Finkl Steel

FX-XTRA®

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

Hot Work
Die Steel

Typical Applications

- Hammer Dies
- Press Dies
- Insert Dies
- Punches
- Extrusion Dies
- Headers
- Casting Dies

General

Delivery Condition: Hardened and tempered

Hardness Ranges

Finkl Std.	HBW	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 performance 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.

The higher hardness ranges, **FX Temper 1** (43-46 HRC) and **Temper H** (47-50 HRC), are for applications where higher die temperatures, 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.

Characteristics

- Good Temper Resistance
- High Toughness
- Good Wear Resistance
- Through-hardenability up to 20” thick

  For larger dies, we recommend the 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 HBW) 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 inquiry or order. For additional data or metallurgical assistance, please contact us.*

® Finkl Steel Trademark

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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 HBW	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 HBW	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 HBW	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 HBW	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

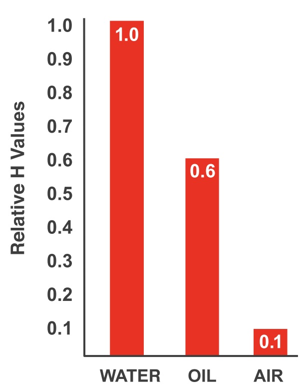
Mechanical Properties for Commercial-Sized Die Blocks

Mechanical properties developed from laboratory sized test bars, as in the table at left, 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 quenched surface. Properties of full-sized blocks should be viewed with this factor taken into consideration.

The Water Quench Advantage: Quench Severity

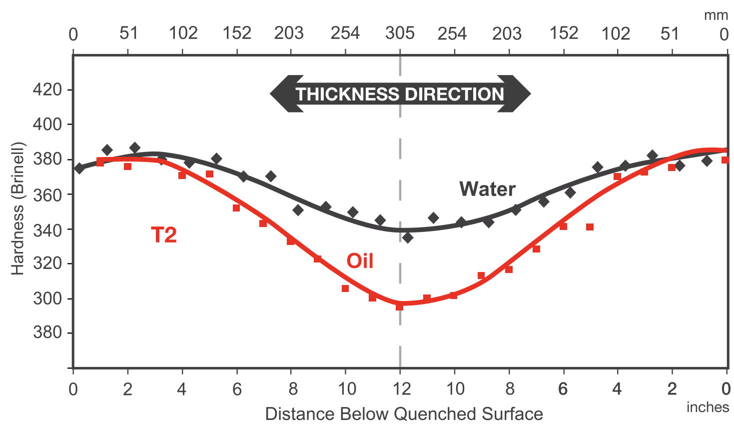
Employing a *Cold Water Quench* rather than a less effective oil or polymer quench, achieves the highest possible H-value (Heat extraction rate during the quench), and the best possible microstructure and hardness throughout a cross-section.

Relative H-Values



Hardness Profile Comparison Water vs. Oil Quench

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



Selective Shank Tempering

For high hardness die blocks (T1, TH, or TXH), selective tempering of the shank side is available to reduce hardness 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.

Die Preheating

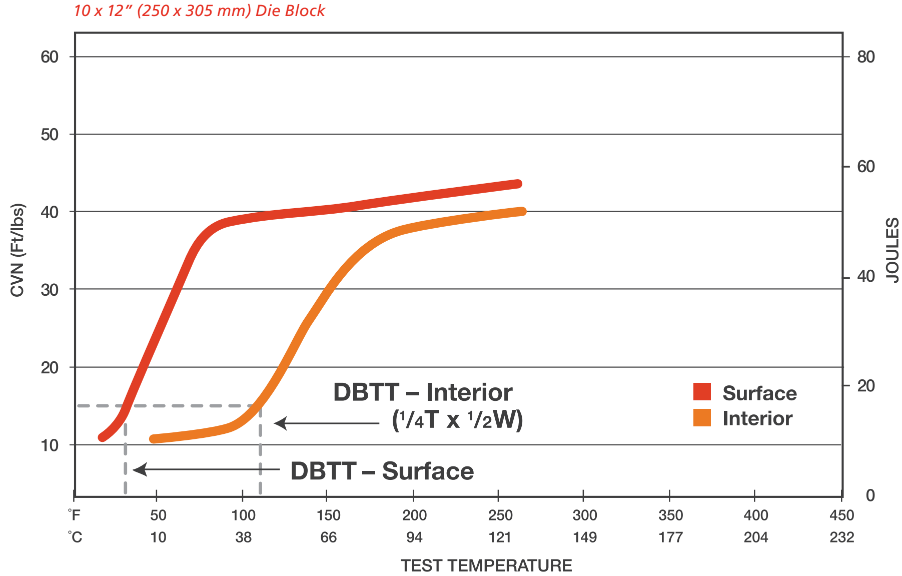
The DBTT for a die block is influenced by the hardness and microstructure. For this reason, the minimum recommended die preheating temperatures change with block thickness and hardness according to the provided table below.

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 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" (250 x 305 mm) Die Block



Recommended FX® Dies Steel Minimum Preheating Temperatures ˚F

		Die Block Thickness			
	inches / mm	5 / 127	10 / 254	15 / 381	20 / 508
Die Hardness (Increased Wear Resistance ↑ Increased Fracture Sensitivity)	XH	300	350	NA	NA
	H	250	300	350	350
	T1	200	250	300	300
	T2	70	150	200	200
	T3	70	70	200	200
	T4	70	70	70	200

Conversion: ˚F 70 150 200 250 300 350
˚C 20 65 95 129 150 175

Physical Properties

Property	Units	Test Temperature		
		20°C/68°F	200°C/390°F	400°C/750°F
Density	kg/m^3	7800	7750	7700
	lbs/in^3	0.282	0.280	0.277
Coefficient of Thermal Expansion	cm/cm/°C	$11.9x10^{-6}$	$12.7x10^{-6}$	$13.6x10^{-6}$
	in/in/°F	$6.6x10^{-6}$	$7.0x10^{-6}$	$7.5x10^{-6}$
Thermal Conductivity	W/(m.K)	29.1	29.6	31.1
	$Btu/(h.ft^2.°F/in)$	202	205	216
Modulus of Elasticity	N/mm2 (MPa)	$205x10^3$	$200x10^3$	$185x10^3$
	lbs/in^2 (psi)	$29.7x10^6$	$29.0x10^6$	$26.8x10^6$
Specific Heat	J/Kg.°C	460	492	538
	Btu/lb.°F	0.110	0.118	0.129
Poisson's Ratio	—	0.3	0.3	0.3

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Heat Treating

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 HBW maximum.

Full Anneal

Softening with additional refinement to the micro-structure 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 HBW

Tempering

Lower hardness may be achieved by heating above the tempering temperature used to establish the existing hardness of the die block. The below table provides the nominal tempering temperatures used to establish original hardness.

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

Finkl Std.	HBW	HRC	Temperature
XH	495-534	51-54	450°F (232°C)
H	444-477	47-50	880°F (471°C)
T1	401-429	43-46	1020°F (549°C)
T2	352-388	38-42	1120°F (604°C)
T3	311-341	33-37	1180°F (638°C)

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-weld 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 1500/1600°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 at left

Finkl Steel

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

Finkl Steel – Houston
14710 Cypress North Houston Road
Cypress, TX 77429
TOLL-FREE: 800-640-2050

www.finkl.com