COMPAX® SUPREME

Mold quality tool steel

COLD WORK | PLASTIC MOULDING | HOT WORK | HIGH PERFORMANCE STEEL

UDDEHOLM

General

Compax Supreme is a chromium-molybdenum alloyed steel characterized by:

- high toughness
- good wear resistance
- high impact resistance
- good through hardening properties
- good machinability
- excellent polishability
- good dimensional stability during hardening

Typical analysis %	C 0.53	Si 0.3	Mn 0.7	Cr 3.2	Mo 1.5	S max 0.005
Standard spec.	AISI S 7					
Delivery condition	Soft annealed to approx. 200 HB					
Color code	Blue/white					

Applications

MOLDS FOR PLASTICS

Compax Supreme has been developed as a mold quality steel, based on the widely used AISI S-7 grade.

The steel is extremely clean and has a homogeneous microstructure. These features are achieved through strict processing control and maximum sulfur content of 0.005%. This quality level is verified by ultrasonic testing to high requirements.

The result is a steel that machines consistently, is predictable in heat treatment and can be polished to extremely high surface finishes. Further, the toughness of the steel is enhanced, for greater performance security and increased tool life.

By holding the carbon content to the high end of the carbon range a consistent hardness is assured, important in molds with larger cross-sections.

Compax Supreme is manufactured in the form of hot rolled and forged bars with a machined, decarb-free finish, with plus tolerances to allow finishing at a nominal inch size, where required.

PLASTICS MOLDING

	HRC
Plastic injection, compression and transfer molds	54–58
Slides, ejector pins, core pins, stripper rings	52–58

TOOLS FOR METAL STAMPING

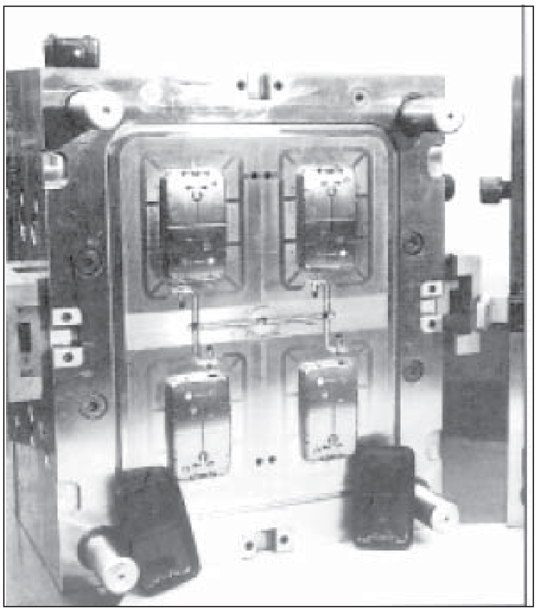
Compax Supreme is also suitable for a wide range of heavy duty blanking, shearing and forming tools, due to its excellent combination of toughness and wear resistance. Its relatively high carbon content makes the achievement of the maximum recommended working hardness of 58 HRC easier to achieve in larger cross sections.

BLANKING AND SHEARING

	Material thickness	Material hardness (HB) ≤ 180 HRC	Material hardness (HB) > 180 HRC
Tools for: Blanking, punching cropping, shearing, trimming	up to 1/8" (3 mm)	56–58	56–58
	1/8–1/4" (3–6 mm)	56–58	54–56
	1/4–13/32" (6–10 mm)	54–56	52–54
Shear blades – cold		56–58	
Shredding knives		56–58	
Shear blades – hot		50–54	
Circular shears		54–58	
Trimming tools for forgings		56–58	

FORMING

	HRC
Coining dies – cold	56–58
Cold extrusion dies, punches	56–58
Tube and section forming rolls; plain rolls	52–58
Cold heading tools	56–58
Master hobs for cold hobbing	56–58



Compax mold core inserts were used to produce Motorola, Energy Products Division powersupply housings for cellular products. Tooling built by: Moldmakers, Incorporated.

Properties

PHYSICAL DATA

Hardened and tempered to hardness HRC 57.
Data at room and elevated temperatures.

Temperature	68°F (20°C)	390°F (200°C)	750°F (400°C)
Density			
lbs/in³	0.282	0.280	0.278
kg/m³	7 800	7 750	7 700
Modulus of elasticity			
N/mm²	197 000	192 000	177 000
tsi	12 700	12 500	11 500
psi	29×10^6	28×10^6	26×10^6
Coefficient of thermal expansion			
/°F from 68°F	–	6.7×10^{-6}	6.9×10^{-6}
/°C from 20°C	–	12.2×10^{-6}	12.5×10^{-6}
Thermal conductivity			
Btu in/(ft² h °F)	202	207	215
W/m °C	28.9	30.0	31.0
Specific heat			
Btu/lb °F	0.11	–	–
J/kg °C	460	–	–

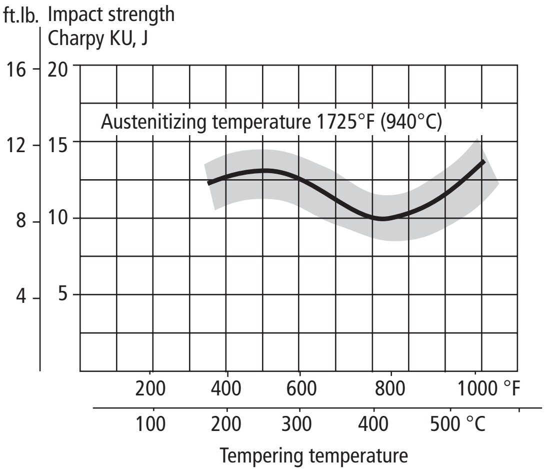
COMPRESSIVE STRENGTH

The figures are to be considered as approximate.

Hardness HRC	Compressive strength $R_{c0.2}$ ksi	Compressive strength $R_{c0.2}$ N/mm²
58	300	2070
55	295	2030
50	240	1650
45	200	1380

IMPACT STRENGTH AT ROOM TEMPERATURE

The impact strength values are to be regarded only as approximate by virtue of the scatter resulting from this method of testing. All samples have been taken in the rolling direction of a bar 1" (25 mm) diameter.



Heat Treatment

SOFT ANNEALING

Protect the steel and heat through to 1530°F (830°C). Then cool in the furnace at 20°F (10°C) per hour to 1000°F (540°C), then freely in air.

STRESS-RELIEVING

After rough machining the tool should be heated through to 1200°F (650°C), holding time 2 hours. Cool slowly to 930°F (500°C), then freely in air.

HARDENING

Preheating temperature: 1110–1290°F (600–700°C)
Austenitizing temperature: 1690–1780°F (920–970°C), but normally 1725°F (940°C).

Temperature °F	Temperature °C	Soaking time* minutes	Hardness before tempering (HRC)
1690	920	60	59±2
1725	940	45	60±2
1760	960	30	60±2

* *Soaking time = time at hardening temperature after the tool is fully heated through.*

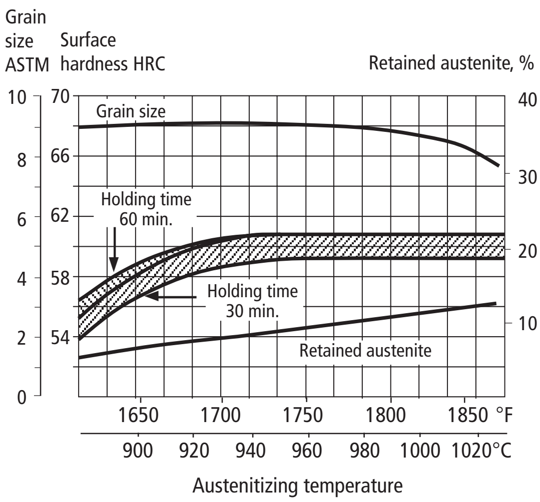
Protect the part against decarburization and oxidization during hardening.

QUENCHING MEDIA

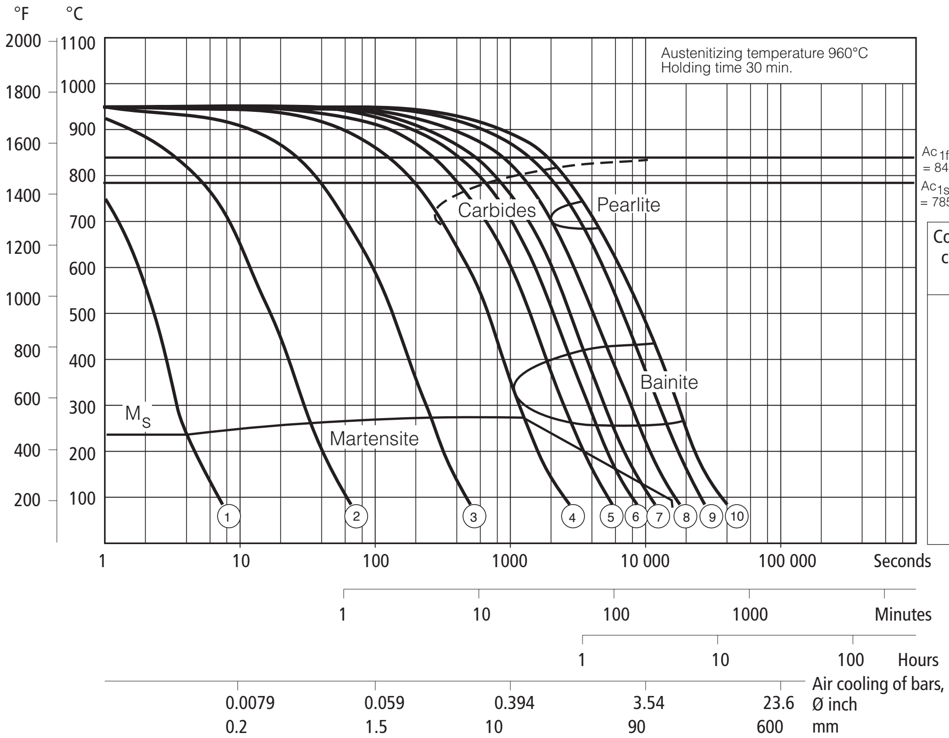
- Vacuum furnace with sufficient overpressure
- Forced air or gas
- Martempering bath at 360–480°F (180–250°C), then cool in air
- Oil (large cross sections)

Note 1: Quenching in oil gives an increased risk for dimensional changes and cracks.
Note 2: Temper the tool as soon as its temperature reaches 120–160°F (50–70°C).

Hardness, grain size and retained austenite as a function of the austenitizing temperature.



CCT graph
Austenitizing temperature 960°C. Holding time 30 minutes.

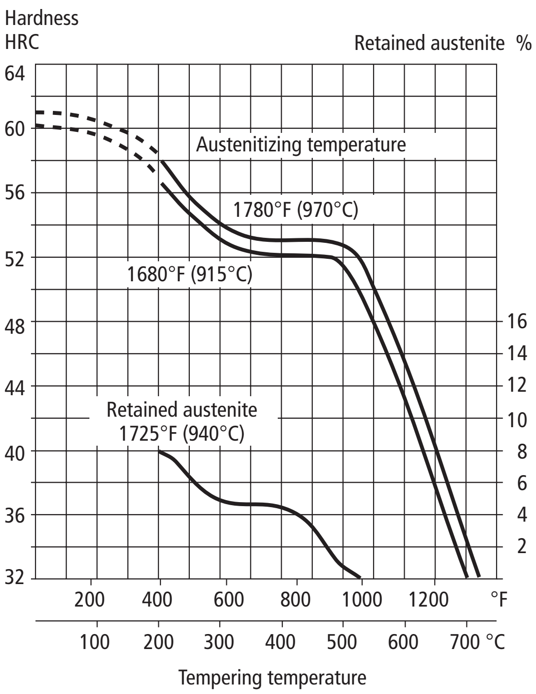


Cooling curve No.	Hardness HV 10	$T_{800-500}$ (sec.)
1	824	1
2	782	13
3	724	100
4	707	502
5	627	1071
6	560	1596
7	530	2138
8	478	3228
9	450	5215
10	446	7320

TEMPERING

Choose the tempering temperature according to the hardness required by reference to the tempering graph. Temper twice with intermediate cooling to room temperature. Lowest tempering temperature 360°F (180°C). Holding time at temperature minimum 2 hours.

Tempering graph

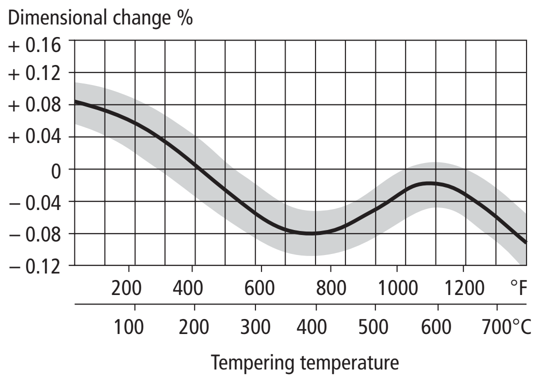


DIMENSIONAL CHANGES DURING HARDENING

Sample plate, 4" x 4" x 1" (100 x 100 x 25 mm)

Hardening from 1725°F (940°C)		Width %	Length %	Thick-ness %
Oil hardened	Min. Max.	+ 0.08 + 0.10	+ 0.09 + 0.10	 + 0.15
Air hardened	Min. Max.	+ 0.09 + 0.10	+ 0.10 + 0.13	 + 0.20

DIMENSIONAL CHANGES DURING TEMPERING



Note: Dimensional changes on hardening and tempering should be added together.

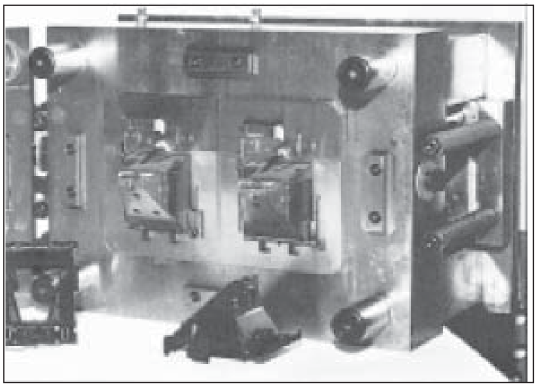
NITRIDING

Nitriding gives a hard surface which is very resistant to wear and erosion. A nitrided surface also increases the corrosion resistance. The surface hardness after nitriding at a temperature of 980°F (525°C) in ammonia gas will be approx. 1000 HV.

Nitriding temperature °F	Nitriding temperature °C	Nitriding time hours	Depth of case approx. inch	Depth of case approx. mm
980	525	20	0.010	0.25

NITROCARBURIZING

Nitrocarburizing at 1070°F (570°C) will give a surface hardness of approx. 850 HV. After 2 hours' treatment, the hard layer will be approx. 0.0004 in. (0.01 mm).



Compax Supreme mold to produce Polaroid 600 camera body, made by Global Precision Inc. The core inserts are made from Stavax ESR.

Machining recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. Additional information is available in "Cutting Data Recommendation" from Uddeholm.

TURNING

Cutting data parameters	Turning with carbide: Rough turning	Turning with carbide: Fine turning	Turning with high speed steel: Fine turning
Cutting speed (v_c) f.p.m.	490–655	655–820	65–82
m/min.	150–200	200–250	20–25
Feed (f) i.p.r.	0.008–0.016	0.002–0.008	0.002–0.012
mm/r	0.2–0.4	0.05–0.2	0.05–0.3
Depth of cut (a_p) inch	0.08–0.16	0.02–0.08	0.02–0.12
mm	2–4	0.5–2	0.5–3
Carbide designation US	C6–C5	C7	–
ISO	P20–P30 Coated carbide	P10 Coated carbide or cermet	

MILLING

Face and square shoulder face milling

Cutting data parameters	Milling with carbide: Rough milling	Milling with carbide: Fine milling
Cutting speed (v_c) f.p.m.	525–790	790–920
m/min.	160–240	240–280
Feed (f_z) in/tooth	0.008–0.016	0.004–0.008
mm/tooth	0.2–0.4	0.1–0.2
Depth of cut (a_p) inch	0.08–0.2	–0.08
mm	2–5	–2
Carbide designation US	C6–C5	C7–C6
ISO	P20–P40 Coated carbide	P10–P20 Coated carbide

End milling

Cutting data parameters	Type of milling Solid carbide	 Carbide indexable insert	 High speed steel
Cutting speed (v_c) f.p.m. m/min.	460–590 140–180	490–690 150–210	85–100[1)] 25–30[1)]
Feed (f_z) in/tooth mm/tooth	0.001–0.008[2)] 0.03–0.2[2)]	0.003–0.008[2)] 0.08–0.2[2)]	0.002–0.014[2)] 0.05–0.35[2)]
Carbide designation US ISO	 C2 K20	 C6–C5 P20–P30 Coated carbide	 – –

[1)] For coated HSS end mill v_c = 150–165 f.p.m. (45–50 m/min).
[2)] Depending on radial depth of cut and cutter diameter.

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	50–55*	15–17*	0.002–0.006	0.05–0.15
3/16–3/8	5–10	50–55*	15–17*	0.006–0.008	0.15–0.20
3/8 –5/8	10–15	50–55*	15–17*	0.008–0.010	0.20–0.25
5/8 –3/4	15–20	50–55*	15–17*	0.010–0.014	0.25–0.35

** For coated HSS drill v_c = 85–90 f.p.m. (26–28 m/min.).*

Carbide drill

Cutting data parameters	Type of drill Indexable insert	 Solid carbide	 Brazed carbide[1)]
Cutting speed (v_c) f.p.m. m/min.	655–720 200–220	360–460 110–140	230–295 70–90
Feed (f) i.p.r. mm/r	0.002–0.01[2)] 0.05–0.25[2)]	0.004–0.01[2)] 0.10–0.25[2)]	0.006–0.01[2)] 0.15–0.25[2)]

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

GRINDING

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

Type of grinding	Wheel recommendation Soft annealed condition	 Hardened condition
Face grinding straight wheel	A 46 H V	A 46 HV
Face grinding segments	A 24 G V	A 36 G V
Cylindrical grinding	A 46 L V	A 60 KV
Internal grinding	A 46 J V	A 60 J V
Profile grinding	A 100 L V	A 120 K V

Electrical-discharge machining (EDM)

If spark-erosion is performed in the hardened and tempered condition, the tool should then be given an additional temper at about 40°F (20°C) lower than previous tempering temperature.

Hard-chromium-plating

After hard-chromium-plating, the tool should be tempered for approx. 4 hours at 350°F (180°C) in order to avoid hydrogen embrittlement.

Polishing

Compax Supreme has good polishability in the hardened and tempered condition.

After grinding, polishing is undertaken with aluminum oxide or diamond paste.

Typical procedure:

1. Grind to 0.002 in. (0.05 mm) from finished size.
2. Polish with diamond paste grade 45, to obtain a dull, even surface.
3. Polish with diamond paste grade 15.
4. Polish with diamond paste grade 2.
5. For particularly high demands on surface finish, polish with diamond paste grade 1.

Note: Each steel grade has an optimum polishing time which largely depends on hardness and polishing technique. Overpolishing can lead to a poor surface finish (e.g. an "orange peel" effect).

Further information is given in the Uddeholm publication "Polishing of Tool Steel".

Welding recommendations

GENERAL

Good results can be obtained when welding Compax Supreme. The following recommendations are made:

In general, the following is valid:

- Always keep the arc length as short as possible. The coated electrode should be angled at 90° to the joint sides to avoid undercut. In addition, the electrode should be held at an angle of 75–80° to the direction of forward travel.
- Larger repair welds must be made at elevated temperature. The temperature of the workpiece should be held as constant as possible during welding. The best way to keep the tool at constant temperature during welding is to use an insulated box with thermostatically regulated electrical heating elements inside the walls.
- The first two layers should always be welded with the same heat input and with a small diameter electrode (max. 1/8" (3,25 mm) Ø electrode for MMA or max. 120A for TIG welding).
- First of all, the parent metal is clad by using an appropriate number of runs. All other runs should then be made up on top of pre-existing weld metal except in those cases where soft metal electrodes of the type 29Cr/9Ni are used. When a soft weld metal is used, a space of 1.20" (3 mm) must be left below the finished surface so that the hard facing electrode can be used to give the right surface hardness on the welded tool.
- For large weld repairs, the parent metal should be coated with a soft weld metal of the 29/9 type (i.e. 29% Cr, 9% Ni electrodes AWS ER 312 or AWS E312), which gives a tougher weld metal with lower hardness.
- The choice of electrode for welding depends on the hardness required in the weld metal (see following tables).
- In order to obtain the required hardness (as given in the following tables), the weld should be built up with at least 3 layers plus an additional layer which is ground off after welding has been completed. When welding tool steels, the last layer should always be ground off.
- It should be noted that differences between expected and achieved hardness in the weld metal normally depend on how the grinding of the last layer has been carried out.

  Grinding should always be carried out before the temperature in the tool sinks too much. If the grinding is too rough so that the weld becomes red hot, microcracks will appear in the weld metal.

  Use filler material that have the same chemical composition as the base material on dies that will be polished or photo-etched. Cut out thin rods of Compax Supreme material for TIG-welding.
- The following heat treatment cycle is recommended for weld repairs:
  1) Pre-heat the tool to 390–480°F (200–250°C). Keep that temperature during the whole welding operation.
  2) Let the tool cool slowly after welding to 160°F (70°C) when welded in hardened condition.
  3) Stress temper the tool at a temperature 40°F (20°C) below previously used tempering temperature.
  4) When welded in soft annealed condition, soft anneal before hardening.

JOINT PREPARATION

The importance of careful joint preparation cannot be over-emphasized. Cracks should be ground out so that the joint bottom is rounded and the sides of the joint slope at an angle of at least 30° to the vertical. The width of the joint bottom should be at least 0.040 in (1 mm) greater than the electrode diameter (including the coating) which is used. Further recommendations on welding of tool steels can be found in the Uddeholm brochure “Welding of Tool Steel”.

Further information

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

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