Durelloy™

HEAT TREATED HOT ROLL ALLOY

Color Code: RED

Durelloy is a well balanced, fine grained electric furnace alloy steel, delivered standard in the heat treated hardness of Rockwell C 28–32. Durelloy is produced for applications requiring high tensile strength, resistance to wear, shock, and fatigue. Each heat lot must pass rigid quality control procedures which assure consistent physical and chemical standards.

In the pre-heat treated condition, Durelloy is excellent for applications requiring high torque and torsional strains. The combined alloy blend of nickel, chrome, molybdenum, and manganese produces excellent physical properties, depth of heat treatment, resistance to many forms of corrosion, excellent toughness, and good ductility.

Durelloy Replaces Both Carbon And Alloy Grade Standard Steels

Carbon Grades	Chrome-Moly Grades	Chrome-Nickel-Moly Grades
C10xx*	41xx*	43xx*
C11xx		47xx
C12xx	Nickel-Moly Grades	81xx
	46xx	86xx
	48xx	87xx
		88xx
	Nickel-Chrome Grades	93xx
	31xx	98xx
	33xx	

** xx indicates amount of Carbon content.*

Alloy steel marketed under various trade names are included, but are too extensive for listing. Contact your Ameralloy representative or Central Sales Office at 847-967-0600 for assistance in clarification and comparison.

Durelloy Elements Durelloy is a balanced alloy produced in small electric furnace heats.

- **Carbon (C)** Principal hardening element; sets limits for weldability
- **Manganese (MN)** Contributing element for hardness and strength
- **Silicon (SI)** Principal deoxidizer
- **Molybdenum (MO)** Contributing element in hardenability and resisting grain growth
- **Chromium (CR)** Principal element in depth hardening and wear resistance
- **Nickel (NI)** Principal element for strength and toughness
- **Vanadium (V)** Principal element assisting in the formation of stable carbides and a fine microstructure

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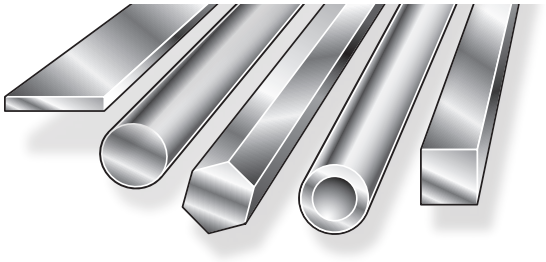


Applications

- Arbors
- Armature shafts
- Axles
- Bolts & studs
- Boring bars
- Bushings
- Cement mill shafts
- Chain links & pins
- Conveyer shafts
- Conveyer rollers
- Crane axles
- Crank shafts
- Drill bit bodies
- Drive shafts & gears
- Feed screws
- Flame hardened parts
- Gears
- Gear shafts
- Hammer shafts
- Hoist shafts
- Hooks
- Hubs
- Impeller shafts
- Journals
- Lead screws
- Line shafts
- Mining equipment
- Motor shafts
- Mandrels
- Nuts
- Pinions
- Pins
- Piston & push rods
- Power shovel shafts
- Pump shafts & rods
- Shafts
- Spindles
- Sprockets
- Studs
- Textile equipment
- Tie rods
- Tool holders
- Tracks
- Track pins
- U-Bolts

Typical Analysis

- Carbon .35/.42
- Silicon .25/.32
- Molybdenum .15/.30
- Vanadium .01/.04
- Manganese .78/1.10
- Chromium .75/1.09
- Nickel 1.70/1.95

Features And Advantages

- Pre-hardened, heat treated, stress relieved
- Machine straightened to minimize distortion and run-out
- Fine grain microstructure
- Free machining (75% machinability rating)
- Work hardening capabilities
- Fatigue resistant
- High shear strength, abrasion resistant
- Precision controlled analysis
- Excellent temperature tensile properties up to 1100°F

Specials, Heat Treat & Machining

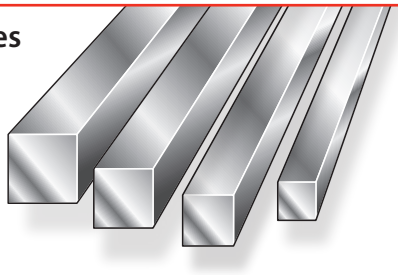
- **Durelloy pre-machined flats** Thickness 1/2"–2", width 2" to 24", length 72". Blanchard ground top and bottom TOL plus .020–.030
- **Durelloy special heat-treat**
- **Durelloy annealed** Every Durelloy size is available in the annealed condition, and can be further heat treated
- **Durelloy forgings** Custom forging to your specifications
- **Custom machining and grinding**

Available Shapes And Sizes

Rounds

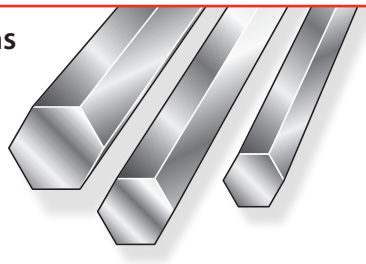
Flats

Squares

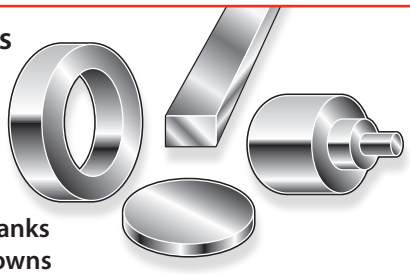


Plates

Hexagons



Specials



- Rings
- Blocks
- Gear blanks
- Step-downs

Durelloy Sizes Available For Immediate Shipment

Rounds

1/2	3-1/8	7-1/4
5/8	3-1/4	7-1/2
3/4	3-3/8	7-3/4
7/8	3-1/2	8
1	3-5/8	8-1/4
1-1/8	3-3/4	8-1/2
1-1/4	4	8-3/4
1-3/8	4-1/8	9
1-1/2	4-1/4	9-1/2
1-5/8	4-3/8	10
1-3/4	4-1/2	10-1/2
1-7/8	4-3/4	11
2	5	11-1/4
2-1/8	5-1/4	11-1/2
2-1/4	5-1/2	12
2-3/8	5-3/4	14
2-1/2	6	15-1/2
2-5/8	6-1/4	16
2-3/4	6-1/2	18
2-7/8	6-3/4	20
3	7	24

Squares

1-1/4
1-1/2
1-3/4
2
2-1/4
2-1/2
2-3/4
3
3-1/2
4
4-1/2
5
5-1/2
6
8

Hexagons

3/8
1/2
5/8
3/4
7/8
1
1-1/8
1-1/4
1-3/8
1-1/2
1-5/8
1-3/4
2
2-1/8
2-1/4
2-3/8
2-1/2
2-3/4
3
3-1/4
3-1/2

Flats

1/2 x 2	1-1/8 x 2-1/2	x 3-1/2
x 3	x 4-1/2	2 x 4
x 4	1-1/4 x 2	x 4-1/2
5/8 x 3	x 2-1/2	x 5
x 2-1/2	x 3	x 6
x 3	x 3-1/2	x 8
x 4	x 4	2-1/2 x 3
x 4-1/2	x 4-1/2	x 3-1/2
3/4 x 1	x 5	x 4
x 2	x 6	x 4-1/2
x 3	x 8	x 5
x 4	1-1/2 x 2	x 6
1 x 1-1/2	x 2-1/2	x 8
x 2	x 3	3 x 4
x 2-1/2	x 3-1/2	x 5
x 3	x 4	x 6
x 3-1/2	x 4-1/2	x 8
x 4	x 5	3-1/2 x 8
x 4-1/2	x 6	4 x 5
x 5	x 8	x 6
x 6	2 x 2-1/2	x 8
	x 3	

Plates

3/8 x 96 x 120
1/2 x 96 x 120
3/4 x 96 x 120
1 x 96 x 120
1-1/4 x 96 x 120
1-1/2 x 96 x 120
2 x 96 x 120
2-1/2 x 96 x 120
3 x 96 x 120
3-1/2 x 96 x 144
4 x 96 x 144
5 x 96 x 144
6 x 96 x 144
8 x 96 x 144

Lengths: 18′-20′ or custom cut to size.

Mechanical Properties As stocked in the heat treated (hardened) condition

Tensile Strength PSI	Yield Point PSI	Elongated In 2" %	Reduction Of Area %	Brinell Hardness BHN	Charpy V-Notch FT-LB
155/172,000	140/155,000	21.0/18.0	62/54	312/330	60/25

Properties are typical over a wide range of cross-sectional dimensions. Refer to following charts.

Tempering, Tensile, Yield Data

Section Size Inches	Tempering Temperature °F/°C	Tensile Strength PSI	Yield Point PSI	Elongated In 2" %	Reduction Of Area %	Surface Hardness BHN	Charpy V-Notch FT-LB	Mid-Radius Hardness BHN
1	AQ	—	—	—	—	698	—	698
	800/427	246,500	234,000	12.5	48.5	480	13	480
	1000/538	198,250	189,500	18.5	58.0	412	22	412
	1200/649	166,500	154,750	20.5	60.8	302	54	302
2	AQ	—	—	—	—	660	—	660
	800/427	238,750	226,000	14.5	52.5	469	15	469
	1000/538	202,000	190,750	18.6	59.0	412	22	412
	1200/649	164,000	155,500	21.2	61.5	340	56	340
4	AQ	—	—	—	—	586	—	586
	800/427	222,000	208,500	16.0	54.0	442	20	440
	1000/538	196,750	184,500	19.0	60.5	410	25	402
	1200/649	162,250	154,000	21.5	64.0	336	58	332
6	AQ	—	—	—	—	498	—	488
	800/427	205,500	190,250	16.8	55.0	408	24	398
	1000/538	192,000	178,000	19.8	61.8	398	27	390
	1200/649	160,000	149,500	21.8	64.6	330	62	326
8	AQ	—	—	—	—	412	—	396
	800/427	198,750	183,500	18.2	56.2	396	24	390
	1000/538	190,500	172,500	20.5	62.5	388	28	380
	1200/649	154,500	146,250	22.0	65.5	322	68	316

Durelloy bar samples oil-quenched from 1550°F (843°C).

Normalized Air cooled from 1550°F – 1650°F (843°C – 899°C)

Section Size Inches	Tensile Strength PSI	Yield Point %	Elongated In 2" %	Reduction Of Area %	Brinell Hardness BHN	Charpy V-Notch FT-LB
1	214,500	176,000	15.3	53.7	402	13
2	208,750	172,500	15.7	54.2	394	14
4	198,000	165,750	16.5	55.1	376	16
6	184,500	151,250	17.2	56.0	358	18
8	168,000	138,500	17.8	56.4	332	20

Annealed Slow cooled from 1600°F (871°C)

1	116,250	84,500	28.5	68.2	210	81

Critical Points

Heating At 50° Per Hour		Cooling At 50° Per Hour		
AC[1]	AC[3]	AR[3]	AR[1]	Ms
1360°F	1495°F	1350°F	1220°F	525°F
738°C	813°C	732°C	660°C	274°C

Forging

Heat thoroughly to 2250°F (1232°C) Max. Reheat as often as necessary to finish forging operation, but do not work below 1550°F (816°C). May be air-cooled *(normalized)* or oil-quenched after forging. For maximum properties, tempering is recommended prior to cooling below 150°F (66°C). Refer to *Metallurgical Data* for resultant properties.

Annealing

Heat to 1500°–1600°F (816°–871°C). Hold for 1 hour per inch of greatest thickness. Slow cool to 500°F (260°C). Air cool. Refer to *Metallurgical Data* for resultant properties.

Normalizing

Heat to 1550°–1650°F (843°–899°C). Soak thoroughly. Air cool. Refer to *Metallurgical Data* for resultant properties.

Hardening

- **Heating** Heat slowly and uniformly to 1550°–1650°F (843°–899°C). Hold for 1 hour per inch of greatest thickness. Soak thoroughly.
- **Quenching** Oil-quenching preferred. Agitate quenching medium as section size increases to accelerate process and provide more uniform cooling.
- **Tempering** All steels possess residual stresses and brittleness after normalizing or hardening by quenching, regardless of quenching medium. When possible, tempering is necessary to relieve these stresses and impart the required combination of strength and ductility (toughness). Tempering consists of heating to a temperature below the lower critical (AC1–1360°F), and holding for 1 hour per inch of greatest thickness. Follow tempering by cooling in still air.

Begin tempering before quenched section cools below 150°F.

Durelloy can be tempered in the range of 300°–1300°F (149°–704°C), depending on the application and final properties desired (wear vs. toughness ratio). The lower the tempering temperature, the higher the resultant hardness and resistance to wear. The higher the tempering temperature, the lower the resultant hardness and the greater the strength/toughness combination.

Hardness properties of .505" diameter test specimens,oil-quenched from 1550°F (843°C) and tempered as shown:

Tempering Temperature		Hardness
°F	°C	BHN
300	149	612
500	260	548
700	371	498
900	482	439
1100	593	365
1300	704	289

Refer to *Metallurgical Data* for resultant properties. Optimum properties depend on adequate facilities and processing. Duralloy-HT, from Ameralloy stock, should be used when possible.

surface hardening

Surface (Case) Hardening

• **Flame hardening** In some applications, it is desirable that surfaces subjected to extreme wear be harder than other surfaces of the same piece. The surfaces to be further hardened are heated with an oxyacetylene flame torch to a temperature of 1500°–1700°F (red/orange color), then rapidly quenched.

The exact quenching medium is determined by the percentage of heated surface. Small surfaces of larger pieces can simply be air-quenched because of rapid cooling due to the conduction of heat away from the small heated surface into the larger adjacent surfaces. Pieces with a larger percentage of surfaces to be hardened should be quenched by spraying with water. Residual heat after quenching will relieve hardening stresses.

This flame hardening process can yield hardenesses 0f 578–698 BHN with a hardness depth of up to 1/4".

• **Carburizing** Carburizing is the process of adding additional carbon to surface of steel by heating the metal to a temperature below its melting point in contact with carbonaceous solids *(pack-carburizing),* liquids *(liquid-carburizing),* or gases *(gas-carburizing).* High surface hardnesses are obtained while the core retains strength, ductility, and toughness.

Localized carburizing may also be accomplished by applying a protective coating which the carbon will not penetrate. Commercial pastes are widely available.

Durelloy carburizing case depths (inches), when carburized and quenched immediately in agitated oil and tempered at 300°–400°F. Resultant surface hardness of 615/700 BHN:

Hours	1550°F (843°C)	1650°F (899°C)	1750°F (954°C)	1850°F (1010°C)
2	.024	.034	.046	.062
4	.033	.047	.064	.089
6	.040	.058	.079	.109
8	.046	.067	.090	.123
10	.051	.072	.101	.137
12	.057	.079	.111	.151
16	.065	.089	.126	.172
20	.072	.101	.141	.192
24	.079	.111	.155	.208

Carburized at 1750°F for 8 hours. Quenched in agitated oil. Tempered at 300°F

Carburized at 1750°F for 8 hours. Quenched in agitated oil. Tempered at 400°F

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field welding data

Durelloy HR (hot roll) and Durelloy TGP heat treated alloy steel can be welded using standard welding methods.

No special electrode needed. Standard low-hydrogen rods recommended for maximum strengths. Most popular AWS designations are E7016, 7018, 10016 and (10018–preferred).

- Because of the carbon and other alloy elements, pre-heating to approximately (800 degrees) is recommended. Keep at pre-heated temperature during welding to prevent under-bed cracking.

- Welding rods should be clean and dry. Insure welding surface is clean. Hold inter-pass temperature at (800 degrees). Use minimum recommended arc voltage and amperage and reduce amperage slightly for secondary and finishing passes.

- Use the smallest-diameter electrode, rod or wire that will do the job.

- Travel slowly and straight.

- Use several small stringer beads rather than deposits. A weave bead of (2½) times the rod diameter can be used. Brush slag and dirt from the beads frequently.

- When welding cracks, cracks should be U-ed not V-ed; sharp angles tend to induce cracking. Take care to grind away any and all existing cracks.

- To relieve welding stresses, a post-heat of approximately (400 degrees) should be maintained for (2) hours.