DATA SHEET

Finkl Steel

CX®

AISI N/A - W.Nr. N/A - ~34NiCrMoV12-5

HOT WORK TOOL STEEL

TYPICAL APPLICATIONS

- Hammer Dies
- Die Holders
- Piston Rods
- Rams
- Bolster Plates
- Peripheral production components or non-forging applications requiring excellent fracture toughness

GENERAL:

Delivery Condition:

Hardened and tempered

Hardness Range:

Finkl Std.	HB	HRC
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.

CX® is specially designed to provide maximum fracture toughness over a full range of service temperatures normally encountered in forging applications.

High Nickel Content

Nickel is unique among alloying additions in steel. It is a natural ferrite strengthener that strongly enhances fracture toughness.

Lower Carbon Content

The lower Carbon content, relative to most die steels, favors higher fracture toughness over heat and abrasion resistance.

Typical Chemical Analysis - % weight

C	Mn	Si	Ni	Cr	Mo	V
0.34	0.50	0.25	2.85	1.15	0.75	0.10

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

CX® is characterized by :

- Extremely low DBTT (Ductile-Brittle Transition Temperature)
- High Fracture Toughness
- Excellent Machinability

Extremely Low DBTT
(Ductile-Brittle Transition Temperature)

The combination of the lower Carbon and higher Nickel content of this grade offers excellent ductility and fracture toughness at all service temperatures; even under startup conditions in unheated environments.

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

CX®

CX® TENSILE PROPERTIES

1" Laboratory Test Bars, Longitudinal Capability Testing

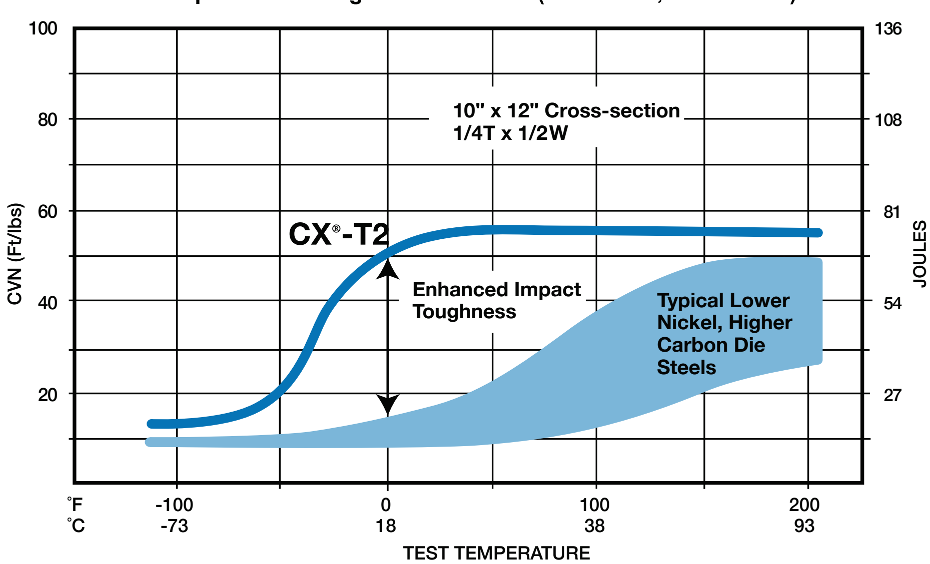
Tested Block Hardness Category	Test Temperature		Hardness at Test Temp.	Tensile Strength		Yield Strength		Elongation in 2"	Reduction Area .505"
	˚F	˚C	BHN	ksi	MPa	ksi	MPa	%	%
Temper **1** 401-429 BHN	80	27	415	209	1441	194	1337	13.5	42
	300	149	401	196	1351	182	1255	14.2	44
	600	316	375	183	1261	168	1158	16.0	49
	800	427	321	156	1075	139	958	18.5	54
	900	482	293	137	945	129	889	21.8	64
	1000	538	241	120	827	112	722	25.1	69
Temper **2** 352-388 BHN	80	27	375	187	1289	168	1158	17.0	48
	300	149	363	182	1255	160	1103	17.4	49
	600	316	331	166	1145	146	1007	17.8	51
	800	427	277	137	945	121	834	18.8	64
	900	482	235	113	779	97	669	22.8	72
	1000	538	197	94	648	78	538	27.7	78
Temper **3** 311-341 BHN	80	27	331	165	1138	147	1014	18.0	50
	300	149	321	160	1103	140	965	18.8	52
	600	316	302	150	1034	132	910	21.8	54
	800	427	248	123	848	108	745	24.2	63
	900	482	223	108	745	95	655	28.0	75
	1000	538	187	90	621	73	503	36.8	84

Mechanical Properties for Commercial-Sized Die Blocks

Longitudinal mechanical properties developed from laboratory-sized test bars, as in the above table, are useful for comparing properties to other grades of steel taken from similar-sized test bars. *Full-sized blocks, however, experience a "mass-effect"* during quenching that reduces the effectiveness of the quench. This results in a lower as-quenched hardness, and affects the microstructure and tempering response. The specific affect on commercial-sized blocks depends upon actual cross-section size and test location with respect to the quench surface. Test orientation with respect to grain flow of the steel affects ductility and toughness values. Comparing properties between different grades, or even the same grade, of steel taken from commercial-sized blocks should be considered with these factors taken into account.

Charpy V-Notch Impact Toughness Comparison

Comparison Testing at T2 Hardness (38/42 HRC, 352/388 HB)



Superior Impact Toughness at All Service Temperatures

CX® retains high impact toughness to very low temperatures. This provides improved crack resistance not only at common die operating temperatures, but also at much lower temperatures that may be present during start-up conditions.

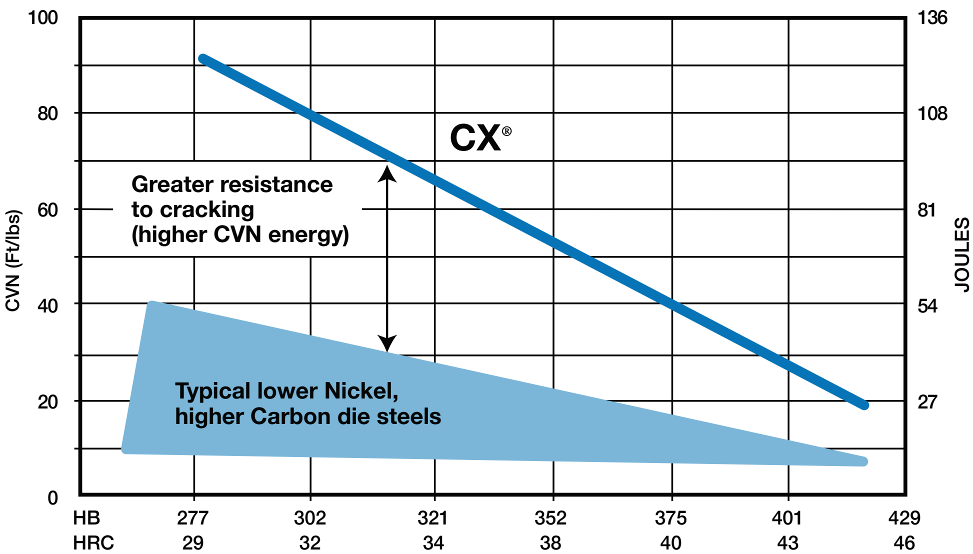
DATA SHEET

HOT WORK TOOL STEEL

CX®

Charpy V-Notch (CVN) Impact Toughness Comparison

Comparison Testing at Room Temperature



Superior Impact Toughness at All Hardness Levels

CX® Die Steel maintains a fracture toughness advantage over typical, lower Nickel, higher Carbon die steel at all hardness levels.

High impact toughness (offering great crack resistance) is characteristic of CX® , especially in the T2 and T3 hardness ranges used for many die steel applications and high-strength industrial parts.

Recommended CX® Die Steel Minimum Preheating Temperatures ˚F

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

Conversion:

˚F	70	150	200	250	300
˚C	21	66	93	121	149

Die Preheating

The excellent low-temperature performance of CX® allows most dies (see accompanying table) to be used without the need for preheating. This property also permits generous use of lubricant/coolant to reduce die cavity pressures and maintain lower operating temperatures. Both factors favor longer die life without concern for overcooling the die to a brittle condition.

Applications Especially Suitable for CX®

High fracture toughness throughout wide temperature ranges and hardness conditions makes this grade well suited for the following applications:

- Hammer dies running at **lower service temperatures** due to slower production rates, smaller forgings, heavy lubrication practices (overcooling the dies), or frequent production interruptions with no reheating capability, or facilities with no die heating capability.
- An **upgrade for forge tooling** that is not directly exposed to the heat of forging, but still endures impact loads, e.g., rams, piston rods, die holders, sow blocks, bolster plates, etc., especially those with a history of early cracking.
- Industrial components such as shafts, rolls and gears serving in **critical applications** where fracture toughness is paramount, or where service is performed in unheated environments.

DATA SHEET

HOT WORK TOOL STEEL

CX®

Heat Treating CX®

Tempering

Lowering the hardness of CX® 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:

Tempering Table

Nominal Tempering Temperatures for Water-Quenched Forgings

Temperature	Finkl Std.	HB	HRC
1000˚F (538˚C)	T1	401-429	43-46
1100˚F (593˚C)	T2	352-388	38-42
1140˚F (615˚C)	T3	311-341	33-37
1180˚F (638˚C)	T4	277-302	29-32

Sub-Critical Anneal

Softening may be achieved through Sub-Critical Annealing by holding at 1180˚F (638˚C) for an extended period, typically 1.5 hrs/inch (1.5 hrs/25 mm). Expected hardness is approximately 248 HB 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 1150˚F (621˚C) and Hold 4 hrs
- Furnace Cool to 800˚F (425˚C)
- Air Cool to ambient temperature

Expected hardness is approximately 229 HB

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)

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. Lower severity quenchants may require a downward adjustment to tempering temperature.

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	11.9×10^{-6} cm/cm/˚C	12.7×10^{-6}	13.6×10^{-6}
	6.6×10^{-6} in/in/˚F	7.0×10^{-6}	7.5×10^{-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	205×10^3 N/mm²	200×10^3	185×10^3
	29.7×10^6 lbs/in²	29.0×10^6	26.8×10^6
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

FINKL PARTNER PROGRAM®

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

Finkl Steel