Powder metallurgy Tool Steel

A11 PM

CHEMICAL COMPOSITION

<table>
<thead>
<tr>
<th>C</th>
<th>Cr</th>
<th>Mo</th>
<th>W</th>
<th>Co</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.45</td>
<td>5.25</td>
<td>1.3</td>
<td>-</td>
<td>-</td>
<td>9.75</td>
</tr>
</tbody>
</table>

STANDARDS

- USA: AISI A11

DELIVERY HARDNESS

Soft annealed  max. 280 HB
Cold drawn max. 320 HB
Cold rolled max. 320 HB

DESCRIPTION

A11 PM is a high vanadium grade for wearing applications

APPLICATIONS

- Knives
- Wear parts
- Cold work

FORM SUPPLIED

- Coils
- Coarse Round bars
- Flat and square bars
- Sheets
- Discs
- Pieces cut from sheets

Available surface conditions: peeled, rough machined, cold rolled, hot rolled.

HEAT TREATMENT

- Soft annealing in a protective atmosphere at 1560-1650°F for 3 hours, followed by slow cooling at 20°F/h down to 1290°F, then air cooling.
- Stress-relieving at 1110°F to 1290°F for approximately 2 hours, slow cooling down to 930°F.
- Hardening in a protective atmosphere with pre-heating in 2 steps at 840-930°F and 1560-1650°F and austenitising at a temperature suitable for chosen working hardness. Cooling down to 100-120°F.
- Tempering at 1040°F three times for at least 1 hour each time. Cooling to room temperature (77°F) between temperings.

GUIDELINES FOR HARDENING

![Graph showing HRC values vs. Tempering temperature]

Tempering temperature
Hardness after hardening, quenching and tempering 3x1 hour

PROCESSING

A11 PM can be worked as follows:

- machining (grinding, turning, milling)
- polishing
- plastic forming
- electrical discharge machining
- welding (special procedure including preheating and filler materials of base material composition).

GRINDING

During grinding, local heating of the surface, which may alter the temper, must be avoided. Grinding wheel manufacturers can furnish advice on the choice of grinding wheels.

SURFACE TREATMENT

The steel grade is a good substrate material for PVD and CVD coating. If nitriding is requested a small zone of 2-15 μm is recommended. The steel grade can also be steam-tempered if so desired.

04/05
PROPERTIES

PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th></th>
<th>Temperature</th>
<th>70°F</th>
<th>750°F</th>
<th>1110°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density lb/in³ (1)</td>
<td></td>
<td>0.27</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td>Modulus of elasticity (2)</td>
<td></td>
<td>3.2x10⁷</td>
<td>2.8x10⁷</td>
<td>2.5 x10⁷</td>
</tr>
<tr>
<td>Thermal expansion ratio, per °F (2)</td>
<td></td>
<td>-</td>
<td>6.6 x10⁻⁶</td>
<td>6.8 x10⁻⁶</td>
</tr>
<tr>
<td>Thermal conductivity Btu/ft h °F (2)</td>
<td></td>
<td>12</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>Specific heat Btu/lb °F (2)</td>
<td></td>
<td>0.10</td>
<td>0.12</td>
<td>0.14</td>
</tr>
</tbody>
</table>

(1)=Soft annealed
(2)=Hardened 2155°F and tempered 1040°F, 3 x 1 hour

COMPRESSION YIELD STRESS

Rc 0.2
kN/mm²

Test piece: hour glass with 2/5 inch Ø waist

IMPACT STRENGTH

FT LB

Hardening temperature in °F
Original dimensions 1/3x1/2 mm
Tempering 3 x 1 hour at 1040°F
Unnotched test piece 9/32 x13/32 x 25/32 inch

COMPARATIVE PROPERTIES

Machinability Wear resistance Toughness Hot hardness Grindability

NB: High quality surface
Rmb = Ultimate bend strength in ksi
Reb = Bend yield strength in ksi
Tot. work = Total work in ft lb

4-POINT BEND STRENGTH