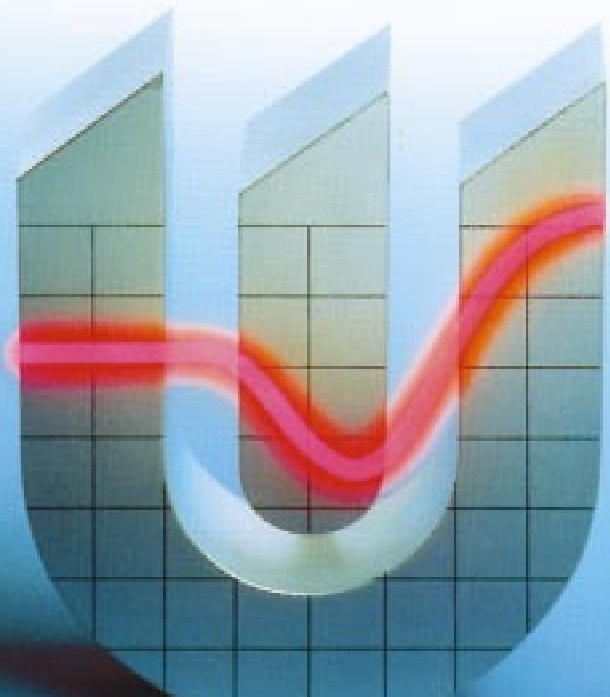
VANADIS 60 – SuperClean™
P/M – high speed steel for cold work



UDDEHOLM

Great Tooling Starts Here!

Applications

VANADIS 60 is a high alloyed high performance P/M high speed steel with an addition of cobalt.

VANADIS 60 is particularly suitable for cold work tooling where highest wear resistance and highest compressive strength are required at the same time.

General

VANADIS 60 is a W-Mo-V-Co alloyed P/M high speed steel characterized by:

- Highest wear resistance
- Maximum compressive strength
- Good through hardening properties
- Good toughness
- Good dimensional stability on heat treatment
- Very good temper resistance.

Typical analysis %	C 2.3	Cr 4.2	Mo 7.0	W 6.5	V 6.5	Co 10.5
Standard specification	W.-Nr. 1.3241					
Delivery condition	Soft annealed, max. 340 HB					
Color code	Gold					

VANADIS 60 is a super highly alloyed P/M high speed steel with a high cobalt and vanadium content.

Properties

SPECIAL PROPERTIES

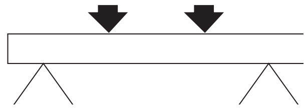
VANADIS 60 could be hardened to a very high hardness and compressive strength. *VANADIS 60* has further the same good dimensional stability during heat treatment as the other *VANADIS* grades. The toughness is despite the very high alloying content very good. The machinability is lower compared to lower alloyed HSS. The grindability of *VANADIS 60* is equal or better than other high alloyed HSS, but somewhat lower than for *VANADIS 30*. *VANADIS 60* has a very high hot hardness.

PHYSICAL DATA

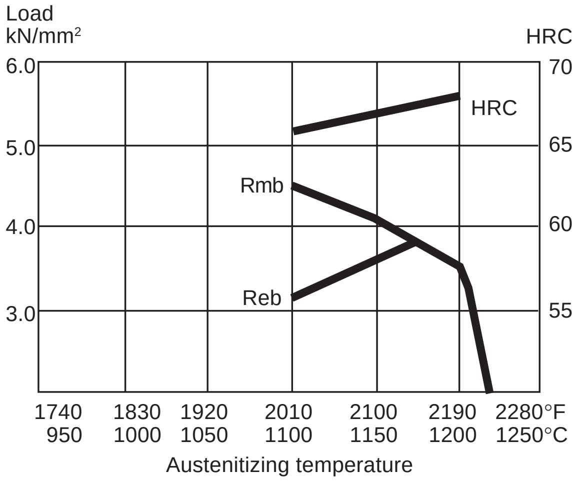
Temperature	68°F (20°C)	750°F (400°C)	1112°F (600°C)
Density, lbs/in^3 (1)	0.286	0.283	0.281
kg/m^3 (1)	7960	7860	7810
Modulus of elasticity ksi (2)	36 x 10^3	32 x 10^3	20 x 10^3
MPa (2)	250 000	222 000	200 000
Coefficient of thermal expansion per °F from 68°F (2)	–	5.9 x 10^{-6}	6.1 x 10^{-6}
°C from 20°C (2)	–	10.6 x 10^{-6}	11.1 x 10^{-6}
Thermal conductivity Btu in/(ft^2 h°F) (2)	145	173	166
W/m•°C (2)	21	25	24
Specific heat Btu/lb °F (2)	0.10	0.12	0.14
J/kg °C (2)	420	510	600

(1) = for the soft annealed condition.
(2) = for the hardened and tempered condition.

BEND STRENGTH

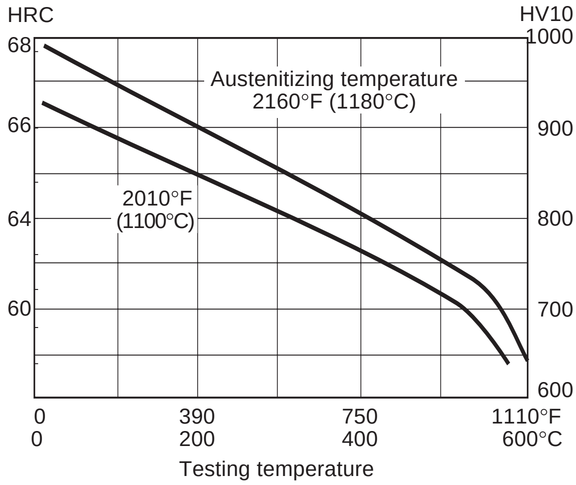


Four-point bend testing.
Specimen size: 0.2" (5 mm) Ø
Loading rate: 0.2"/min. (5 mm/min.)
Austenitizing temperature: 2010–2210°F (1100–1210°C)
Tempering: 3 x 1 h at 1040°F (560°C), air cooling to room temperature.



HIGH TEMPERATURE PROPERTIES

VANADIS 60 hot hardness



Heat treatment

SOFT ANNEALING

Protect the steel and heat through to 1560–1650° F (850–900° C). Then cool in the furnace at 20° F/h (10° C/h) to 1290° F (700° C), then freely in air.

STRESS RELIEVING

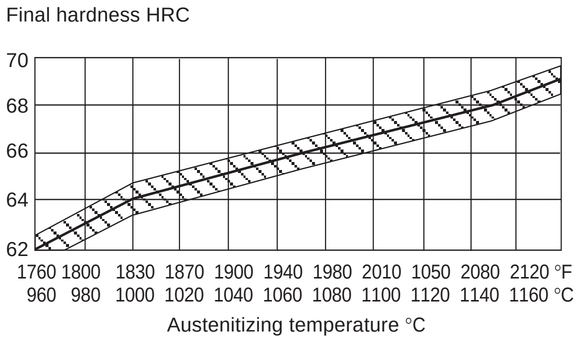
After rough machining the tool should be heated through to 1110–1290° F (600–700° C), holding time 2 hours. Cool slowly to 930° F (500° C), then freely in air.

TEMPERING

Pre-heating temperature: 840–930° F (450–500° C) and 1560–1650° F (850–900° C).
Austenitizing temperature: 2010–2155° F (1100–1180° C), according to the desired final hardness, see diagram below.

The tool should be protected against decarburization and oxidation during hardening.

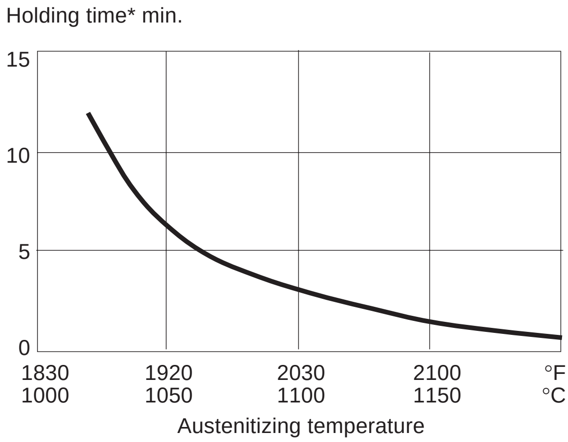
Hardness after tempering 3 times for one hour at 1040°F (560°C).



Hardness for different austenitizing temperatures after tempering 3 times for one hour at 1040°F (560°C) (±1 HRC).

HRC	°C	°F
62	960	1760
64	1000	1832
66	1070	1960
68	1150	2102
69	1180	2156

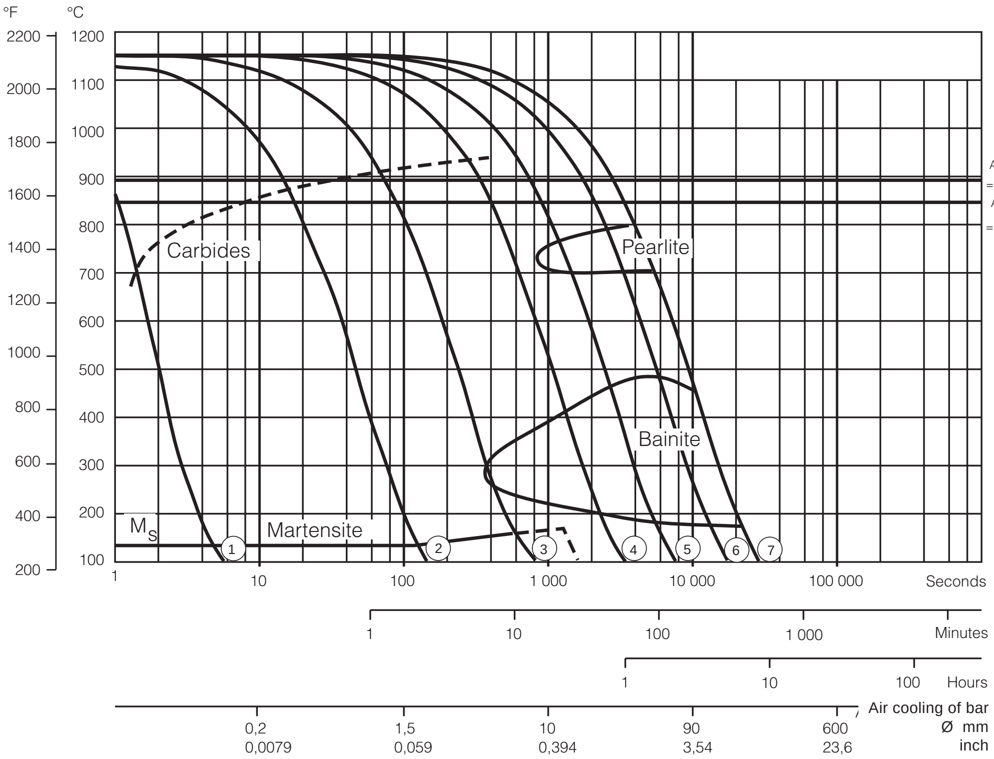
Recommended holding time



*) *Holding time = time at austenitizing temperature after the tool is fully heated through.*

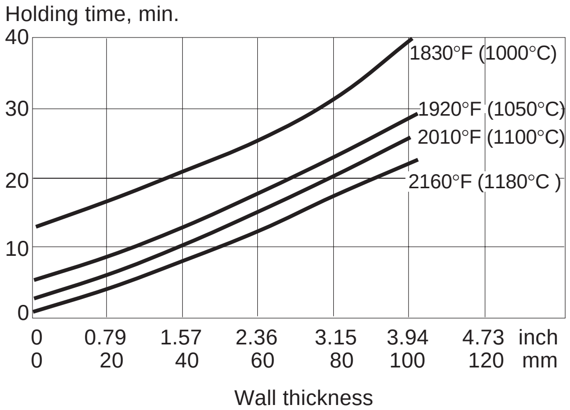
CCT-graph (continuous cooling)

Austenitizing temperature 1920° F (1150° C). Holding time 10 minutes.



Graph No.	Hard-ness Hv 10	$T_{800-500}$ (sec.)
1	946	1
2	946	28
3	946	140
4	772	630
5	620	1390
6	498	3205
7	450	5215

Total soaking time in a salt bath after pre-heating in two stages at 840°F (450°C) and 1560°F (850°C).



QUENCHING MEDIA

- Martempering bath at approx. 1004° F (540° C)
- Vacuum furnace with high speed gas at sufficient overpressure.

Note. 1: Quenching should be continued until the temperature of the tool reaches approx. 77° F (25° C). The tool should then be tempered immediately.

Note. 2: In order to obtain a high toughness, the cooling speed in the core should be at least 20° F/sec. (10° C/sec.). This is valid for cooling from the austenitizing temperature down to approx. 1004° F (540° C). After temperature equalization between the surface and core, the cooling rate of approx. 10° F/sec. (5° C/sec.) can be used. The above cooling cycle results in less distortion and residual stresses.

TEMPERING

For cold work applications tempering should always be carried out at 1040° F (560° C) irrespective of the austenitizing temperature. Temper three times for one hour at full temperature. The tool should be cooled to room temperature between the tempers. The retained austenite content will be less than 1% after this tempering cycle.

DIMENSIONAL CHANGES

Dimensional changes after hardening and tempering.
Heat treatment: austenitizing between 1920–2070° F (1050–1130° C) and tempering 3 x 1 h at 1040° F (560° C).
Specimen size: 2.91 x 2.91 x 2.91 in. (80 x 80 x 80 mm) and 3.94 x 3.94 x 0.99 in. (100 x 100 x 25 mm).
Dimensional changes: growth in length, width and thickness: +0.03% to +0.13%.

Cutting data recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local condition.

TURNING

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with HSS: Fine turning
Cutting speed (v_c) f.p.m. m/min	 200–300 60–90	 300–365 90–110	 27 8
Feed (f) i.p.r. mm/r	 0.008–0.016 0.20–0.40	 0.002–0.008 0.05–0.20	 0.002–0.012 0.05–0.30
Depth of cut (a_p) inch mm	 0.08–0.16 2–4	 0.02–0.08 0.5–2	 0.02–0.12 0.5–3
Carbide designation ISO	P10–P20*	P10*	–

** Use a wear resistant coated carbide grade, for example Sandvik Coromant GC4015 or SECO TP100.*

DRILLING

High speed steel twist drill

Drill diameter inch	Drill diameter mm	Cutting speed v_c f.p.m.	Cutting speed v_c m/min.	Feed f i.p.r.	Feed f mm/r
–3/16	– 5	17–33*	5–10*	0.002–0.006	0.05–0.15
3/16–3/8	5–10	17–33*	5–10*	0.006–0.010	0.15–0.25
3/8–5/8	10–15	17–33*	5–10*	0.010–0.014	0.25–0.35
5/8–3/4	15–20	17–33*	5–10*	0.014–0.016	0.35–0.40

** For TiCN coated HSS drill v_c ~ 33–50 f.p.m. (10–15 m/min.)*

Carbide drill

Cutting data parameters	Type of drill: Indexable insert	Type of drill: Solid carbide	Type of drill: Brazed carbide[1]
Cutting speed, v_c m/min f.p.m.	 80–100 265–335	 30 100	 25 85
Feed, f mm/r i.p.r.	 0.08–0.14[2] 0.003–0.006[2]	 0.10–0.15[2] 0.004–0.006[2]	 0.10–0.20[2] 0.004–0.008[2]

[1] Drill with internal cooling channels and brazed carbide tip.
[2] Depending on drill diameter.

MILLING

Face and square shoulder milling

Cutting data parameters	Milling with carbide: Rough milling	Milling with carbide: Fine milling	Milling with HSS: Fine milling
Cutting speed (v_c) f.p.m. m/min	 135–200 40–60	 200–265 60–80	 27 8
Feed (f_z) inch/tooth mm/tooth	 0.008–0.012 0.20–0.30	 0.004–0.008 0.10–0.20	 0.004 0.10
Depth of cut (a_p) inch mm	 0.08–0.16 2–4	 0.04–0.08 1–2	 0.04–0.08 1–2
Carbide designation ISO	K15*	K15*	–

** Use a wear resistant coated carbide grade, for example Sandvik Coromant GC3015 or SECO T15M.*

End milling

Cutting data parameters	Type of mill: Solid carbide	Type of mill: Carbide indexable insert	Type of mill: TiCN coated high speed steel
Cutting speed (v_c) f.p.m. m/min	 100–115 30–35	 135–200 40–60	 33–50 10–15
Feed (f_z) inch/tooth mm/tooth	 0.0004–0.008[2] 0.01–0.20[2]	 0.002–0.008[2] 0.06–0.20[2]	 0.0004–0.012* 0.01–0.30*
Carbide designation ISO	K20	P25 Coated carbide	–

** Depending on radial depth of cut and cutter diameter.*

GRINDING

General grinding wheel recommendation is given below. More information can be found in the Uddeholm publication "Grinding of Tool Steel".

Type of grinding	Soft annealed condition	Hardened condition
Face grinding straight wheel	A 46 HV	B107 R75 B3[1] 3SG 46 GVS[2] C 46 GV
Face grinding segments	A 24 GV	3SG 46 FVSPF[2] A 46 FV
Cylindrical grinding	A 60 JV	B126 R75 B3[1] 5SG 70 IVS[2] C 60 IV
Internal grinding	A 46 JV	B107 R75 B3[1] 3SG 60 JVS[2] C 60 HV
Profile grinding	A 100 LV	B107 R100 V[1] 5SG 80 JVS[2] C 120 HV

[1] If possible, CBN wheels should be used for these applications.
[2] Grinding wheel from Norton Co.

EDM

If EDM is performed in the hardened and tempered condition, finish with “finesparking”, i.e. low current, high frequency. For optimal performance the EDM’d surface should then be ground/ polished and the tool retempered at approx. 995°F (535°C).

Further information

Please, contact your local Uddeholm office for further information on the selection, heat treatment, application and availability of Uddeholm tool steels.

Relative comparison of Uddeholm cold work tool steel

MATERIAL PROPERTIES AND RESISTANCE TO FAILURE MECHANISMS