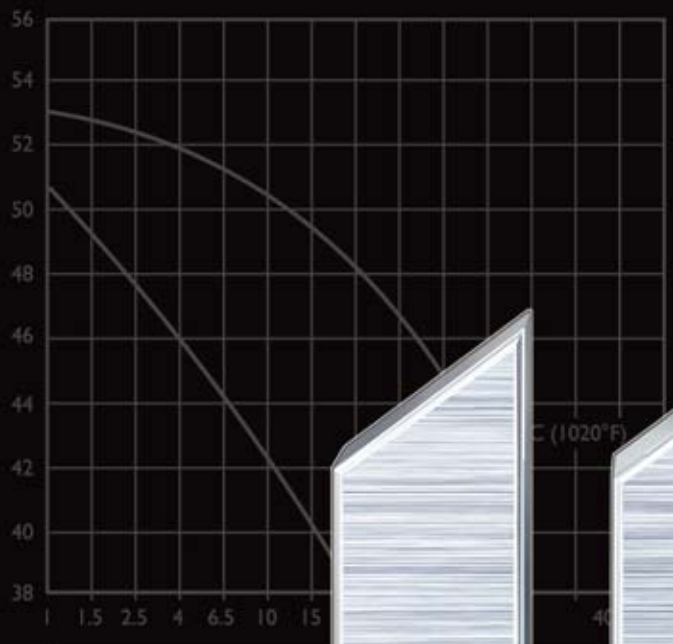
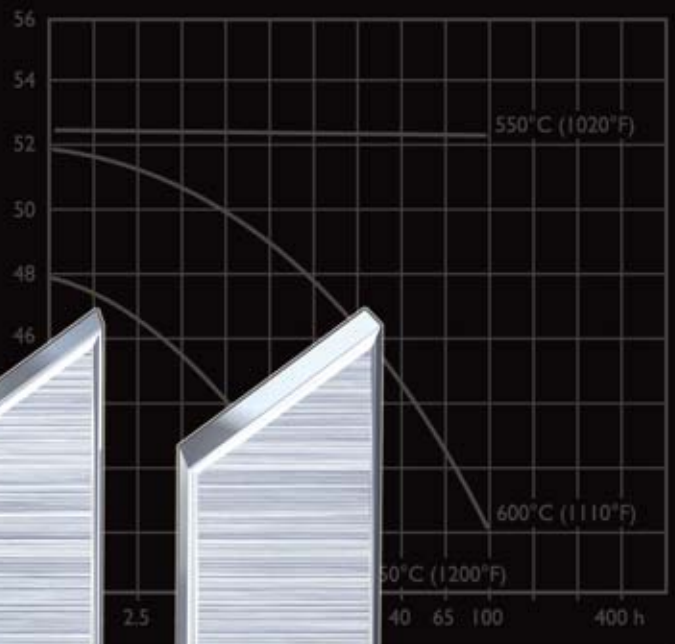
# Premium P20 Modified

**Prehardened mold steel**

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




| Typical analysis % | C 2,05 | | | | Mn 0,8 | Cr 4,5 | W 0,2 |
|---|---|---|---|---|---|---|---|
| Standard specifikation | AISI D6, ( | | | | | 03) (W.Nr. 1.2796) | |
| Delivery condition | Soft anne | | | | | o approx. 200 HB | |
| Colour code | Red | | | | | | |

| Temperature | 20°C (68°F) | | | 200°C (390°F) | 400°C (750°F) |
|---|---|---|---|---|---|
| Density kg/m³ | 7 770 | | | 7 650 | 7 650 |
| lbs/m³ | 0,281 | | | 0,276 | 0,275 |
| Modulus of elasticity N/mm² | 194 000 | 188 000 | | 189 000 | 173 000 |
| psi | 28,1 x 10⁶ | 27,3 x 10⁶ | | 27,4 x 10⁶ | 25,1 x 10⁶ |
| Coefficient of thermal expansion per °C from 20°C | to 100°C 11,7 x 10⁻⁶ | to 200°C 12 x 10⁻⁶ | to 400°C 13,0 x 10⁻⁶ | to 100°C 12,3 x 10⁻⁶ | to 200°C 14 x 10⁻⁶ | to 400°C 15,1 x 10⁻⁶ |
| per °F from 68°F | to 212°F 6,5 x 10⁻⁶ | to 400°F 6,7 x 10⁻⁶ | to 750°F 7,3 x 10⁻⁶ | to 212°F 6,1 x 10⁻⁶ | to 400°F 6,7 x 10⁻⁶ | to 750°F 7,3 x 10⁻⁶ |
| Thermal conductivity W/m °C | - | 27 | 32 | 20,5 | 21,5 | 23,0 |
| Btu in (ft²h°F | - | 187 | 221 | 142 | 149 | 159 |
| Specific heat K/kg °C | 455 | 525 | 608 | 460 | - | - |
| Btu/lbs °F | 0,109 | 0,126 | 0,145 | 0,110 | - | - |

# General

P20 Modified is a Cr-Mo-alloyed steel which is supplied in the hardened and tempered condition. P20 Modified offers the following benefits:

- No hardening risks
- No hardening costs
- Time saving, e.g. no waiting for heat treatment
- Lower tool cost (e.g. no distortion to rectify)
- Modifications easily carried out
- Can be subsequently nitrided to increase surface wear resistance or locally flame hardened to reduce surface damage

P20 Modified is manufactured to consistently high quality standards, giving a steel with the following characteristics:

- Good polishing and texturing properties
- Good machinability
- Uniform hardness

Heavier sections are supplied premachined which offers the following advantages compared with unmachined material:

- Saving of weight
- Non-decarburized surface
- Exact nominal size (plus tolerance)
- Less machining
- Absence of scale minimizes machine and tool wear

| | |
|---|---|
| Standard spec. | AISI P20 modified |
| Delivery condition | Hardened and tempered to 285–340 HB* |
| Color code | Yellow/green |

** Custom forged blocks can be supplied to specified hardness levels by customers.*

# Applications

- For large injection and compression molds
- Extrusion dies for thermoplastics
- Blow molds
- High strength holders, plates and bolsters
- Forming tools, press-brake dies (possibly flame hardened or nitrided)
- Aluminum die casting prototype dies
- Zinc die casting dies
- Long run die shoes
- Structural components, shafts

# Properties

### PHYSICAL DATA

Hardened and tempered to 310 HB.

| Temperature | 68°F (20°C) | 390°F (200°C) |
|---|---|---|
| Density, lbs/in$^3$ | 0.282 | 0.280 |
| kg/m$^3$ | 7,800 | 7,750 |
| Coefficient of thermal expansion | | |
| per °F from 68°F | – | 7.0 x 10$^{-6}$ |
| per °C from 20° | – | 12.7 x 10$^{-6}$ |
| Thermal conductivity | | |
| Btu in/ft$^2$ h °F | 202 | 205 |
| W/m °C | 29.0 | 29.5 |
| Modulus of elasticity | | |
| psi | 29.7 x 10$^6$ | 29.0 x 10$^6$ |
| N/mm$^2$ | 205,000 | 200,000 |
| Specific heat capacity | | |
| Btu/lb°F | 0.110 | – |
| J/kg °C | 460 | – |

### MECHANICAL PROPERTIES

**Tensile strength**

Approximate values. Hardness 300 HB.

| Testing temperature | | 68°F (20°C) |
|---|---|---|
| Tensile strength $R_m$ | psi | 138,000–160,000 |
| | N/mm$^2$ | 950–1,100 |
| Yield strength $R_{p0.2}$ | psi | ≥101,000 |
| | N/mm$^2$ | ≥700 |
| Elongation, A | % | ≥12 |

# Heat treatment

P20 Modified is intended for use in the hardened and tempered condition, i.e. the delivery condition. When, however, the steel is to be heat treated to a higher hardness or case hardened, the following instructions may be helpful.

### SOFT ANNEALING

Protect the steel and heat through to 1330°F (720°C). Then cool in the furnace at 50°F (10°C) per hour to 1110°F (600°C), then freely in air.

### STRESS-RELIEVING

After rough machining the tool should be heated through to 1020°F (550°C), holding time 2 hours. Cool slowly to room temperature.

### HARDENING

*Note:* The steel should be fully soft annealed before hardening.

*Preheating temperature:* 930–1110°F (500–600°C).
*Austenitizing temperature:* 1620°F (880°C).

The steel should be heated through to the austenitizing temperature and held at temperature for 30 minutes.

*Protect the tool against decarburization and oxidation during the hardening process.*

### QUENCHING MEDIA

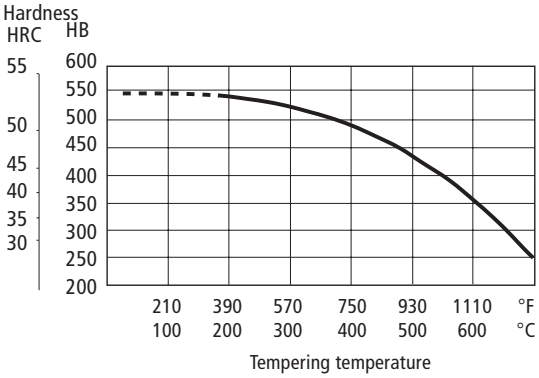
- High speed gas/circulating atmosphere. (Only suitable for small dimensions)
- Oil
- Martempering bath 570°F (300°C), max. 4 minutes, then air

*Note:* Temper immediately tool reaches 120–160°F (50–70°C).

### TEMPERING GRAPH

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) for small inserts, but preferred minimum is 480°F (250°C). Holding time at temperature minimum 2 hours.

The diagram is valid for small samples 0.6 x 0.6 x 1.6 inch. (15 x 15 x 40 mm) austenitized 30 min. at 1620°F (880°C), quenched in air and tempered 2 + 2 hours.




### FLAME AND INDUCTION HARDENING

P20 Modified can be flame or induction hardened to a hardness of approx. 50 HRC. Cooling in air is preferable. Further information can be obtained from the Uddeholm Technical Services Report "Flame hardening of Impax Supreme".

### NITRIDING AND NITROCARBURIZING

Nitriding gives a hard surface which is very resistant to wear and erosion. A nitrided surface also increases the corrosion resistance.

For best result the following steps should be followed:

1. Rough machining
2. Stress tempering at 1020°F (550°C)
3. Grinding
4. Nitriding

Following surface hardness and nitriding depths will be achieved after nitriding.

| | Temperature °F | Temperature °C | Time h | Surface hardness (HV) | Depth of case approx in | Depth of case approx mm |
|---|---|---|---|---|---|---|
| Gas-nitriding | 980 | 525 | 20 | 650 | 0.012 | 0.30 |
| | 980 | 525 | 30 | 650 | 0.014 | 0.35 |
| Ion-nitriding | 900 | 480 | 24 | 700 | 0.012 | 0.30 |
| | 900 | 480 | 48 | 700 | 0.016 | 0.40 |
| Nitrocar-burizing | 1060 | 570 | 2 | 700 | 0.004 | 0.10 |

# Machining recommendations

The cutting data below are to be considered as guiding values which must be adapted to existing local conditions. More information can be found in our "Cutting data recommendations".

## TURNING

| Cutting data parameters | Turning with carbide | | Turning with high speed steel |
|---|---|---|---|
| | Rough turning | Fine turning | Fine turning |
| Cutting speed ($v_c$) | | | |
| f.p.m. | 394–558 | 558–722 | 49–66 |
| m/min. | 120–170 | 170–220 | 15–20 |
| 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 | 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 | Fine milling |
| Cutting speed, ($v_c$) | | |
| f.p.m. | 265–492 | 492–623 |
| m/min. | 80–150 | 150–190 |
| Feed, ($f_z$) | | |
| inch/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 | 0,08–0,16 | –0,08 |
| mm | 2–4 | –2 |
| Carbide designation | | |
| US | C6,C5 | C7, C6 |
| ISO | P20–P40 Coated carbide | P10–P20 Coated carbide or Cermet |

### End milling

| Cutting data parameters | Milling cutter | | |
|---|---|---|---|
| | Solid carbide | Carbide indexable insert | High speed steel |
| Cutting speed ($v_c$) | | | |
| f.p.m. | 230–361 | 262–394 | 49–66[1] |
| m/min. | 70–110 | 80–120 | 15–20[1] |
| Feed ($f_z$) | | | |
| inch/tooth | 0,001–0,008[2] | 0,003–0,008[2] | 0,002–0,014[2] |
| mm/tooth | 0,03–0,20[2] | 0,08–0,20[2] | 0,05–0,35[2] |
| Carbide designation US | | C6,C5 | |
| ISO | – | P20–P40 | – |

*[1] For coated HSS end mill $v_c$ =115–131 f.p.m. (35–40 m/min.)*

*[2] Depending on radial depth of cut and cutter diameter*

## DRILLING

### High speed steel twist drill

| Drill diameter | | Cutting speed ($v_c$) | | Feed (f) | |
|---|---|---|---|---|---|
| inch | mm | f.p.m. | m/min | i.p.r. | mm/r |
| –3/16 | –5 | 46–52 | 14–16* | 0,003–0,006 | 0,08–0,15 |
| 3/16–3/8 | 5–10 | 46–52 | 14–16* | 0,006–0,010 | 0,15–0,25 |
| 3/8–5/8 | 10–15 | 46–52 | 14–16* | 0,010–0,012 | 0,25–0,30 |
| 5/8–3/4 | 15–20 | 46–52 | 14–16* | 0,012–0,014 | 0,30–0,35 |

**For coated HSS drill $v_c$ =79–85 f.p.m. (24–26 m/min.)*

### Carbide drill

| Cutting data parameters | Type of drill | | |
|---|---|---|---|
| | Indexable insert | Solid carbide | Brazed carbide[1] |
| Cutting speed ($v_c$) | | | |
| f.p.m. | 600–656 | 394–492 | 197–262 |
| m/min. | 180–200 | 120–150 | 60–80 |
| Feed (f) | | | |
| i.p.r. | 0,002–0,01[2] | 0,004–0,01[2] | 0,006–0,01[2] |
| mm/r | 0,05–0,25[2] | 0,10–0,25[2] | 0,15–0,25[2] |

*[1] Drill with internal cooling channels and brazed carbide tip*

*[2] Depending on drill diameter*

## GRINDING

A 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 |
|---|---|
| Face grinding straight wheel | A 46 HV |
| Face grinding segments | A 24 GV |
| Cylindrical grinding | A 60 LV |
| Internal grinding | A 46 JV |
| Profile grinding | A 100 LV |

# Electrical-discharge machining

If spark-erosion, EDM, is performed in the as delivered condition, the tool should then be given an additional temper at approx. 1020°F (550°C). If the steel has been rehardened, the additional tempering temperature should be 50°F (25°C) lower than the last tempering temperature used.

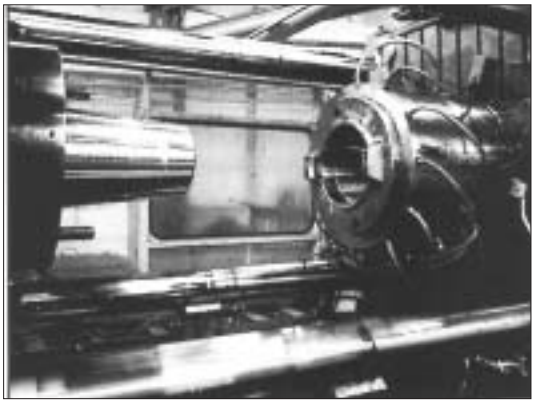
Further information can be obtained from the Uddeholm brochure "EDM of tool steel".

# Welding

Good results when welding tool steel can be achieved if proper precautions are taken during welding (elevated working temperature, joint preparation, choice of consumables and welding procedure). If the tool is to be polished or textured, it is necessary to work with an electrode type of matching composition.

| Welding method | TIG | MMA (SMAW) |
|---|---|---|
| Working temp. | 390–480°F (200–250°C) | 390–480°F (200–250°C) |
| Consumables | P20 Grade | P20 Grade |
| Hardness after welding | 320–350 HB | 320–350 HB |

Further information is given in the Uddeholm brochure "Welding of Tool Steel".



*Large mold to produce laundry-baskets. Suitable grade for this molding tool is Premium P20 Modified.*

# Hard-chromium-plating

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

# Texturing

P20 Modified is particularly suitable for texturing by the photo-etching process. Its very low sulfur content ensures accurate and consistent pattern reproduction.

For heavy sections an extra tempering at 1020°F (550°C) before texturing is recommended.

# Polishing

P20 Modified has good polishability in the hardened and tempered condition. After grinding, polishing is undertaken with aluminum oxide or diamond paste.

*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 mold steel".

# Further information

Contact your Bohler-Uddeholm office for further information on the selection, heat treatment, application and availability of Bohler-Uddeholm tool steels.

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Edition: 2, 09.2004