CRUCIBLE

CPM Rex 45 is an 8% cobalt modification of M3 high speed steel made by the CPM (Crucible Particle Metallurgy) Process. It has red hardness comparable to that of M42 but offers abrasion resistance even better than that of M3. With its excellent red hardness, good wear resistance and good toughness, CPM Rex 45 is suitable for difficult machining applications or high cutting speed applications.

The CPM process results in a homogeneous microstructure with a finer, more uniform carbide distribution imparting superior dimensional stability, grindability and toughness when compared to steels produced by conventional processes. The CPM process also allows the design of more highly alloyed grades which cannot be produced by conventional steelmaking.

**High Speed Steel Comparator**

![Graph showing wear resistance, red hardness, and toughness comparison between CPM Steel and Conventional Steel](image)

**Typical Applications**

- Gear Hobs
- Milling Cutters
- End Mills
- Extrusion Punches
- Form Tools
- Shaper Cutters
- Broaches
- Taps

**Physical Properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>CPM Rex 45</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elastic Modulus</td>
<td>31 X10^6 psi</td>
<td>214 GPa</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>8.05</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>0.291 lbs/in^3</td>
<td>8.05 g/cm^3</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>(6.3 \times 10^{-6}) °F/°C</td>
<td>(11.4 \times 10^{-6}) °F/°C</td>
</tr>
<tr>
<td></td>
<td>(6.4 \times 10^{-6}) °F/°C</td>
<td>(11.5 \times 10^{-6}) °F/°C</td>
</tr>
</tbody>
</table>

**Machinability and Grindability**

**Machinability** of CPM Rex 45 in the annealed condition is approximately 30% of W1 Tool Steel (1%C).

**Grindability** of CPM Rex 45 compares favorably with regular high speed steels because of its fine, uniformly distributed carbides. Conventional grinding wheels designed for high speed steels can be used. In special cases, the advice of a grinding wheel manufacturer should be sought.

**Crucible Industries LLC**

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**Critical Temperature:** 1500°F (815°C)

**Forging:** 2000-2100°F (1095-1150°C). Do not forge below 1700°F (925°C). Slow cool after forging.

**Annealing**
Heat to 1600°F (870°C), hold 2 hours, slow cool no faster than 25°F (15°C) per hour to 1000°F (540°C), then furnace cool or cool in still air to room temperature.

**Annealed Hardness:** Approx. BHN 255/285

**Stress Relieving**
Annealed parts: Heat to 1100-1300°F (595-705°C), hold 2 hours, then furnace cool or cool in still air.

Hardened parts: Heat to 25°F (15°C) below original tempering temperature, or 1000°F (540°C) minimum, hold 2 hours, then furnace cool or cool in still air.

**Hardening (Salt or High Pressure Vacuum preferred)**

Pre-heat: Heat to 1500-1550°F (815-845°C), hold long enough to soak through. For vacuum heat treating, an additional pre-heat at 1850-1900°F (1010-1040°C) is recommended to minimize hold time needed at austenitizing temperature.

**Austenitize:** 2100-2190°F (1150-1200°C)
Standard recommendation to achieve HRC 66-68 is 2175°F (1190°C).

**Quench:** Quench rapidly to below 1100°F (595°C), equalize, then air cool to hand warm, below 125°F (50°C). Salt or interrupted oil quenching usually gives the best heat treat response for high speed steels. A fast quench rate from hardening temperature to below 1100°F (595°C) is critical to achieve optimum heat treat response.

**Temper:** 1000°F (540°C) minimum. Triple tempering is required, hold 2 hr. minimum at temperature. Cool to room temperature between tempers.

**Straightening:** Best done warm 400°F minimum (205°C). Straightening after salt quenching and before cooling to below 400°F (205°C) is preferred.

**Size Change During Hardening**

<table>
<thead>
<tr>
<th>Hardening Temp.</th>
<th>Tempering Temp.</th>
<th>HRC</th>
<th>Size Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>2175°F (1190°C)</td>
<td>1025°F (550°C)</td>
<td>67</td>
<td>+0.002 in/in (+0.051 mm/mm)</td>
</tr>
</tbody>
</table>

**Heat Treat Response**

<table>
<thead>
<tr>
<th>Hardness (HRC) - Oil or Salt Quench (Note A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tempering Temperature</td>
</tr>
<tr>
<td>°F (°C)</td>
</tr>
<tr>
<td>As-Quenched</td>
</tr>
<tr>
<td>1000 (540)</td>
</tr>
</tbody>
</table>

Optimum for Maximum toughness and Effective Stress Relieving

<table>
<thead>
<tr>
<th>Min. Tempering Temp.</th>
<th>10°F</th>
<th>10°F</th>
<th>5°F</th>
<th>5°F</th>
<th>3°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Tempering Temp.</td>
<td>5°C</td>
<td>5°C</td>
<td>5°C</td>
<td>5°C</td>
<td>5°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardening Temp.</th>
<th>Tempering Temp.</th>
<th>Hardness</th>
<th>Charpy Impact</th>
<th>Bend Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>2175 (1190)</td>
<td>1025 (550)</td>
<td>67</td>
<td>15 20</td>
<td>702 4826</td>
</tr>
<tr>
<td>2150 (1175)</td>
<td>1025 (550)</td>
<td>66.5</td>
<td>18 24</td>
<td>712 4895</td>
</tr>
<tr>
<td>2125 (1165)</td>
<td>1040 (560)</td>
<td>65</td>
<td>20 27</td>
<td>685 4709</td>
</tr>
</tbody>
</table>

**Toughness:** Lower hardening temperatures (underhardening) provide finer grain size and increased toughness.

**Surface Treatments**

CPM Rex 45 can be nitrided or PVD coated if desired. If a CVD treatment is used, subsequent hardening is...