# DATA SHEET

Finkl Steel

## FX-XTRA®

~AISI N/A - ~W.Nr. 1.2714 Mod

HOT WORK TOOL STEEL

### TYPICAL APPLICATIONS

- Hammer Dies & Rams
- Press Dies and Coining Dies
- Sow Blocks and Knockout Pins
- Punches and Inserts
- Headers and Insert Die Holders
- Gear Applications

### GENERAL:

**Delivery Condition:**

Hardened and tempered

**Hardness Range:**

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

**FX-XTRA®**, also known as **FX®**, is a Ni-Cr-Mo steel offered in a wide range of heat treated conditions for versatile service in the forging industry.

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

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.

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

### Typical Chemical Analysis* - % weight

| C | Mn | Si | Ni | Cr | Mo | V |
|---|---|---|---|---|---|---|
| 0.50 | 0.85 | 0.25 | 0.90 | 1.15 | 0.50 | 0.07 |

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

**FX-XTRA®** is quenched in water. Best properties in steel are produced with the highest achievable quench severity.

**FX-XTRA®** is characterized by:

- Good Temper Resistance
- High Toughness
- Good Wear Resistance
- Through-hardenability up to 20" thick. For larger dies, we recommend grade DURODI® or hardening and tempering after contour roughing in the annealed condition.

### 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 HB) is available.

**Note: Provided technical data and information in this data sheet are typical values. Normal variations in chemistry, size and conditions of heat treatment may cause deviations from these values. We suggest that information be verified at time of enquiry or order. For additional data or metallurgical assistance, please contact us.**

# DATA SHEET

HOT WORK TOOL STEEL

**FX-XTRA®**

## FX® TENSILE PROPERTIES

**1" Laboratory Test Bars, Longitudinal Capability Testing**

| Tested Block Hardness Category | Test Temperature | | Tensile Strength | | Yield Strength | | Elongation in 2" | Reduction Area .505" |
|---|---|---|---|---|---|---|---|---|
| | °F | °C | ksi | MPa | ksi | MPa | % | % |
| Temper H 444-477 BHN | 80 | 27 | 218 | 1503 | 202 | 1393 | 12.5 | 41 |
| | 300 | 149 | 207 | 1428 | 178 | 1228 | 12.0 | 39 |
| | 600 | 316 | 196 | 1352 | 160 | 1103 | 15.0 | 38 |
| | 800 | 427 | 165 | 1138 | 142 | 979 | 16.0 | 55 |
| Temper 1 401-429 BHN | 80 | 27 | 205 | 1414 | 187 | 1290 | 12.7 | 34 |
| | 300 | 149 | 196 | 1352 | 166 | 1145 | 12.5 | 35 |
| | 600 | 316 | 183 | 1262 | 150 | 1034 | 13.0 | 36 |
| | 800 | 427 | 156 | 1076 | 133 | 917 | 15.2 | 55 |
| | 900 | 482 | 137 | 945 | 123 | 848 | 17.0 | 61 |
| | 1000 | 538 | 109 | 752 | 95 | 655 | 24.0 | 66 |
| Temper 2 352-388 BHN | 80 | 27 | 174 | 1200 | 146 | 1007 | 15.5 | 50 |
| | 300 | 149 | 157 | 1083 | 128 | 883 | 15.8 | 48 |
| | 600 | 316 | 147 | 1014 | 119 | 821 | 17.2 | 47 |
| | 700 | 371 | 144 | 993 | 113 | 779 | 16.5 | 56 |
| | 800 | 427 | 130 | 897 | 105 | 724 | 18.2 | 64 |
| | 900 | 482 | 113 | 779 | 97 | 669 | 20.5 | 71 |
| | 1000 | 538 | 94 | 648 | 78 | 538 | 23.8 | 78 |
| | 1100 | 593 | 52 | 359 | 39 | 269 | 22.8 | 64 |
| Temper 3 311-341 BHN | 80 | 27 | 151 | 1041 | 130 | 897 | 18.2 | 50 |
| | 300 | 149 | 140 | 966 | 112 | 772 | 17.5 | 49 |
| | 400 | 204 | 136 | 938 | 102 | 703 | 19.0 | 48 |
| | 500 | 260 | 136 | 938 | 103 | 710 | 22.0 | 43 |
| | 600 | 316 | 134 | 924 | 95 | 655 | 21.8 | 49 |
| | 700 | 371 | 121 | 834 | 89 | 614 | 22.0 | 55 |
| | 800 | 427 | 108 | 745 | 82 | 566 | 24.2 | 63 |
| | 900 | 482 | 93 | 641 | 78 | 538 | 28.0 | 75 |
| | 1000 | 538 | 75 | 517 | 67 | 462 | 36.8 | 84 |
| | 1100 | 593 | 55 | 379 | 46 | 317 | 54.0 | 86 |

### 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.

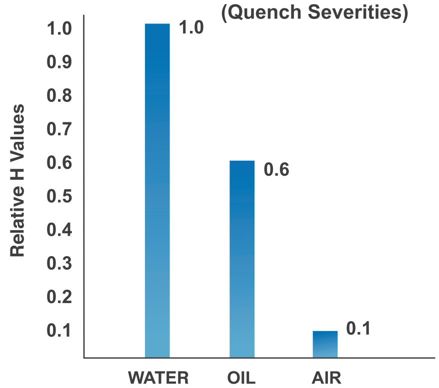
### The Water Quench Advantage

### 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.

**Relative H-Values**

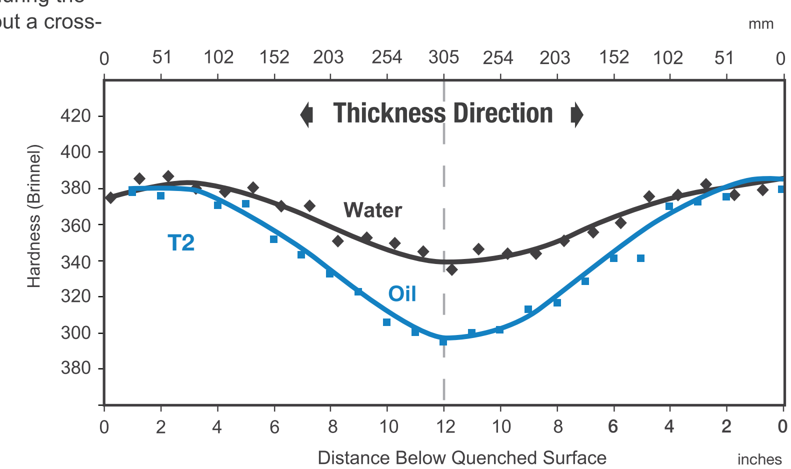
**(Quench Severities)**




**Hardness Profile Comparison**

**Water versus Oil Quench**

**24" x 48" (610 x 1220 mm) Quenched Cross-Sections**

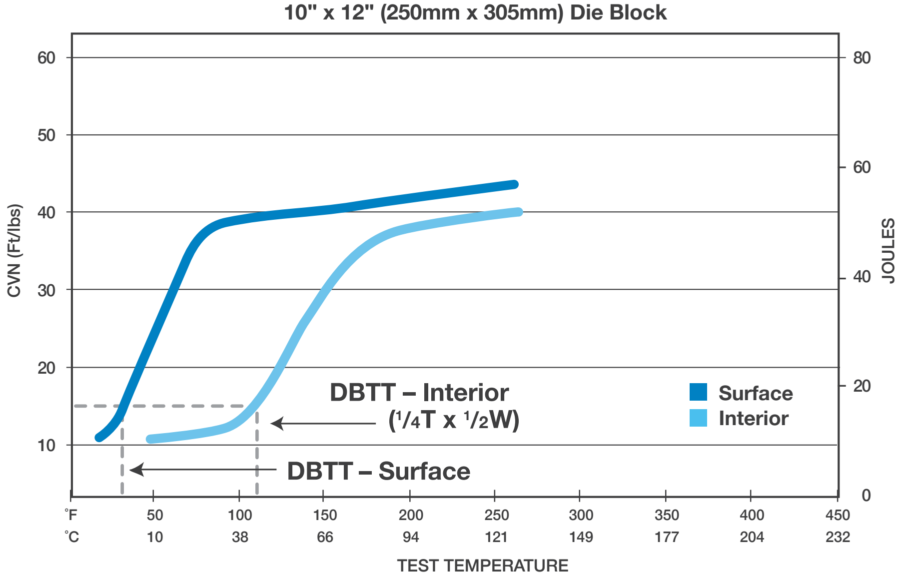


# DATA SHEET

## HOT WORK TOOL STEEL
## FX-XTRA®

**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. The DBTT is influenced by the chemistry, hardness and microstructure of the steel. Therefore, the DBTT may differ 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.

**FX® Temper 2**
**10" x 12" (250mm x 305mm) Die Block**




### 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.

### 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.

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

**Die Block (Thickness)**

| Increased Wear Resistance / Increased Fracture Sensitivity | DIE HARDNESS (inches / mm) | 5 / 127 | 10 / 254 | 15 / 381 | 20 / 508 |
|---|---|---|---|---|---|
| | XH | 300 | 350 | NA | NA |
| | H | 250 | 300 | 350 | 350 |
| | 1 | 200 | 250 | 300 | 300 |
| | 2 | 70 | 150 | 200 | 200 |
| | 3 | 70 | 70 | 200 | 200 |
| | 4 | 70 | 70 | 70 | 200 |

**Conversion:**

| | | | | | | |
|---|---|---|---|---|---|---|
| ˚F | 70 | 150 | 200 | 250 | 300 | 350 |
| ˚C | 20 | 65 | 95 | 120 | 150 | 175 |

**Physical Properties**

| Test Temperature | 20˚C/68˚F | 200˚C/390˚F | 400˚C/750˚F |
|---|---|---|---|
| Density | 7800 Kg/m³ | 7750 | 7700 |
| | 0.282 lbs/in³ | 0.280 | 0.277 |
| Coefficient of Thermal Expansion | 11.9x10⁻⁶ cm/cm/˚C | 12.7x10⁻⁶ | 13.6x10⁻⁶ |
| | 6.6x10⁻⁶ in/in/˚F | 7.0x10⁻⁶ | 7.5x10⁻⁶ |
| Thermal Conductivity | 29.0 J/m²/m/s/˚C | 29.5 | 31.0 |
| | 202 BTU/ft²/in/hr/˚F | 205 | 216 |
| Modulus of Elasticity | 205x10³ N/mm² | 200x10³ | 185x10³ |
| | 29.7x10⁶ lbs/in² | 29.0x10⁶ | 26.8x10⁶ |
| Specific Heat | 460 J/Kg ˚C | 492 | 538 |
| | 0.110 BTU/lb ˚F | 0.118 | 0.129 |
| Poisson's Ratio | 0.3 | 0.3 | 0.3 |

# DATA SHEET

## HOT WORK TOOL STEEL

## FX-XTRA®

### Heat Treating FX-XTRA®

**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/inches (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

**Tempering**
Lower hardness may be achieved by heating 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:

**Tempering Table**
Nominal Tempering Temperatures for Water-Quenched Forgings

| Temperature | Finkl Std. | BHN | HRC |
|---|---|---|---|
| 450˚F (232˚C) | XH | 495-534 | 51-54 |
| 880˚F (471˚C) | H | 444-477 | 47-50 |
| 1020˚F (549˚C) | T1 | 401-429 | 43-46 |
| 1120˚F (604˚C) | T2 | 352-388 | 38-42 |
| 1180˚F (638˚C) | T3 | 311-341 | 33-37 |
| 1220˚F (660˚C) | T4 | 277-30 | 29-32 |

**Welding**
Your selection of welding rod 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
- Post-heat/Stress Relieving: 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 above).

**Hardening**
Increasing the hardness requires heating to an austenitizing temperature 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.



**Finkl Steel—Chicago**
1355 E. 93rd Street
Chicago, IL 60619
773.975.2510
TOLL-FREE: 800.621.1460
FAX: 773.348.5347

**Finkl Steel—Sorel**
100 McCarthy Street St-Joseph-de-Sorel, QC, Canada J3R 3M8
450.746.4122
TOLL-FREE: 800.363.9484

**Finkl Steel—Composite**
2300 W. Jefferson Avenue
Detroit, MI 48216
313.496.1226
TOLL-FREE: 800.521.0520

www.finkl.com

Finkl Steel