DATA SHEET

Finkl Steel

WF-XTRA®

AISI N/A – W.Nr. N/A - ~35CrMoV11-10

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
H	444-477	47-50
T1	401-429	43-46
T2	352-388	38-42
T3	311-341	33-37
Annealed	229 approx	20 approx

WF-XTRA, also known as WF, is a special Ni-Cr-Mo-V steel offered in a wide range of heat treated conditions for versatile performance in the forging industry.

It is designed for higher strength requirements by utilizing a higher alloy content. This allows standard die hardness to be achieved with a lower Carbon level for improved fracture toughness and greater heat-checking resistance.

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.

Typical Chemical Analysis*–% weight

C	Mn	Si	Ni	Cr	Mo	V
0.37	0.65	0.45	0.80	2.50	1.00	0.10

**Covered under one or more of the following U.S. Patents: 5,110,379; 5,180,444; 5,827,376; 6,398,885*

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

Characteristics

- Great fracture toughness
- Improved heat-checking resistance
- High wear resistance
- Good temper resistance

Wear Resistance

Increased levels of of the strong carbide-forming alloys (Chromium, Molybdenum and Vanadium) provide a higher concentration of hard carbide particles that enhance wear resistance.

Temper Resistance

Higher levels of Chromium, Molybdenum and Vanadium precipitate carbides at elevated temperatures to help counteract the loss of surface hardness normally experienced from contact with hot forging stock.

**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.*

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WF 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	235	1621	210	1448	11.5	39
	300	149	225	1552	199	1372	12.0	39
	600	316	210	1448	186	1283	12.0	35
	800	427	185	1276	160	1103	16.0	42
	1000	538	140	966	125	862	18.5	59
Temper 1 401-429 HBW	80	27	210	1448	188	1297	12.5	35
	300	149	200	1379	176	1214	13.0	35
	600	316	188	1297	163	1124	13.5	37
	800	427	160	1103	135	931	15.8	47
	900	482	145	1000	125	862	18.0	62
	1000	538	117	807	97	669	23.5	65
Temper 2 352-388 HBW	80	27	180	1241	156	1076	13.5	41
	300	149	174	1200	148	1021	13.5	46
	600	316	163	1124	136	938	13.0	38
	700	371	157	1083	130	894	14.5	49
	800	427	147	1014	122	841	18.0	62
	900	482	139	959	115	793	20.0	71
	1000	538	118	814	100	690	22.0	76
	1100	593	92	634	74	510	25.5	79

Mechanical Properties for Commercial-Sized Die Blocks

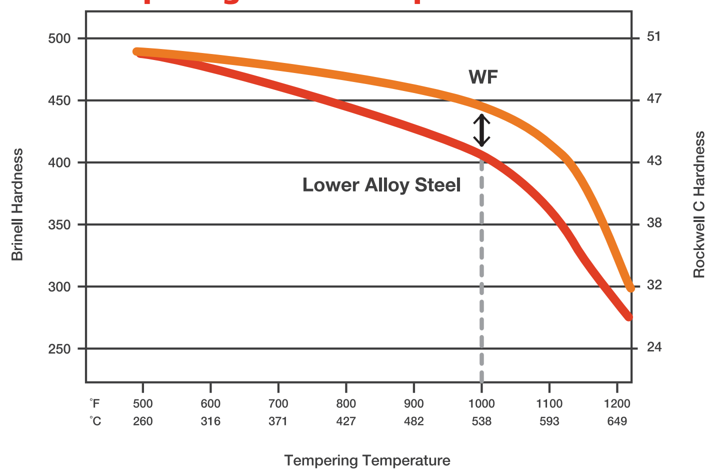
Mechanical properties developed from laboratory sized test bars, as in the table above, are useful for comparing properties to other grades of steel from similar-sized test bars. Full-sized blocks, however, experience a "mass-effect" during the quenching process that reduces the effectiveness of the 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.

Temper Resistance

Repetitive exposure of a die to hot forging stock can lower the surface hardness in a die impression through a cumulative tempering effect. Such hardness loss accelerates wear and reduces die life.

The alloy composition of WF provides improved temper resistance for better hardness retention and extended die life.

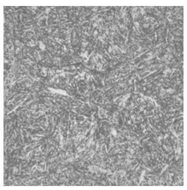
Tempering Curve Comparison



Microstructure

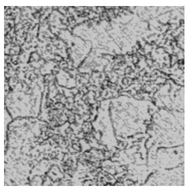
WF-XTRA avoids formation of Crack-Prone, Grain-Boundary Carbide Networks

The balanced chemistry of WF-XTRA offers enhanced heat and wear resistance without the tendency to form embrittling, grain-boundary carbide networks characteristic of H13.



500X, 5% Nital

WF-XTRA *typical water quenched microstructure is characterized by uniform carbide distribution that promotes good fracture toughness*



500X, 5% Nital

H13 *typical gas quenched microstructure at interior of large cross-section contains brittle, crack-prone carbide networks*

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.

Recommended WF® Die Preheating Temperatures ˚F

Die Hardness	inches / mm	Die Block Thickness 5 / 127	10 / 254	15 / 381	20 / 508
	XH	300	350	NA	NA
	H	325	375	425	425
	T1	275	325	375	375
	T2	145	225	275	275
	T3	145	245	275	275

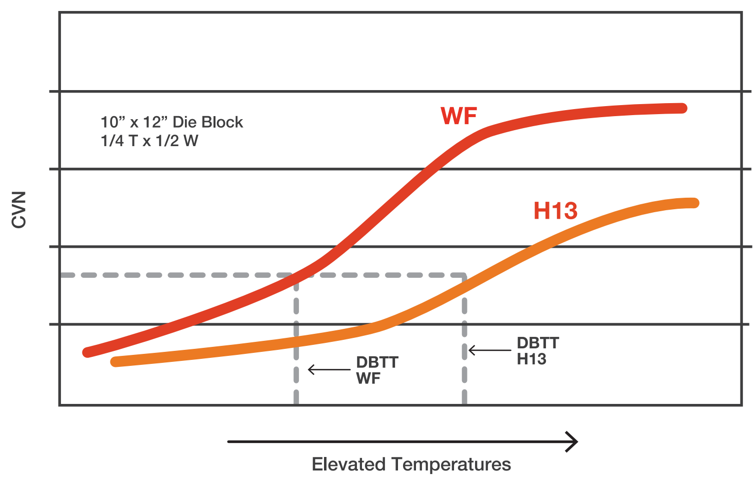
Increased Wear Resistance ↑ Increased Fracture Sensitivity

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

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.

Impact Toughness at Elevated Temperatures



Physical Properties

Property	Units	Test Temperature 20°C/68°F	200°C/390°F	400°C/750°F
Density	kg/m³	7800	7750	7700
	lbs/in³	0.282	0.280	0.277
Coefficient of Thermal Expansion	cm/cm/°C	11.9×10^{-6}	12.7×10^{-6}	13.6×10^{-6}
	in/in/°F	6.6×10^{-6}	7.0×10^{-6}	7.5×10^{-6}
Thermal Conductivity	W/(m.K)	29.0	29.5	31.0
	Btu/(h.ft².°F/in)	202	205	216
Modulus of Elasticity	N/mm2 (MPa)	205×10^{3}	200×10^{3}	185×10^{3}
	lbs/in² (psi)	29.7×10^{6}	29.0×10^{6}	26.8×10^{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 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 HBW

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*

Finkl Std.	HBW	HRC	Temperature
XH	495-534	51-54	500°F (260°C)
H	444-477	47-50	900°F (482°C)
T1	401-429	43-46	1040°F (560°C)
T2	352-388	38-42	1140°F (615°C)
T3	311-341	33-37	1200°F (684°C)
T4	277-30	29-32	1230°F (666°C)

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

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).

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