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Vacuum Dew Point and Alloy Depletion in Tool Steel

A vacuum furnace is not an empty furnace. Its residual gas has a measurable dew point, and at the pressures used for tool steel it still allows chromium to leave the surface while molybdenum and tungsten stay. The tables below give the dew point at each vacuum level, the vacuum each material class needs, and the surface composition change of a high speed steel held at temperature.

Reference only. This is a reference summary of published practice and it is not a specification of ours. The values are reproduced from the source tables, and what a particular furnace produces depends on the pumping system, the leak rate and the cycle. Final selection is confirmed on the job.

A vacuum is a gas atmosphere, and it has a dew point

Vacuum, torr	10^{-1}	10^{-2}	10^{-3}	10^{-4}
-40	-61	-76	-90	

Dew point of the residual gas at four vacuum levels, assuming the residual gas contains 70% water vapour. Read across to see how much dryness each decade of pressure buys.

Vacuum, torr	20% water vapour	70% water vapour	100% water vapour
1	-35	-21	-17
10^{-1}	-55	-43	-40
10^{-2}	-70	-61	-58
10^{-3}	-86	-77	-74
10^{-4}	-92	-90	-89

Dew point as a function of water vapour content at five vacuum levels. The three columns run from a dry residual gas to one that is entirely water vapour, and the spread between them narrows as the pressure falls.

Why the oxides cannot be dissociated by pumping

The vacuum each material class needs

Material to be heat treated	Vacuum, torr
Copper	1 to 10^{-1}
Nickel	10^{-1}
Alloyed tool steel and high speed steel	10^{-1} to 10^{-2}
Heat resistant steel	10^{-3} to 10^{-2}
Molybdenum, tungsten	10^{-4}
Niobium, tantalum	10^{-5}
Beryllium	10^{-7}
Stainless steel	10^{-3} to 10^{-5}

Degree of vacuum required for the heat treatment of various materials. The tool steel and high speed steel row is the one that matters for a tool room order, and it is two to four decades away from the stainless and refractory rows.

The alloying elements that leave the surface

Material quality	C	W	Mo	Cr	V	Co
High speed steel	0.8	6.0	5.0	4.3	2.0	4.75
Chromium steel	0.48	1.6	–	1.0	–	–

Composition of the chromium and high speed steels examined in the vacuum surface study, in per cent. The high speed steel is the higher alloyed of the two and it is the one the surface figures below belong to.

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Element	Surface content at the start, %	Surface content after the hold, %	Direction of change
Chromium	4.3	about 1.5	falls
Iron	about 77.5	about 60	falls
Tungsten	6.0	about 11	rises
Molybdenum	5.0	about 10.5	rises

Surface composition of the high speed steel of the table above, held at 1000 °C under 10^{-4} torr. The start values are the analysis of the steel, and the values after the hold are read from the source figure and are therefore approximate. Chromium and iron leave the surface while tungsten and molybdenum concentrate in it.

Decarburisation, and why it matters less on a tool steel

Checking that the chamber is really holding vacuum

Where this leaves a vacuum tool steel order

Aobo Steel, tool steel supplier

Aobo Steel supplies tool steel to distributors and mold, tool and die shops, including D2, D3, DC53, A2, O1, H13, H11, H10, H21, S7, M2, M42, L6, P20 and 420 and 440C stainless. Forged or hot rolled, annealed or pre-hardened, cut to your sizes, with test certificates.

Source, Controlled Atmospheres for Heat Treatment, R. Nemenyi and G. H. J. Bennett, Pergamon Press, 1984.

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