FX-XTRA

**General Characteristics**
An alloy of Ni-Cr-Mo offered in a wide range of heat treated conditions for versatile service in the forging industry.

**FX Temper 2**
The most popular, FX Temper 2 (38-42 HRC) is a remarkably strong die steel with balanced wear and fracture toughness characteristics.

**FX Temper 3**
The more ductile, FX Temper 3 (33-37 HRC) is for die blocks, rams, shafts, die holders, v-guides, sow blocks and other general industrial uses favoring fracture toughness over abrasion demands.

**FX Temper 1 and FX Temper H**
Higher hardness FX Temper 1 (43-46 HRC) or FX Temper H (47-50 HRC) is for applications where higher die temperatures and cavity pressures, or wear-prone components demand more abrasion resistance.

The balanced chemistry of FX-XTRA offers a wide range of mechanical properties suitable for a variety of industrial applications. A. Finkl & Sons Co. Sales and Technical personnel are available to help you achieve your performance goals.

**Finkl Standard Hardness Ranges**

<table>
<thead>
<tr>
<th>Finkl Std.</th>
<th>BHN</th>
<th>HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>XH</td>
<td>495-534</td>
<td>51-54</td>
</tr>
<tr>
<td>H</td>
<td>444-477</td>
<td>47-50</td>
</tr>
<tr>
<td>T1</td>
<td>401-429</td>
<td>43-46</td>
</tr>
<tr>
<td>T2</td>
<td>352-388</td>
<td>38-42</td>
</tr>
<tr>
<td>T3</td>
<td>311-341</td>
<td>33-37</td>
</tr>
<tr>
<td>T4</td>
<td>277-302</td>
<td>29-32</td>
</tr>
<tr>
<td>Annealed</td>
<td>229 approx</td>
<td>20 approx.</td>
</tr>
</tbody>
</table>

**Nominal Chemistry** (Wt. %)
- 0.50% CARBON
- 0.85% MANGANESE
- 0.25% SILICON
- 0.90% NICKEL
- 1.15% CHROMIUM
- 0.50% MOLYBDENUM
- 0.05% VANADIUM
- 12.5 Ideal Diameter (DI)**

* Plus patented microalloying additions
* * For more information on this topic, please refer to the Finkl Die Handbooks.

**Machinability**
Machinability at all hardness levels is enhanced through patented micro-alloying additions, but where maximum machinability is desired, a fully annealed condition (approximately 229 BHN) is available.

**Recommended Applications**
- Hammer Dies and Hammer Rams
- Press Dies and Coining Dies
- Sow Blocks and Knockout Pins
- Punches and Inserts
- Headers and Insert Die Holders
- Gripper Dies and Hammer Guides
- Gripper Die Inserts and Piston Heads
- Guide Pins and Hammer Keys
- Extrusion Press-Backup Tools
- Gear Applications

* Covered under one or more of the following U.S. Patents: 5,496,516; 5,180,444; 5,827,376; 6,398,885

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Comparing interior hardness profiles of two large 24-inch thick blocks reveals the advantage of a cold water quench.

Mechanical Properties for Commercial-Sized Die Blocks

Mechanical properties developed from laboratory-sized test bars, as in the above table, are useful for comparing properties to other grades of steel from similar-sized test bars. Full-sized blocks, however, experience a “mass-effect” during the quenching process that reduces the effectiveness of the quench. The extent of the hardness and strength loss is determined by the cross-section size and test-depth below the quench surface. Properties of full-sized blocks should be viewed with this factor taken into account.

The Water Quench Advantage

Quench Severity

Employing a Cold Water Quench rather than a less effective oil or polymer quench achieves the highest possible H-value (Heat extraction rate during the quench) and the best possible microstructure and hardness throughout a cross-section.
**FX-XTRA Impact Toughness**

**Impact Toughness—Ductile-Brittle Transition Temperature (DBTT)**

The DBTT is common to all die steels, and is the temperature where the fracture characteristics transition from a brittle, crack-prone condition to a more ductile, crack resistant condition.

One definition of DBTT is where the Charpy V-Notch (CVN) test temperature produces impact-toughness energy of 15 ft-lbs.

The DBTT is influenced by the chemistry, hardness and microstructure of the steel. Different DBTT temperatures, therefore, may occur between surface and interior locations of die blocks.

Heating beyond the DBTT offers a rapid improvement to impact toughness until the “Upper Energy Shelf” is reached.

**Die Preheating**

The DBTT for a die block is influenced by the hardness and microstructure. For this reason, the minimum recommended die-preheating temperatures change with block thickness and hardness according to the provided table. [For more information on this topic, please refer to the Finkl Die Handbooks.]

**Selective Shank Tempering**

For high hardness die blocks (T1, TH, TXH) selective tempering is available to reduce hardness *only on the shank side* by approximately one Finkl “Temper Range”, or about four Rockwell points. The modified shank hardness gradually transitions to the base hardness at approximately three-inches below the shank surface. This option improves machinability and fracture toughness in the critical shank area.

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**Recommended FX® Die Steel Minimum Preheating Temperatures °F**

<table>
<thead>
<tr>
<th>Die Block (Thickness)</th>
<th>inches</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>127</td>
<td>254</td>
<td>381</td>
<td>508</td>
</tr>
<tr>
<td>XH</td>
<td></td>
<td>300</td>
<td>350</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>H</td>
<td></td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>350</td>
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<tr>
<td>1</td>
<td></td>
<td>200</td>
<td>250</td>
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</tr>
<tr>
<td>2</td>
<td></td>
<td>70</td>
<td>150</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>70</td>
<td>70</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>200</td>
</tr>
</tbody>
</table>

**Conversion:**

°F | 70  | 150  | 200  | 250  | 300  | 350  |
---|-----|------|------|------|------|------|
°C | 20  | 65   | 95   | 120  | 150  | 175  |
Welding
The purpose of welding, e.g., joining, hard facing, or matching the die block hardness, will determine the appropriate welding rod for a particular application. Your selection should be discussed with a welding rod supplier. Beyond the choice of welding rod, there are many variables affecting the success of a weld. One common cause of failure is an embrittled Heat Affected Zone (HAZ). To minimize the risk of this type of failure, a preheating and post-heating procedure should be employed:

- Preheat: 800°F (425°C)
- Maintain minimum of 400°F (200°C) during welding
- Postheat: To avoid softening of the base hardness, heat to a temperature that is 50°F (30°C) below the tempering temperature used to establish the base hardness (see Tempering Table below).

Heat Treating FX-XTRA
Critical Temperatures at a Rate of 200°F/hr (110°C/hr):

| Ac3 / Ar3  | 1360 / 1340°F (737 / 727°C) |
| Ac1 / Ar1  | 840 / 720°F (449 / 382°C)   |

Lowering the hardness of FX-XTRA may be achieved by tempering above the tempering temperature used to establish the existing hardness of the die block. Nominal tempering temperatures employed to establish the standard hardness ranges are:

Sub-Critical Anneal
Softening may be achieved through Sub-Critical annealing by holding at 1220°F (660°C) for an extended period, typically 1.5 hrs/inch (1.5 hrs/25 mm). Expected hardness is approximately 248 BHN maximum.

Full Anneal
Softening with additional refinement to the microstructure may be achieved through a Full Anneal:

- Heat to 1440/1460°F (780/800°C) and Hold 1/2 hr/inch (25mm)
- Drop to 1220°F (660°C) and Hold 4 hrs.
- Furnace Cool to 800°F (425°C)
- Air Cool to ambient temperature

Expected hardness is approximately 229 BHN

Hardening
Increasing the hardness requires heating to an austenitizing temperature (1550-1600°F/840-870°C) followed by a quenching operation. (Some oxidation/decarburization will occur on the block surface unless heating is performed in a vacuum or protective atmosphere furnace.) Quenching is a high stress operation introducing a risk of cracking, particularly for a machined block with contours, sharp edges, drilled holes or thin-web features. For such product, employing a quenchant with a lower quench-severity rating will lower the risk of cracking.

- Heat to 1550/1600°F (840/870°C) and Hold 1/2 hr./inch (25mm)
- Drop to 1450°F (790°C) and Hold 2 hrs.
- Quench (Oil, Polymer or Molten salt bath)
- Immediately temper according to the Tempering Table to the left.

Physical Properties

<table>
<thead>
<tr>
<th>Test Temperature</th>
<th>20°C/68°F</th>
<th>200°C/390°F</th>
<th>400°C/750°F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kg/m³</td>
<td>7800</td>
<td>7750</td>
<td>7700</td>
</tr>
<tr>
<td>lbs/in³</td>
<td>0.282</td>
<td>0.280</td>
<td>0.277</td>
</tr>
<tr>
<td><strong>Coefficient of Thermal Expansion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cm/cm°C</td>
<td>11.9x10⁻⁴</td>
<td>12.7x10⁻⁴</td>
<td>13.6x10⁻⁴</td>
</tr>
<tr>
<td>in/in°F</td>
<td>6.6x10⁻⁴</td>
<td>7.0x10⁻⁴</td>
<td>7.5x10⁻⁴</td>
</tr>
<tr>
<td><strong>Thermal Conductivity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J/m²/m/s/°C</td>
<td>29.0</td>
<td>29.5</td>
<td>31.0</td>
</tr>
<tr>
<td>202 BTU/ft²/in/hr/°F</td>
<td></td>
<td>205</td>
<td>216</td>
</tr>
<tr>
<td><strong>Modulus of Elasticity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/mm²</td>
<td>205x10³</td>
<td>200x10³</td>
<td>185x10³</td>
</tr>
<tr>
<td>lbs/in²</td>
<td>29.7x10⁶</td>
<td>29.0x10⁶</td>
<td>26.8x10⁶</td>
</tr>
<tr>
<td><strong>Specific Heat</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J/Kg °C</td>
<td>460</td>
<td>492</td>
<td>538</td>
</tr>
<tr>
<td>0.110 BTU/lb °F</td>
<td>0.118</td>
<td>0.129</td>
<td></td>
</tr>
<tr>
<td><strong>Poisson’s Ratio</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
</tr>
</tbody>
</table>

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