

DATA SHEET



FINKL STEEL

SCHMOLZ + BICKENBACH GROUP

FX[®] - FINKL DIE

~AISI N/A - ~W.Nr. 1.2242 - ~59CrV4

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[®] 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[®] is quenched in water. Best properties in steel are produced with the highest achievable quench severity.

FX[®] is characterized by :

- Good Temper resistance
- High Toughness
- Good Wear resistance
- Through hardenability up to 20" thick
For larger dies, we recommend grade DURODIE or hardening and tempering after contour roughing in 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.

[®]Finkl Steel Trademark

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FX[®]

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

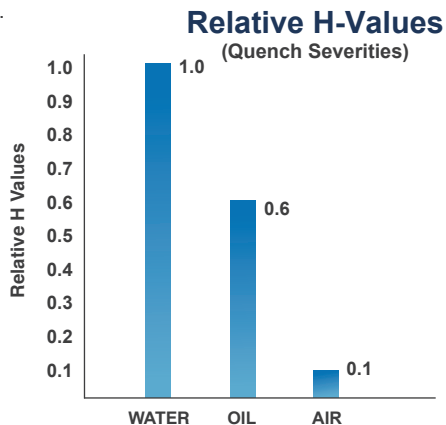
Mechanical Properties for Commercial-Sized Die Blocks

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

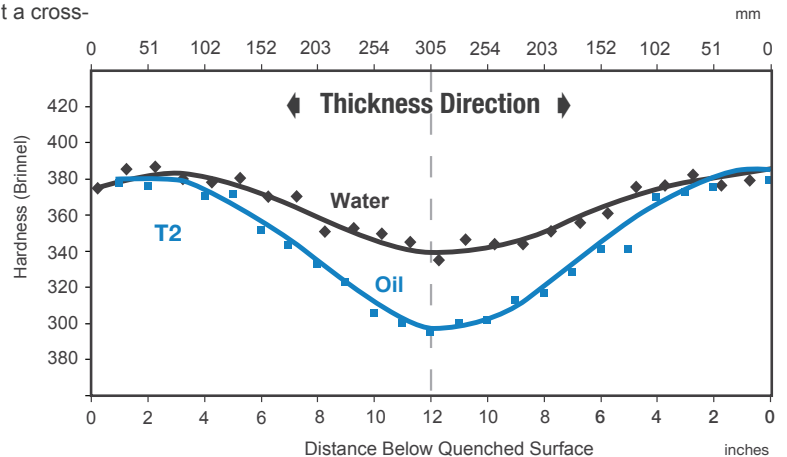
Employing a *Cold Water Quench* rather than a less effective oil or polymer quench achieves the high-est possible H-value (Heat extraction rate during the quench) and the best possible microstructure and hardness throughout a cross-section.



Hardness Profile Comparison

Water versus Oil Quench

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

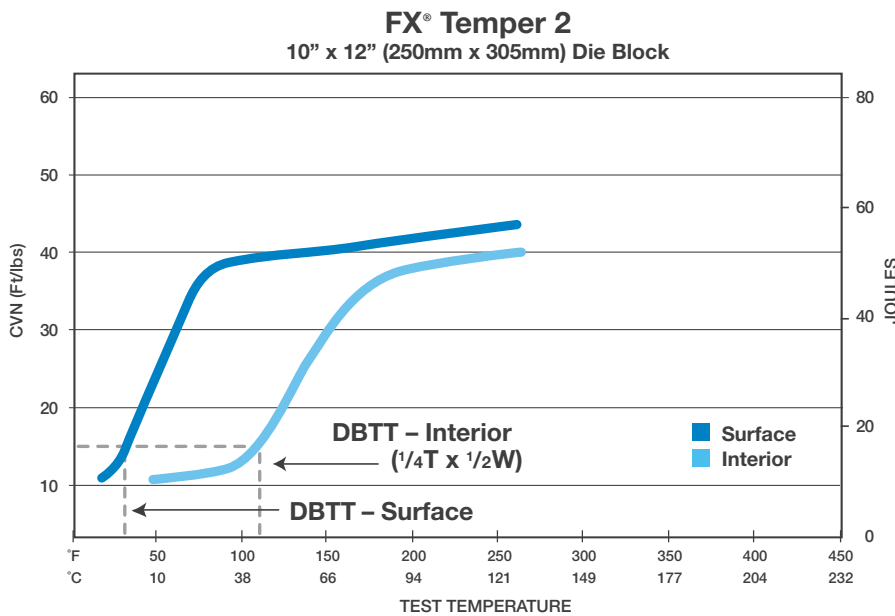


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Impact Toughness—Ductile-Brittle Transition Temperature (DBTT)

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 micro-structure 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.

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)

		inches	5	10	15	20	
		mm	127	254	381	508	
Increased Wear Resistance Increased Fracture Sensitivity	DIE HARDNESS	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/m ³	7750	7700
	0.282 lbs/in ³	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/m ² /m/s/°C	29.5	31.0
	202 BTU/ft ² /in/hr/°F	205	216
Modulus of Elasticity	205x10 ³ N/mm ²	200x10 ³	185x10 ³
	29.7x10 ⁶ lbs/in ²	29.0x10 ⁶	26.8x10 ⁶
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

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HOT WORK TOOL STEEL FX[®]

Heat Treating FX[®]

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 approxi-mately 248 BHN 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 BHN

Tempering

Lowering the 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	(-)!'(51-54
880°F (471°C)	H	(((!(++	47-50
1020°F (549°C)	T1	(\$%(&	43-46
1120°F (604°C)	T2	')&' , ,	38-42
1180°F (638°C)	T3	' %/4' (%	33-37
1220°F (660°C)	T4	&+!' \$	29-32

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.



Contact your Finkl representative to learn about this unique, online business service.

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