Finkl Steel

DURODI®

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

Hot Work
Die 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 Ranges

Finkl Std.	HBW	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

DURODI, also known as DU, is specifically designed to provide maximum abrasion and heat resistance over a full range of service temperatures encountered in forging applications.

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 HBW) is available.

Counterblow Hammers

Large counterblow hammer dies are subjected to incredibly high impact and flow stresses. The combination of water quenching and the hardenability of DURODI provide the hardness and microstructure that are required for this application.

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

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

Characteristics

- Improved high temperature yield strength over standard grades
- Improved temper resistance
- High through-hardenability up to 40 inches
- High toughness
- Excellent thermal shock resistance

Aluminum and Titanium Forging

DURODI offers the toughness required for aluminum and titanium hammer forging where strain rates and the formation of abrasive aluminum oxides can cause wear.

Warm Ferrous Forging

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

**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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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 HBW	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 HBW	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 HBW	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

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.

Recommended DURODI Die Steel Minimum Preheating Temperatures °F

		Die Block Thickness			
	inches mm	5 127	10 254	15 381	20 508
Increased Wear Resistance ↑ Increased Fracture Sensitivity — Die Hardness	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

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	$11.9x10^{-6}$	$12.7x10^{-6}$	$13.6x10^{-6}$
	in/in/°F	$6.6x10^{-6}$	$7.0x10^{-6}$	$7.5x10^{-6}$
Thermal Conductivity	W/(m.K)	29.0	29.5	31.0
	Btu/(h.ft².°F/in)	202	205	216
Modulus of Elasticity	N/mm2 (MPa)	$205x10^3$	$200x10^3$	$185x10^3$
	lbs/in² (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

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.

Metallurgical Service

The Metallurgical Laboratory provides standard mechanical properties testing for *Tensile Testing* (ASTM A 370), *Impact Testing* (ASTM E 23), *Hardness Testing* (ASTM E10, E18, A956), *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 performance.

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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 255 HBW 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 HBW

Tempering

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

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

Finkl Std.	HBW	HRC	Temperature
XH	495-534	51-54	900°F (482°C)
H	444-477	47-50	1020°F (482°C)
T1	401-429	43-46	1080°F (582°C)
T2	352-388	38-42	1120°F (604°C)
T3	311-341	33-37	1150°F (621°C)
T4	277-302	29-32	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-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 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 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 or Polymer)
- Immediately temper according to the Tempering Table at left. Lower severity quenchants may require a downward adjustment to tempering temperature

Finkl Steel

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