DATA SHEET

FINKL STEEL
SCHMOLZ + BICKENBACH GROUP

DX® - *DURODI*

~AISI L6 - W.Nr. 1.2714mod - 55NiCrMoV7

HOT WORK TOOL STEEL

TYPICAL APPLICATIONS

- Press Dies
- Hammer Dies & inserts
- Punches
- Herf Machine Dies & punches
- Dies & inserts for stainless, high temperature alloys and non-ferrous forgings
- Reducer rolls

GENERAL:

Delivery Condition:

Hardened and tempered

Hardness Range:

Finkl Std.	HB	HRC
TXH	495-534	51-54
TH	444-477	47-50
T1	401-429	43-46
T2	352-388	38-42
Annealed	255 approx	25 approx.

DX® is specially designed to provide maximum abrasion and heat resistance over a full range of service temperature normally encountered in forging applications.

Aluminum and Titanium Forging

Appropriate for hammer forging of alumi-num where strain rates and the formation of abrasive aluminum-oxide exert strong wear forces on the die.

Warm (Ferrous) Forging

Forging steel at lower temperatures offers improved dimensional precision and improved heating efficiency, but sub-jects the dies to increased cavity pressures and strong abrasion forces. Water quenched DURODI offers excellent performance under these conditions through a balanced combi-nation of enhanced wear resistance and good impact toughness.

Typical Chemical Analysis - % weight

C	Mn	Si	Ni	Cr	Mo	V
0.55	0.65	0.50	1.65	1.00	0.80	0.07

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

DX® is characterized by :

- Improved High Temperature Yield Strength over standard grades
- Improved Temper resistance
- High Through Hardenability up to 40"
- High Toughness
- Excellent Thermal shock 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 255 HB) is available.

Counterblow Hammers

Large counterblow hammer dies are subjected to incredibly high impact forces and flow stresses. The combination of water quenching and the deep hardening capacity of DURODI provide the microstructure and hardness needed for large counterblow hammer dies.

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

DU 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	231	1593	198	1365	13.2	38.0
	300	149	224	1544	187	1289	13.2	36.1
	600	316	211	1455	166	1145	18.8	59.6
	800	427	182	1255	154	1062	18.8	64.9
	900	482	164	1131	142	979	20.0	67.2
Temper 1 401-429 BHN	80	27	197	1358	172	1186	15.0	40.2
	300	149	190	1310	160	1103	14.0	38.8
	700	371	168	1158	135	931	19.2	64.1
	800	427	157	1082	127	876	19.5	68.3
	1000	538	118	814	99	683	24.0	77.8
Temper 2 352-388 BHN	80	27	173	1193	151	1041	16.6	45.7
	300	149	166	1145	139	958	14.2	41.5
	600	316	160	1103	121	834	20.0	58.6
	800	427	135	931	108	745	22.2	71.1
	900	482	116	800	97	669	23.8	77.5
	1000	538	102	703	89	614	28.0	83.2

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.

Die Preheating

Heating beyond the recommended minimum preheating temperature by 200˚ to 300˚F (95˚ to 150˚C) will achieve the full toughness ("Upper Shelf" energy) capability of the die steel.

Recommended DURODI® Die Steel Minimum Preheating Temperatures ˚F

Die Block (Thickness)

DIE HARDNESS (↑ Increased Wear Resistance / Increased Fracture Sensitivity)	5 inches / 127 mm	10 inches / 254 mm	15 inches / 381 mm	20 inches / 508 mm
XH	300	350	400	400
H	250	300	350	400
T1	200	250	250	300
T2	150	150	200	250
T3	150	150	200	200

Conversion:

˚F	150	200	250	300	350	400
˚C	65	95	120	150	175	204

Heat Treating DURODI

Tempering according to the temperatures in the following table is employed with water-quenching to establish the standard hardness ranges. For a given hardness, employing *lower* temperatures may be used for **Stress Relieving** with minimal effect on the base hardness.

Tempering Table
Nominal Tempering Temperatures for Water-Quenched Forgings

Temperature	Finkl Std.	HB	HRC
900˚F (482˚C)	XH	495-534	51-54
1020˚F (482˚C)	H	444-477	47-50
1080˚F (582˚C)	T1	401-429	43-46
1120˚F (604˚C)	T2	352-388	38-42
1150˚F (621˚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 1220˚F (660˚C) for an extended period, typically 1.5 hrs/inch (1.5 hrs/25 mm). Expected hardness is approxi-mately 255 HB maximum.

Full Anneal
Softening with additional refinement to the micro-structure may be achieved through a *Full Anneal:*

- Heat to 1460/1480˚F (793/804˚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 HB

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 protec-tive 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 1680/1700˚F (916/927˚C) and Hold 1/2 hr./ inch (25mm)
- Drop to 1470˚F (800 ˚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.

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
- Postheat/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).

DATA SHEET

HOT WORK TOOL STEEL

DX®

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

METALLURGICAL SERVICE

The Metallurgical Laboratory provides standard mechanical properties testing for *Tensile Testing* (ASTM A 370), *Impact Testing* (ASTM E 23), *Hardness Testing* (ASTM E 10, E 18, A 956), *Macroetch Testing* (ASTM E 381), and other metallurgical testing with certification of results where requested.

Metallurgical facilities are made available to customers through your sales representative to assist in analysis of technical issues that may arise during processing or performance of Finkl forgings. Reports and consultation are offered as a service to customers with the aim of improving product performance.

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