa (ksi)	862 (125)	1234 (179)
Yield strength (0.2% offset), MPa (ksi)	586 (85)	1138 (165)
Elongation in 50 mm (2 in.), %	24	16
Reduction of area, %	59	40
Hardness, HRC	26 max	36-39
Hardness, HB	262 max	341-375

Source, Table 15-6, Mechanical properties of P21 mold steel, printed page 298 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 291 of the copy consulted. The solution treated column is the steel quenched from the solution temperature and machined in that condition. The aged column is the same steel after holding 20 to 24 h at the aging temperature.

Hardness left by each aging temperature

Aging temperature (°C)	Aging temperature (°F)	Hardness (HRC)
510	950	38-41
525	975	36-39
540	1000	34-38
550	1025	29-34
565	1050	27-32

Source, Table 15-7, Effect of aging temperature on hardness of P21 mold steel, printed page 298 of Tool Steels (G. A. Roberts and G. Krauss), PDF page 291 of the copy consulted. Aging time was 20 to 24 h at each temperature.

Reading the three grades together

Read the three grades at the point in the process where each one is used. P4 gives its core strength only after carburizing and heat treatment, and the case over that core is what carries the wear. P20 reaches 1310 MPa tensile with 36 to 38 HRC in a single hardening and tempering cycle, which is why it is used where the whole block has to be strong. P21 reaches the highest tensile figure of the three at 1234 MPa, but only after two furnace steps, one to solution treat the blank at 26 HRC maximum and one to age it after machining. On P21 the aging temperature sets the hardness, from 38 to 41 HRC at 510 °C down to 27 to 32 HRC at 565 °C.

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), Tables 15-3, 15-5, 15-6 and 15-7 on printed pages 296, 297 and 298, the chapter on mold steels.

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