

Ameralloy[®]

TOOL AND DIE STEELS



Ameralloy[®] Oil

Ameralloy[®] Air

Ameralloy[®]-60

Ameralloy[®] D-2

Amera-Graf[™]

Ameralloy[®] W1 & W2

Ameralloy[®] Drill Rods

Ameralloy[®] Precision Flat Ground

Ameralloy[®]-5

Ameralloy[®]-7

Ameralloy[®]-13

Ameralloy[®]-20

Amera-Mold[™]

Ameralloy[®]-6

Ameralloy[®]-FH

Ameralloy[®] High Speed-2

Ameralloy-T[™]

Durelloy-PM[™]

Ameralloy[®] Oil

OIL HARDENING STEEL **AISI 0-1**



Ameralloy Oil is an electric furnace, fully deoxidized tool steel and is produced under conditions of strictest tool steel practice. Ameralloy Oil is one of the best general purpose oil hardening tool and die steels. It machines with relative ease to a high finish. With reasonable care, Ameralloy Oil can be hardened safely with very little dimensional change. It has a good combination of abrasion resistance and toughness for a wide variety of tool and die applications.

Typical Analysis

- Carbon .90
- Manganese 1.20
- Chromium .65
- Vanadium .30
- Tungsten .55
- Silicon .30
- Molybdenum .15

Heat Treatment

- **Forging** 1850°–1950°F, stop at 1500°F, cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1450°F, furnace-cool. Brinell 202 max.
- **Hardening** 1475°F, oil-quench to 150°F
- **Tempering** 300°– 450°F, average hardness after heat treatment Rockwell C 61–63

Features And Advantages

- Good machinability
- Spheroidize annealed prior to shipment
- Safe hardening
- Maximum surface hardness
- Keen cutting edges
- Low distortion in heat treatment
- High core strength
- Controlled analysis
- Good toughness and wear resistance

Applications

- Cold forming
- Blanking
- Bending dies
- Broaches
- Knurling tools
- Gages

Characteristics

- **Machinability** Annealed to Brinell 202 max., Ameralloy Oil machines easily and approaches the machinability of straight-carbon water hardening tool steel. Where a 1% carbon steel is rated at 100, Ameralloy Oil has a rating of 90.
- **Dimensional stability** When quenched from proper hardening temperature, this grade normally expands .0015 in./in. plus. In many instances, slight scaling occurs during heat treatment which tends to counteract the expansion. Like all tool steels, hardening of Ameralloy Oil to insure minimum size change necessitates careful study of the die or tool and the furnace used for heat treatment.

- **Critical points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1390° to 1450°F

Cooling – Ar range 1280° to 1260°F

- **Decarburization** Ameralloy Oil is not inherently subject to excessive decarburization or to a soft skin on the surface. Good furnace practice as to atmosphere, time, and temperature will result in excellent properties.

General Instructions

- **Forging** Heat slowly to 1850°–1950°F and do not forge below 1500°F. If a preheater is available, hold at 1200°F until uniformly heated before heating to the forging temperature. After forging, bury in an insulation medium for slow cooling.
- **Annealing** The recommended practice is to use controlled-atmosphere furnaces. When not available, pack-anneal in an inert material. For a quick annealing cycle to develop fair machining properties, heat slowly to 1375°–1425°F, and cool slowly in the furnace. To develop the lowest hardness and best spheroidization for optimum machinability, heat slowly to 1400°F and furnace cool at 20°F per hour to 900°F. The piece may then be removed from the furnace and cooled in air. Hardness after this cycle will be Brinell 202 max.
- **Hardening** If pack-hardening cannot be used or is not essential, a slight oxidizing atmosphere should be used in heating to the hardening temperature of 1450°–1475°F for minimum decarburization and distortion. On large parts, pack-harden and preheat at approximately 1200°F with a thorough soaking before raising to the quenching temperature of 1475°–1500°F. Hold at

the quenching temperature for 1/2 hour per inch of greatest cross section. Follow by quenching in oil to 150°F and temper immediately.

Ameralloy-tested hardness and fracture grain ratings for various oil-quenching temperatures:

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1400°	9	60
1425°	9	62
1450°	9½	63
1475°	9½	65
1500°	9½	65
1525°	9¼	65
1550°	9¼	65

- **Tempering** Employ varying temperatures from 300°–450°F depending on size and properties required. Tempering at 350°F is satisfactory for general purpose use. Temperatures above 450°F are rarely used on Ameralloy Oil. The hardness levels produced by tempering above 450°F can also be produced in shock-resisting grades. Where greater toughness is required, Ameralloy recommends using a shock-resisting steel.

Small tools should be held at the tempering temperature for at least 1 hour, and larger tools for 2 hours per inch of greatest thickness. If a second temper is used, it should be 25° lower than the first.

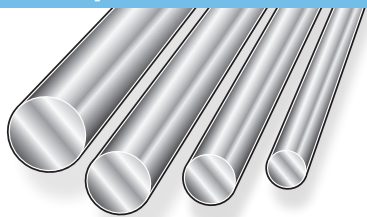
Resulting Rockwell hardness for various tempering temperatures. Obtained from 1" round samples oil-quenched from 1475°F and tempered for 2 hours.

Tempering Temperature (°F)	Rockwell C
None	65
300°	63
350°	62.5
400°	62
450°	61
500°	60
600°	57
700°	53
800°	50
900°	47
1000°	44
1100°	39
1200°	31
1300°	22

Above results on 1" diameter specimens may be used as a guide in tempering tools to desired hardness. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

Available Shapes And Sizes

Rounds



Flats



Squares



ROUNDS: Lengths precut to any size desired, or 10'-12' R/L lengths. **FLATS & SQUARES:** Standard 8'-10' R/L lengths. Wider widths and non-standards available upon request. Prompt forging service available.

Rounds Decarb Free Or Hot Rolled Annealed

1/4	1	2	4	8
9/32	1-1/16	2-1/8	4-1/4	8-1/4
5/16	1-1/8	2-1/4	4-1/2	8-1/2
3/8	1-3/16	2-3/8	4-3/4	8-3/4
7/16	1-1/4	2-1/2	5-1/4	9
1/2	1-5/16	2-9/16	5-1/2	9-1/2
9/16	1-3/8	2-5/8	5-3/4	10
5/8	1-1/2	2-3/4	6	10-1/2
11/16	1-5/8	2-7/8	6-1/4	11
3/4	1-3/4	3	6-1/2	12
13/16	1-7/8	3-1/8	6-3/4	
7/8		3-1/4	7	
15/16		3-1/2	7-1/4	
		3-5/8	7-1/2	
		3-3/4		

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1/2	x 5/8	x 3/4	x 7/8	x 1
x 3/4	x 3/4	x 7/8	x 1	x 1-1/4
x 7/8	x 7/8	x 1	x 1-1/8	x 1-1/2
x 1	x 1	x 1-1/8	x 1-1/4	x 1-3/4
x 1-1/8	x 1-1/8	x 1-1/4	x 1-1/2	x 2
x 1-1/4	x 1-1/4	x 1-3/8	x 1-3/4	x 2-1/4
x 1-3/8	x 1-1/2	x 1-1/2	x 2	x 2-1/2
x 1-1/2	x 1-3/4	x 1-3/4	x 2-1/4	x 2-3/4
x 1-3/4	x 1-7/8	x 2	x 2-1/2	x 3
x 1-7/8	x 2	x 2-1/4	x 2-3/4	x 3-1/2
x 2	x 2-1/4	x 2-1/2	x 3	x 4
x 2-1/4	x 2-1/2	x 2-3/4	x 3-1/2	x 4-1/2
x 2-1/2	x 2-3/4	x 3	x 4	x 5
x 2-3/4	x 3	x 3-1/2	x 4-1/2	x 5-1/2
x 3	x 3-1/4	x 4	x 5	x 6
x 3-1/4	x 3-1/2	x 4-1/2	x 6	x 7
x 3-1/2	x 4	x 5	x 7	x 8
x 3-3/4	x 4-1/2	x 6	x 8	x 10
x 4	x 5	x 8	x 10	x 12
x 4-1/2	x 6	x 10	x 12	
x 5	x 8	x 12		
x 6	x 10			
x 8	x 12			
x 10				
x 12				

1-1/8	1-1/4	1-3/8	1-1/2	1-3/4
x 1-1/8	x 1-1/4	x 1-3/8	x 1-1/2	x 1-3/4
x 1-1/4	x 1-1/2	x 1-1/2	x 1-3/4	x 2
x 1-1/2	x 1-3/4	x 1-3/4	x 2	x 2-1/4
x 1-3/4	x 2	x 2	x 2-1/4	x 2-1/2
x 2	x 2-1/4	x 2-1/4	x 2-1/2	x 2-3/4
x 2-1/4	x 2-1/2	x 2-1/2	x 2-3/4	x 3
x 2-1/2	x 2-3/4	x 2-3/4	x 3	x 3-1/2
x 2-3/4	x 3	x 3	x 3-1/2	x 4
x 3	x 3-1/2	x 3-1/2	x 4	x 4-1/2
x 3-1/2	x 4	x 4	x 4-1/2	x 5
x 4	x 4-1/2	x 4-1/2	x 5	x 6
x 4-1/2	x 5	x 5	x 6	x 7
x 5	x 5-1/2	x 6	x 7	x 8
x 6	x 6	x 8	x 8	x 10
x 8	x 7	x 10	x 9	x 12
x 10	x 8	x 12	x 10	
x 12	x 10		x 12	
	x 12			

2	2-1/4	2-1/2	3	3-1/2
x 2	x 2-1/4	x 2-1/2	x 3	x 3-1/2
x 2-1/4	x 2-1/2	x 2-3/4	x 3-1/2	x 4
x 2-1/2	x 3	x 3	x 4	x 4-1/2
x 2-3/4	x 3-1/2	x 3-1/2	x 4-1/2	x 5
x 3	x 4	x 4	x 5	x 6
x 3-1/2	x 4-1/2	x 4-1/2	x 6	x 8
x 4	x 5	x 5	x 8	x 10
x 4-1/2	x 6	x 6	x 10	x 12
x 5		x 7	x 12	
x 5-1/2		x 8		
x 6		x 10		
x 7		x 12		
x 8				
x 10				
x 12				

4	4-1/2	5	6
x 4	x 4-1/2	x 5	x 6
x 4-1/2	x 5	x 6	x 8
x 5	x 6	x 8	x 10
x 6	x 8	x 10	x 12
x 8	x 10	x 12	
x 10	x 12		
x 12			

Ameralloy[®] Air

AIR HARDENING STEEL **AISI A-2**



Ameralloy Air is an air-hardening tool steel possessing excellent non-deforming properties. Its wear resistance is midway between the high carbon/high chromium Ameralloy D, and the manganese oil hardening steel, Ameralloy Oil.

While Ameralloy Air may be hardened by quenching in either air or oil, air-quenching is recommended to virtually eliminate the risk of breakage. Ameralloy Air is particularly adapted to applications that demand toughness and high abrasion resistance.

Typical Analysis

- Carbon 1.00
- Chromium 5.75
- Vanadium .25
- Molybdenum 1.15
- Silicon .20
- Manganese .60

Heat Treatment

- **Forging** 1700°–1950°F, stop at 1750°F, cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1650°F, furnace-cool. Brinell 212 max.
- **Preheating** 1200°F prior to hardening
- **Hardening** 1775°F, air-quench to 150°F
- **Tempering** 350°–400°F, resulting hardness Rockwell C 60–61

Features And Advantages

- Low distortion in heat treatment
- High abrasion resistance and hardness
- Good hardenability

Applications

- Cold forming
- Blanking
- Bending dies
- Forming rolls
- Broaches
- Knurling tools
- Gages

Characteristics

- **Machinability** If properly annealed to Brinell 212, Ameralloy Air has a machinability of 65, as compared with a 1% carbon tool steel rated at 100.
- **Dimensional stability** When air-quenched from the proper hardening temperature, this grade generally expands .001 in./in. of cross section.
- **Critical points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1475° to 1540°F

Cooling – Ar range 1310° to 670°F

General Instructions

- **Forging** Before forging Ameralloy Air, preheat at 1250°F and soak thoroughly. Then raise temperature to 2000°–2050°F, and hold until the steel is uniformly heated. Forging should be discontinued at 1700°F. Reheat as often as necessary to complete the forging operation. Immediately after forging, bury in an insulating medium to avoid cooling cracks.
- **Annealing** Ameralloy Air should always be annealed after forging. To prevent decarburization, use a controlled atmosphere furnace or pack in a sealed container using inert material. To anneal for lowest hardness, heat slowly to 1650°F and hold at this temperature for approximately two hours per inch of greatest cross section. Cool at a rate of 20°F per hour to 1150°F and reheat to 1350°F. Hold three hours per inch of greatest cross section. Furnace-cool at 20°F per hour to 1100°F, then furnace-cool to 900°F, then air-cool. Resulting hardness from this treatment will be Brinell 212 max.
- **Hardening** To prevent decarburization, pack in inert material, or the treatment can be carried out in a salt bath or controlled atmosphere furnace. Preheat to 1200°F and hold at this temperature until thoroughly soaked. Heat to 1750°–1800°F, and hold for one hour per inch of greatest cross section. Remove from the furnace and cool in air. Although Ameralloy is primarily an air hardening grade, flash oil-quenching is occasionally used on large sections. However, tools must be removed from the oil when they reach 1000°F, then air-cooled to 150°F. Temper immediately to minimize the possibility of cracking.

Ameralloy-tested fracture grain size and Rockwell C hardness of specimens 1" square x 4" long, quenched in air and oil after holding one hour at 1600°–1900°F:

Still Air Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1600°	7	48
1650°	9½	54
1700°	9¾	59.5
1750°	9¾	64
1800°	10	64
1850°	9½	63
1900°	9¼	62

Oil Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1600°	9¾	54
1650°	9¾	55
1700°	9¾	62
1750°	9¾	65
1800°	9¾	64
1850°	9.625	63.5
1900°	9¾	62

- **Tempering** After cooling in the quench to approximately 150°F, temper immediately. For most applications, Ameralloy Air should be tempered at 350°–400°F at a minimum holding time of 2 hours per inch of greatest cross section.

Rockwell C hardness of specimens 1" square when air-quenched from 1775°F or oil-quenched from 1750°F. Tempered at various temperatures:

Tempering Temperature (°F)	Rockwell C	
	1775°F Air-Quench	1750°F Oil-Quench
None	64	65
300°F	62	62.5
400°F	60	61
500°F	56	57.5
600°F	56	56
700°F	56	56
800°F	56	56
900°F	56	56
1000°F	56	55
1100°F	50	50
1200°F	43	45
1300°F	34	34

Above results on 1" diameter specimens may be used as a guide in tempering tools to desired hardness. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

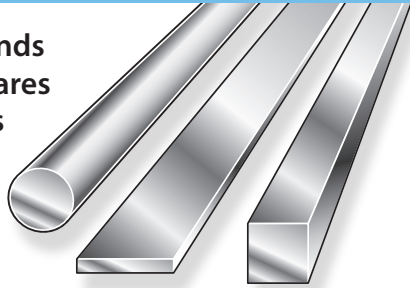
Effect Of Mass

Effectiveness of heat treatment on sections of increasing mass. Sample lengths of at least double the cross section were hardened as shown below. Rockwell C hardness obtained for 1" disc cut from the midsection of sample length:

Size	Treatment	Hardness – (Rc)	
		Surface	Center
1"sq.	Preheat 1200°F, austenitize 1775°F, air-cool to 150°F Temper at 400°F	64 61	64 61
4"sq.	Preheat 1200°F austenitize 1775°F Air-cool to 150°F Temper at 400°F	63 59	60 59
5"sq.	Preheat 1200°F, austenitize 1775°F, oil to 1000°F Air-cool to 150°F Double temper at 400°F	63 59	60 59
6"sq.	Preheat 1200°F, austenitize 1775°F, oil to 1000°F Air-cool to 150°F Double temper at 400°F	62 59	59 57
8"sq.	Preheat 1200°F, austenitize 1775°F, oil to 150°F Double temper at 400°F	62 61	61 59

Available Shapes And Sizes

Rounds
Squares
Flats



ROUNDS: Lengths precut to any size desired, or 8'–10' R/L lengths. **FLATS & SQUARES:** Standard 10'–12' R/L lengths.

Rounds Decarb Free Or Hot Rolled Annealed

1/4	1	2	4	7
5/16	1-1/16	2-1/8	4-1/4	7-1/2
3/8	1-1/8	2-1/4	4-1/2	8
7/16	1-1/4	2-3/8	4-3/4	8-1/2
1/2	1-3/8	2-1/2	5	9
9/16	1-1/2	2-5/8	5-1/4	10
5/8	1-5/8	2-3/4	5-1/2	11
11/16	1-3/4	2-7/8	5-3/4	12
3/4	1-7/8	3	6	
13/16		3-1/8	6-1/4	
7/8		3-1/4	6-1/2	
15/16		3-1/2		
		3-3/4		

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1/2	x 5/8	x 3/4	x 7/8	x 1
x 3/4	x 3/4	x 7/8	x 1	x 1-1/4
x 7/8	x 7/8	x 1	x 1-1/8	x 1-1/2
x 1	x 1	x 1-1/8	x 1-1/4	x 1-3/4
x 1-1/8	x 1-1/8	x 1-1/4	x 1-1/2	x 2
x 1-1/4	x 1-1/4	x 1-3/8	x 1-3/4	x 2-1/4
x 1-3/8	x 1-3/8	x 1-1/2	x 2	x 2-1/2
x 1-1/2	x 1-1/2	x 1-3/4	x 2-1/4	x 2-3/4
x 1-3/4	x 1-3/4	x 1-7/8	x 2-1/2	x 3
x 1-7/8	x 2	x 2	x 2-3/4	x 3-1/2
x 2	x 2-1/4	x 2-1/4	x 3	x 4
x 2-1/4	x 2-1/2	x 2-1/2	x 3-1/2	x 4-1/2
x 2-1/2	x 2-3/4	x 2-3/4	x 4	x 5
x 2-3/4	x 3	x 3	x 4-1/2	x 6
x 3	x 3-1/2	x 3-1/2	x 5	x 7
x 3-1/2	x 4	x 4	x 6	x 8
x 4	x 4-1/2	x 4-1/2	x 7	x 10
x 4-1/2	x 5	x 5	x 8	x 12
x 5	x 6	x 6	x 10	
x 6	x 8	x 8	x 12	
x 8	x 10	x 10		
x 10	x 12			
x 12				
1-1/8	1-1/4	1-3/8	1-1/2	1-3/4
x 1-1/8	x 1-1/4	x 1-3/8	x 1-1/2	x 1-3/4
x 1-1/4	x 1-1/2	x 1-3/4	x 1-3/4	x 2
x 1-1/2	x 1-3/4	x 2	x 2	x 2-1/4
x 1-3/4	x 2	x 2-1/4	x 2-1/4	x 2-1/2
x 2	x 2-1/4	x 2-1/2	x 2-1/2	x 2-3/4
x 2-1/4	x 2-1/2	x 3	x 2-3/4	x 3
x 2-1/2	x 2-3/4	x 3-1/2	x 3	x 3-1/2
x 2-3/4	x 3	x 4	x 3-1/2	x 4
x 3	x 3-1/2	x 4-1/2	x 4	x 4-1/2
x 3-1/2	x 4	x 5	x 4-1/2	x 5
x 4	x 4-1/2	x 6	x 5	x 6
x 4-1/2	x 5	x 8	x 6	x 7
x 5	x 6	x 10	x 7	x 8
x 6	x 7	x 12	x 8	x 10
x 8	x 8		x 10	x 12
x 10	x 10		x 12	
x 12	x 12		x 18-1/4	
	x 18-1/4			
2	2-1/4	2-1/2	3	3-1/2
x 2	x 2-1/4	x 2-1/2	x 3	x 3-1/2
x 2-1/4	x 2-1/2	x 2-3/4	x 3-1/2	x 4
x 2-1/2	x 3	x 3	x 4	x 4-1/2
x 2-3/4	x 3-1/2	x 3-1/2	x 4-1/2	x 5
x 3	x 4	x 4	x 5	x 6
x 3-1/2	x 4-1/2	x 4-1/2	x 6	x 8
x 4	x 5	x 5	x 8	x 10
x 4-1/2	x 6	x 6	x 10	
x 5		x 8		
x 5-1/2		x 10		
x 6		x 12		
x 8				
x 10				
x 12				
4	4-1/2	5	6	
x 4	x 4-1/2	x 5	x 6	
x 4-1/2	x 5	x 6	x 8	
x 5	x 6	x 8	x 10	
x 6	x 8	x 10	x 12	
x 8	x 10	x 12		
x 10	x 12			
x 12				

Ameralloy-60[®]

AIR HARDENING STEEL **AISI A-6**



Color Code:
BLUE WITH
WHITE STRIPE



Ameralloy-60 is an air hardening, cold work die steel that shows less distortion during heat treatment than water or oil hardening steels, and most high alloy air hardening die steels. A 6-inch cube of Ameralloy-60 will harden to Rockwell C 60 in still air. A major advantage is its low hardening temperature range of 1500°–1600°F, usually available only with oil hardening steels.

The minimum distortion characteristics of Ameralloy-60 make it perfectly suited for dies and punches in blanking and forming operations, or for tools where close size tolerance is critical.

Typical Analysis

- Carbon .70
- Manganese 2.10
- Silicon .30
- Chromium 1.00
- Molybdenum 1.35
- Sulfur .09

Heat Treatment

- **Forging** Ameralloy-60 should be heated slowly to the forging temperature of 2000°–2025°F. Do not hot work below 1600°F. Cool slowly in the furnace or bury in Sil-o-cel, fine dry ashes, lime, expanded mica, or other insulating material.
- **Annealing** Ameralloy-60 may be annealed in either a controlled atmosphere furnace or packed in spent pitched coke, spent cast iron chips, lime, fine dry ashes, sand, or ground mica with approximately 10% burned

charcoal added. Heat to 1325°–1375°F and hold approximately 4 hours for each inch of thickness. Cool very slowly at a rate of 20°F per hour to approximately 1000°F. Annealed hardness range is normally Brinell 235 to 245

- **Hardening** The hardening temperature range for Ameralloy-60 is 1500°–1600°F. Tools with simple shapes may be heated to the hardening temperature directly from room temperature. A preheat of 1200°–1250°F should be used for tools with intricate shapes. A slightly oxidizing furnace atmosphere should be used for hardening. Cool in still air or in an air blast.

- **Tempering** To obtain high hardness with minimum distortion, Ameralloy-60 should be tempered at temperatures between 300°–400°F. Tempering time varies with the size of the piece being hardened, but even the smallest tools should be tempered for a minimum of 1 hour. Refer to the hardening and tempering table to determine approximate hardness obtained from various tempering temperatures.

Ameralloy-60

AIR HARDENING STEEL AISI A-6

Hardened from 1500°F

Tempering Temperature (°F)	Energy-Absorbed Hardness (Ft-Lb)	Rockwell C
As Quenched	78	59
300°	81	58.5
350°	56	58
400°	52	57
450°	45.5	57
500°	63.5	56
600°	52	54
800°	99.5	49.5
1000°	Beyond Machine Capacity	45

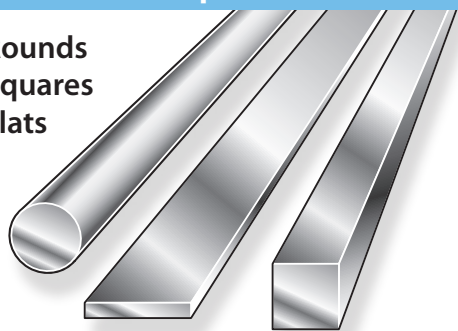
Hardened from 1600°F

Tempering Temperature (°F)	Energy-Absorbed Hardness (Ft-Lb)	Rockwell C
As Quenched	51	63
300°	66	61
350°	106	60
400°	81	59
450°	80.5	58
500°	38	57
600°	100	55
800°	83.5	51
1000°	Beyond Machine Capacity	48

Typical results. Actual data may vary. Not to be construed as maximum or minimum values for final design specification.

Available Shapes And Sizes

Rounds
Squares
Flats



ROUNDS: Lengths precut to any size desired, or 10'-12' R/L lengths. **FLATS & SQUARES:** Standard 8'-10' R/L lengths or cut pieces. Wider widths and non-standards available upon request. Prompt forging service available.

Rounds Decarb Free Or Hot Rolled Annealed

Hot Rolled Annealed

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
1-7/8

2
2-1/4
2-1/2
2-3/4
3
3-1/4
3-1/2
3-3/4
6
6-1/2

Pre-Machined

4
4-1/2
5
5-1/2
6
6-1/2
7
7-1/2
8
9
10

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1/2	x 5/8	x 3/4	x 7/8	x 1
x 1	x 1	x 1	x 1	x 1-1/4
x 1-1/2	x 1-1/2	x 1-1/2	x 1-1/8	x 1-1/2
x 2	x 2	x 2	x 1-1/4	x 1-3/4
x 2-1/2	x 2-1/2	x 2-1/2	x 1-1/2	x 2
x 3	x 3	x 3	x 1-3/4	x 2-1/4
x 4	x 4	x 4	x 2	x 2-1/2
x 5	x 5	x 5	x 2-1/2	x 2-3/4
x 6	x 6	x 6	x 3	x 3
x 8	x 8	x 8	x 3-1/2	x 3-1/2
x 10	x 10	x 10	x 4	x 4
x 12	x 12	x 12	x 5	x 4-1/2
			x 6	x 5
			x 8	x 6
			x 10	x 8
			x 12	x 10
				x 12

1-1/8	1-1/4	1-3/8	1-1/2	1-3/4
x 1-1/8	x 1-1/4	x 1-3/8	x 1-1/2	x 1-3/4
x 1-1/4	x 1-1/2	x 1-1/2	x 1-3/4	x 2
x 1-1/2	x 1-3/4	x 1-3/4	x 2	x 2-1/4
x 1-3/4	x 2	x 2	x 2-1/4	x 2-1/2
x 2	x 2-1/4	x 2-1/4	x 2-1/2	x 2-3/4
x 2-1/4	x 2-1/2	x 2-1/2	x 2-3/4	x 3
x 2-1/2	x 2-3/4	x 2-3/4	x 3	x 3-1/2
x 2-3/4	x 3	x 3	x 3-1/2	x 4
x 3	x 3-1/2	x 3-1/2	x 4	x 4-1/2
x 3-1/2	x 4	x 4	x 4-1/2	x 5
x 4	x 4-1/2	x 5	x 5	x 6
x 5	x 5	x 6	x 6	x 8
x 6	x 6	x 8	x 8	x 10
x 8	x 8	x 10	x 10	x 12
x 10	x 10	x 12	x 12	
x 12	x 12			
	x 18-1/4			

2	2-1/2	3	4	5-6
x 2	x 2-1/2	x 3	x 4	5 x 5
x 2-1/4	x 2-3/4	x 3-1/2	x 4-1/2	5 x 6
x 2-1/2	x 3	x 4	x 5	5 x 8
x 2-3/4	x 3-1/2	x 4-1/2	x 6	5 x 10
x 3	x 4	x 5	x 8	6 x 6
x 3-1/2	x 4-1/2	x 6	x 10	6 x 8
x 4	x 5	x 8	x 12	6 x 10
x 4-1/2	x 6	x 10		
x 5	x 8	x 12		
x 6	x 10			
x 8	x 12			
x 10				
x 12				

Ameralloy® D-2

AIR HARDENING STEEL

AISI D-2



Ameralloy D-2 is a premium quality, high carbon/high chrome air hardening steel for use in high volume production applications. It is recommended for dies with production quotas in the hundreds, thousands, or millions of pieces at minimum cost. Ameralloy D-2 resists edge chipping, sometimes experienced with other types of die steel. This decreases both the number and depth of grinds necessary to maintain the die.

Ameralloy D-2 hardens with a minimum amount of distortion and is perfectly suited for dies where close size tolerance is critical. Ameralloy D-2 is easier to machine than other high carbon/high chrome die steels.

Typical Analysis

- Carbon 1.55
- Silicon .35
- Chromium 12.50
- Vanadium 1.00
- Molybdenum 1.00
- Manganese .55

Applications

- Ring gauges
- Swaging dies
- Plug gauges
- Coining dies
- Shear knives
- Blanking dies
- Trimming dies
- Slitting dies
- Forming dies
- Drawing dies
- Lamination dies
- Thread rolling dies
- Forming rolls
- Lathe centers
- Seaming rolls
- Punches

Features And Advantages

- Maximum die life
- Maximum resistance to edge wear and chipping
- Minimum dimensional change during hardening
- Air hardening/deep hardening
- High compressions strength
- Non-scaling properties with fair resistance to corrosion
- Good machinability for a high alloy steel

Heat Treatment

- **Forging** 1950°–2050°F, stop at 1700°F, cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1650°F, furnace-cool. Brinell 217 max.
- **Preheating** 1200°–1250°F, prior to hardening
- **Hardening** 1850°F, air-quench to 150°F
- **Tempering** 900°F, minimum (see Tempering under General Instructions)

Characteristics

- **Machinability** Ameralloy D-2 has a machinability rating of 65, as compared with a rating of 100 for a 1% carbon steel tool.
- **Dimensional stability** Tests on this grade normally show a slight amount of contraction after hardening with a piece in the as-quenched condition or tempered below 900°F. Tempering at approximately 925°F usually eliminates the contraction and virtually brings the part back to its original size. Ameralloy D-2 has the minimum distortion in heat treatment as compared with other tool steels.
- **Critical points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1520° to 1600°F
Cooling – Ar range 1390° to 1300°F

- **Decarburization** To prevent decarburization, pack in an inert material or heat for hardening in a salt bath or controlled-atmosphere atmosphere furnace, or a vacuum furnace.
- **Grinding** Ameralloy D-2 is somewhat sensitive to grinding stresses resulting from improper practice. Oversize allowance for machining should be held to a minimum to avoid excessive grinding for finishing. The superior abrasion resistance of this grade makes it necessary to use a soft wheel with the coarsest grit commensurate with the finish required. Use a generous amount of coolant to cover the work at all times. Light cut must be made to avoid danger of cracking. For specific grinding operations, consult your grinding wheel representative for aid in selecting the proper grain and grade of wheel.

General Instructions

- **Forging** Due to a combination of high carbon/high chromium, take special care when hot working. Heat slowly and uniformly to 10 approximately 1250°F, and hold temperature sufficiently long to thoroughly soak the piece. For forging, heat to 1950°–2050°F. Discontinue forging at 1700°F and reheat. When forging is complete, cool slowly, preferably burying in dry insulating material.
- **Annealing** To prevent decarburization, use a controlled-atmosphere furnace or pack in inert material in a sealed container. Heat slowly to approximately 1600°–1650°F and hold at temperature for 1½ hours per inch of greatest thickness. Cool slowly at 20° per hour to 900°F, then allow steel to cool down with the furnace. Resulting hardness will be Brinell 217 max.
- **Hardening** When heating, protect the steel by packing or wrapping in inert material. When available, use a well-regulated salt bath, a controlled-atmosphere furnace, or a vacuum

furnace. Preheat to 1200°F and hold at this temperature until thoroughly soaked. Heat to 1850°F and hold at this temperature 1 hour per inch of greatest cross section. The piece may then be removed and cooled in still air to 150°F and tempered immediately. Oil-quenching is required on pieces 6" and larger.

Ameralloy-tested hardness and fracture grain ratings for various air-quenching temperatures:

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1700°	8¾	62
1750°	9¼	64
1800°	9¼	65
1850°	9½	65
1900°	9¼	63

- **Tempering** Double tempering is preferable with the second temper 50°F lower than the first. The tool type and service requirements determine the temperature. For most applications, the tempering range is 900°–960°F. Use a minimum holding time of 2 hours for each inch of greatest cross section. To minimize cracking, temper immediately after hardening, and heat slowly to desired tempering temperature.

In the as-quenched condition, Ameralloy-D2 normally shows a slight amount of contraction in size. Tempering at 900°F or slightly higher usually neutralizes the original shrinkage produced in the quench, and brings the part virtually back to its original size. If the first temper does not completely neutralize the shrinkage, then a second or even a third temper may be used, with each temper raised 10°F over the previous. This produces a hardness in the range of Rockwell C 58 to 60.

After the shrinkage of the part has been neutralized, it is advisable to give the part a final temper to temper any newly formed martensite. This final temper should be done at 25°–50°F below the previous temper.

Rockwell hardness from various heats of steel, air-quenched from 1850°F and tempered a minimum of 2 hours per inch of cross section.

Tempering Temperature (°F)	Rockwell C
None	64
400°	60
500°	58
600°	58
700°	58
800°	57
900°*	58/60
960°	58/60
1000°	56
1100°	48
1200°	40

*See Tempering

Above results may be used as a guide in tempering tools to desired hardness, however, tempering below 900°F is not recommended. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

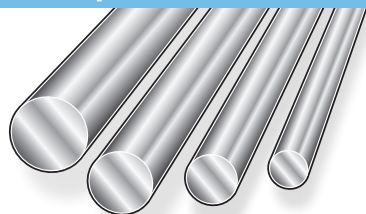
Ameralloy® D-2

AIR HARDENING STEEL

AISI D-2

Available Shapes And Sizes

Rounds



Flats



Squares



ROUNDS: Lengths precut to any size desired, or 10'–12' R/L lengths. **FLATS & SQUARES:** Standard 8'–10' R/L lengths. Wider widths and non-standards available upon request. Prompt forging service available.

Rounds Decarb Free Or Hot Rolled Annealed

1/4	1	2	4	8
5/16	1-1/8	2-1/8	4-1/4	8-1/2
3/8	1-1/4	2-1/4	4-1/2	9
7/16	1-3/8	2-3/8	4-3/4	9-1/2
1/2	1-1/2	2-1/2	5	10
9/16	1-5/8	2-5/8	5-1/4	10-1/2
5/8	1-3/4	2-3/4	5-1/2	11
11/16	1-7/8	2-7/8	5-3/4	11-1/2
3/4		3	6	12
13/16		3-1/8	6-1/4	12-1/2
7/8		3-1/4	6-1/2	13
15/16		3-1/2	7	14
		3-3/4	7-1/2	16

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1/2	x 5/8	x 3/4	x 1	x 1
x 3/4	x 3/4	x 7/8	x 1-1/8	x 1-1/4
x 7/8	x 7/8	x 1	x 1-1/4	x 1-1/2
x 1	x 1	x 1-1/4	x 1-1/2	x 1-3/4
x 1-1/8	x 1-1/8	x 1-3/8	x 1-3/4	x 2
x 1-1/4	x 1-1/4	x 1-1/2	x 2	x 2-1/4
x 1-1/2	x 1-1/2	x 1-3/4	x 2-1/2	x 2-1/2
x 1-3/4	x 1-3/4	x 2	x 2-3/4	x 2-3/4
x 1-7/8	x 2	x 2-1/4	x 3	x 3
x 2	x 2-1/4	x 2-1/2	x 3-1/2	x 3-1/2
x 2-1/4	x 2-1/2	x 2-3/4	x 4	x 4
x 2-1/2	x 2-3/4	x 3	x 4-1/2	x 4-1/2
x 2-3/4	x 3	x 3-1/2	x 5	x 5
x 3	x 3-1/2	x 3-3/4	x 5-1/2	x 6
x 3-1/4	x 3-3/4	x 4	x 6	x 7
x 3-1/2	x 4	x 4-1/2	x 8	x 8
x 3-3/4	x 4-1/2	x 5	x 10	x 10
x 4	x 5	x 6	x 12	x 12
x 4-1/2	x 6	x 8		
x 5	x 8	x 10		
x 6	x 10	x 12		
x 8	x 12			
x 10				
x 12				

1-1/8	1-1/4	1-3/8	1-1/2	1-3/4
x 1-1/8	x 1-1/4	x 1-3/8	x 1-1/2	x 1-3/4
x 1-1/4	x 1-1/2	x 1-3/4	x 1-3/4	x 2
x 1-1/2	x 1-3/4	x 2	x 2	x 2-1/4
x 1-3/4	x 2	x 2-1/2	x 2-1/4	x 2-1/2
x 2	x 2-1/4	x 2-3/4	x 2-1/2	x 2-3/4
x 2-1/4	x 2-1/2	x 3	x 2-3/4	x 3
x 2-1/2	x 2-3/4	x 3-1/2	x 3	x 3-1/2
x 2-3/4	x 3	x 4	x 3-1/2	x 4
x 3	x 3-1/2	x 4-1/2	x 4	x 4-1/2
x 3-1/2	x 4	x 5	x 4-1/2	x 5
x 4	x 4-1/2	x 6	x 5	x 6
x 4-1/2	x 5	x 8	x 6	x 8
x 5	x 6	x 10	x 7	x 10
x 6	x 7		x 8	x 12
x 8	x 8		x 10	
x 10	x 10		x 12	
x 12	x 12			

2	2-1/4	2-1/2	3	3-1/2
x 2	x 2-1/4	x 2-1/2	x 3	x 3-1/2
x 2-1/4	x 2-1/2	x 2-3/4	x 3-1/2	x 4
x 2-1/2	x 3	x 3	x 4	x 4-1/2
x 2-3/4	x 3-1/2	x 3-1/2	x 4-1/2	x 5
x 3	x 4	x 4	x 5	x 6
x 3-1/2	x 6	x 4-1/2	x 6	x 8
x 4	x 8	x 5	x 8	x 10
x 4-1/2	x 10	x 6	x 10	x 12
x 5	x 12	x 8	x 12	
x 5-1/2		x 10		
x 6		x 12		
x 8				
x 10				
x 12				

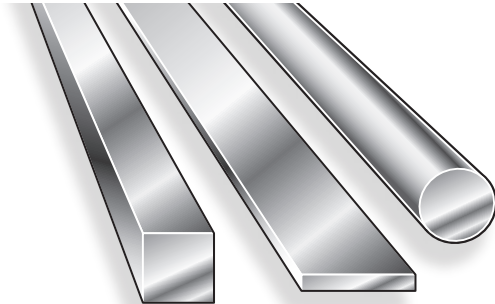
4	4-1/2	5	6
x 4	x 4-1/2	x 5	x 6
x 4-1/2	x 5	x 6	x 8
x 5	x 6	x 8	x 10
x 6	x 8	x 10	x 12
x 8	x 10	x 12	
x 10	x 12		
x 12			

Amera-Graf™

OIL HARDENING STEEL **AISI 0-6**



Color code:
TAN



Amera-Graf is a medium alloy 1.45 carbon oil-hardening tool steel. In its annealed condition, about one-third of the carbon is present as graphitic carbon. The remainder is present as combined carbon in the form of carbides. In this condition, Amera-Graf is the most readily machinable of the oil hardening tool grades.

Typical Analysis

- Carbon 1.45
- Silicon 1.25
- Manganese 1.0
- Molybdenum .25

Features And Advantages

- Excellent machinability
- Good wear resistance

Applications

Forming, shaping, and drawing dies. Suitable for a great variety of cold-work dies calling for physical properties, wear resistance, and edge holding similar to standard oil hardening tool steels like Type 01. Non-galling, self-lubricating characteristics of Amera-Graf make it well suited for dies subject to galling and seizing.

Heat Treatment

- **Forging** 2000°F max., stop at 1700°F, cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1425°–1450°F, furnace-cool to 1000°F, hold 1 hour per inch of greatest cross section. Air cool. Brinell 212 max.
- **Preheating** 1250°F prior to hardening
- **Hardening** 1450°–1500°F, oil-quench to 150°F
- **Tempering** 300°– 400°F, resulting hardness Rockwell C 61–62

Characteristics

- **Machinability** When properly annealed to Brinell 212 max., Amera-Graf has a machinability rating of 125 – as compared with a 1% carbon tool steel rated at 100.
- **Dimensional stability** When oil-quenched from proper hardening temperature, this grade normally expands .0015 in./in. plus.
- **Critical Points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1400° to 1420°F

Cooling – Ar range 1340° to 1280°F

- **Decarburization** Decarburizes more rapidly than other tool steels when heated for forging, annealing, or hardening. This is due to the high silicon and molybdenum content. Care should be taken when heating Amera-Graf to protect it from decarburization. Preheating can be very helpful, as it shortens exposure to high temperature. Use controlled-atmosphere annealing furnace if available. If not available, pack-anneal with inert material in a sealed container.

General Instructions

- **Forging** Preheat Amera-Graf at approx. 1300°F before uniformly heating to a forging temperature of 2000°F. Stop forging at 1700°F. Reheat if necessary. Bury in insulating material immediately after forging.

Heat Treatment (continued)

• **Annealing** Heat Amera-Graf uniformly to a temperature range of 1425°–1450°F. Then cool slowly in the furnace to 1000°F and hold at this temperature approximately 1 hour per inch of greatest cross section. Cool in air. The resulting hardness will be Brinell 217 max.

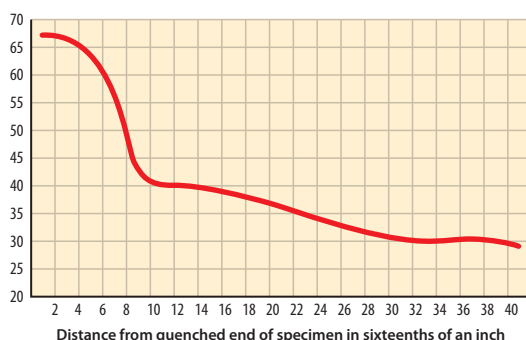
• **Hardening** Preheat Amera-Graf thoroughly at approximately 1250°F, and then heat to the hardening temperature of 1450°–1500°F. For small sections, the lower part of the hardening range should be used; larger sections require higher temperatures. All sections should be equalized at the hardening temperature for 1 hour per inch of greatest cross section before quenching in oil to 150°F. Temper immediately.

• **Tempering** For the majority of tooling work, tempering at 300°–400°F is satisfactory. This will result in a hardness of approximately Rockwell C 61/62. Heat the tools to tempering temperature and hold for approximately 2 hours per inch of greatest cross section.

Resulting Rockwell C hardness obtained from samples oil-quenched from 1475°F and tempered at various temperatures:

Tempering Temperature (°F)	Rockwell C
As Quenched	65
300°	62
400°	61
500°	60
600°	58
700°	54

Jominy Hardenability Curve



Rounds Decarb Free Or Hot Rolled Annealed

1/4	1	2	4	7
3/8	1-1/8	2-1/8	4-1/4	7-1/4
1/2	1-1/4	2-1/4	4-1/2	7-1/2
5/8	1-3/8	2-3/8	4-3/4	8
3/4	1-1/2	2-1/2	5	8-1/2
7/8	1-5/8	2-5/8	5-1/4	9
	1-3/4	2-3/4	5-1/2	9-1/2
	1-13/16	3	5-3/4	10
	1-7/8	3-1/4	6	10-1/2
		3-1/2		11
		3-3/4		12

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1	x 1	x 3/4	x 2-3/4	x 1
x 1-1/2	x 1-1/2	x 1	x 3-1/2	x 1-1/4
x 2	x 2	x 1-1/2		x 1-1/2
x 2-1/2	x 3	x 2		x 2
x 3	x 3-1/2	x 2-1/2		x 2-1/2
x 3-1/2	x 4	x 3		x 3
x 4	x 6	x 3-1/2		x 3-1/2
x 5		x 4		x 4
x 6		x 5		x 4-1/2
		x 6		x 5
		x 8		x 6
				x 8
				x 10

1-1/8	1-1/4	1-3/8	1-1/2	1-3/4
x 1-1/2	x 1-1/4	x 2	x 1-1/2	x 1-3/4
x 2	x 1-1/2	x 2-1/2	x 2	x 2
x 2-1/2	x 1-3/4	x 3	x 2-1/2	x 2-1/2
x 3	x 2	x 4	x 3	x 3
x 3-1/2	x 2-1/4	x 5	x 3-1/2	x 3-1/2
x 5	x 2-1/2		x 4	x 4
x 6	x 3		x 4-1/2	x 5
	x 3-1/2		x 5	x 6
	x 4		x 6	
	x 4-1/2		x 7	
	x 5		x 8	
	x 6			
	x 8			

2	2-1/4	2-1/2	3	3-1/2
x 2	x 2-1/2	x 2-1/2	x 3	x 3-1/2
x 2-1/2	x 3	x 3	x 3-1/2	x 4-1/2
x 3	x 4	x 3-1/2	x 4	
x 3-1/2		x 4	x 4-1/2	
x 4		x 4-1/2	x 5	
x 4-1/2		x 5	x 6	
x 5		x 6	x 8	
x 6		x 7		
x 8				

4	5	6
x 4	x 5	x 6
x 5	x 6	x 8
x 8		x 10

ROUNDS: Lengths precut to any size desired, or 10'–12' R/L lengths. **FLATS & SQUARES:** Standard 8'–10' R/L lengths. Wider widths and non-standards available upon request. Prompt forging service available.

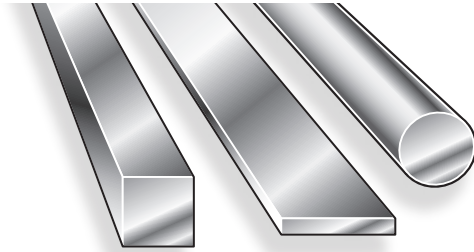
Ameralloy® W1&W2

WATER HARDENING STEEL

AISI W1–W2



Color Code:
LIGHT BLUE



Ameralloy W1 is a straight carbon water hardening tool steel available in a wide range of carbon content. It is a shallow hardening steel – a case hardness of Rockwell C 66 can be attained for excellent abrasion resistance and a softer core for superior toughness.

Ameralloy W2 is a water hardening carbon tool steel containing .25 vanadium. The vanadium induces grain refinement, resists grain growth, and improves fatigue resistance. Ameralloy W2 is generally applied with .95 to 1.05 carbon.

The carbon ranges of Ameralloy W1 and W2 determine attainable hardness and dictate the analysis specified for particular applications.

Applications

- **Carbons about 1.00** Hand chisels, taps, dies, cold trimmer & header dies, forming & blanking dies, small shear blades, chuck jaws.
- **Lower carbons** Hot forming dies, blacksmith tools, hammers, crow bars, rivet sets, shear blades
- **Higher carbons** Milling cutters, taps, drills, slotting & turning tools, engraving tools, gages

Typical Analysis

	W1	W2
Carbon	.60–1.40	.80–1.25
Manganese	.25	.25
Silicon	.20	.25
Vanadium	--	.25

Heat Treatment

	W1	W2
Annealing	1375°–1450°F	1400°–1450°F
Hardening	1400°–1500°F	1450°–1550°F
Tempering	200°–600°F	300°–600°F

Available Shapes And Sizes

Rounds	Squares	Billets	Flats
1/2	4	1/2	4
5/8	4-1/4	5/8	6
3/4	4-1/2	3/4	8
7/8	4-3/4	7/8	
1	5	1	
1-1/8	5-1/4	1-1/8	
1-1/4	5-1/2	1-1/4	
1-3/8	5-3/4	1-3/8	
1-1/2	6	1-1/2	
1-5/8	6-1/4	1-5/8	
1-3/4	6-1/2	1-3/4	
1-7/8	7	2	
2	7-1/2	2-1/4	
2-1/4	8	2-1/2	
2-1/2	9	2-3/4	
2-3/4		3	
2-7/8		3-1/2	
3		4	
3-1/8		5	
3-1/4			
3-3/8			
3-1/2			
3-5/8			
3-3/4			

Also available in ground two adjacent sizes.

Ameralloy® Drill Rods

***Stocking All Standard Sizes
And Tolerances!***

Ameralloy® Oil

OIL HARDENING AISI O-1

Ameralloy Oil is the most widely used grade of drill rod. It is a general purpose tool steel with premium hardening, wear resistance, and toughness.

Typical Analysis

GENERAL
PURPOSE

- Carbon .90
- Manganese 1.20
- Silicon .30
- Tungsten .55
- Chromium .65
- Vanadium .30
- Molybdenum .15

Ameralloy®-60

AIR HARDENING AISI A-6

Ameralloy-60 has a minimum distortion characteristic which makes it particularly well suited for dies and punches in blanking and forming operations. Also recommended for gages or other tools where close size tolerance is required.

Typical Analysis

- Carbon .70
- Molybdenum 1.35
- Manganese 2.10
- Silicon .30
- Chromium 1.00
- Sulfur .09

Ameralloy®-Air

AIR HARDENING AISI A-2

Ameralloy Air is recommended over Ameralloy Oil when increased wear resistance, safe hardening, and less distortion are required.

Typical Analysis

MINIMUM
DISTORTION

- Carbon 1.00
- Molybdenum 1.15
- Manganese .60
- Silicon .20
- Chromium 5.75
- Vanadium .25

Ameralloy® D-2

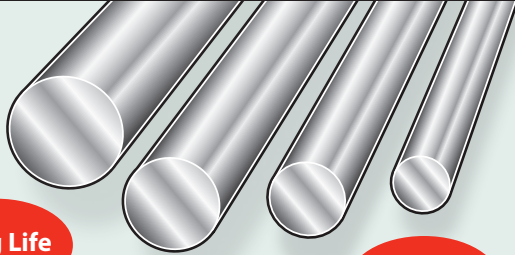
**HIGH CARBON/
HIGH CHROME** AISI D-2

Ameralloy D-2 is an air-hardening steel known for maximum wear resistance. It is ideal for use in tools, dies, and used in long production runs.

Typical Analysis

MAX. WEAR
RESISTANCE

- Carbon 1.55
- Molybdenum 1.00
- Manganese .55
- Silicon .35
- Chromium 12.50
- Vanadium 1.00



Long Life

Close Tolerance

Wear Resistance

Consistent Hardening

Finish All drill rod rounds are furnished ground and polished

Lengths Standard stock sizes are 36" long. Also available in 12' lengths.

Tolerance

Size Range	Standard Tolerance
• Up to .125"	+/- .0003"
• .125" to .499"	+/- .0005"
• .500" to 2.000"	+/- .001"

Ameralloy® w1&w2

WATER HARDENING AISI W1-W2

Ameralloy W1 and W2 are water hardening grades formulated to meet the needs of the machine shop. Well suited for average work where premium grades are not required.

Typical Analysis

	W1	W2
• Carbon	.60-1.40	.80-1.25
• Manganese	.25	.25
• Silicon	.20	.25
• Vanadium	--	.25

High Speed-2

AISI M-2

Ameralloy High Speed-2 is the most widely used type of high speed tool steel. It's higher carbon content and balanced analysis produce properties applicable to all general purpose high speed uses.

Typical Analysis

- Carbon .83
- Molybdenum 5.00
- Tungsten 6.35
- Chromium 4.15
- Vanadium 1.90

Ameralloy®-7

SUPER SHOCK AISI S-7

Ameralloy-7 is our new, premium quality air hardening drill rod. It's the toughest, strongest drill rod for many applications that require maximum strength and impact.

Typical Analysis

- Carbon .50
- Molybdenum 1.40
- Manganese .70
- Silicon .25
- Chromium 3.25

**MAXIMUM
STRENGTH**

Ameralloy®-13

HOT WORK AISI H-13

Ameralloy-13 combines good red hardness with abrasion resistance and resists heat checking. Ameralloy-13 is made from vacuum degassed tool steel ingots. This process plus carefully controlled hot work provides optimum uniformity, consistent response to heat treatment, and long service life.

Typical Analysis

- Carbon .40
- Molybdenum 1.50
- Manganese .40
- Silicon 1.10
- Chromium 5.25
- Vanadium 1.10

**EXTENDED
SERVICE LIFE**

Ameralloy®

Precision Flat Ground

Stocking All Standard Sizes And Tolerances

Ameralloy® Oil

OIL HARDENING AISI O-1

Ameralloy Oil is a widely used grade of precision flat grounds. It is a general purpose tool steel with premium hardening, wear resistance, and toughness.

Typical Analysis

GENERAL
PURPOSE

- Carbon .90
- Manganese 1.20
- Silicon .30
- Tungsten .55
- Chromium .65
- Vanadium .30
- Molybdenum .15

Ameralloy®-60

AIR HARDENING AISI A-6

Ameralloy-60 has a minimum distortion characteristic which makes it particularly well suited for dies and punches in blanking and forming operations.

Typical Analysis

- Carbon .70
- Molybdenum .09
- Manganese 2.10
- Silicon .30
- Chromium 1.00
- Vanadium 1.35

Ameralloy®-Air

AIR HARDENING AISI A-2

Ameralloy Air is recommended over Ameralloy Oil when increased wear resistance, safe hardening, and less distortion are required.

Typical Analysis

MINIMUM
DISTORTION

- Carbon 1.00
- Molybdenum 1.15
- Manganese .60
- Silicon .20
- Chromium 5.75
- Vanadium .25

Ameralloy® D-2

**HIGH CARBON/
HIGH CHROME** AISI D-2

Ameralloy D-2 is an air-hardening steel known for maximum wear resistance. It is ideal for use in tools, dies, and used in long production runs.

Typical Analysis

MAX. WEAR
RESISTANCE

- Carbon 1.55
- Molybdenum 1.00
- Manganese .55
- Silicon .35
- Chromium 12.50
- Vanadium 1.00

Ameralloy Flat Ground Tolerances

Thickness – regular	± .001"
Thickness – oversize	+ .010/.015"
Thickness – metric	+ .05mm/-0
Width – regular	+ .000/.005"
Width – oversize	+ .010/.015"
Width – metric	+ .2mm/-0
Squares – regular	± .001"
Squares – oversize	+ .010/.015"
Length 18"	+ .125/.250"
Length 24"	+ .1875/.375"
Length 36"	+ .250/.500"
Squareness – edge	.003" per inch
Squareness – end	.004" per inch



Ameralloy[®]

LOW CARBON

Typical Analysis

- Carbon .18
- Manganese .50
- Silicon .20
- Phosphorus .04
- Sulphur .04

Durelloy[™] GFS

HEAT TREATED

Typical Tolerance

- Thickness +.005, -.000 Mattison ground
- Width +.005, -.000 Blanchard ground
- Length plus 1/8" saw cut
- Heat treated to 28–32 Rockwell C

Ameralloy-7[®]

SUPER SHOCK AISI S-7

Ameralloy-7 is our new, premium quality air hardening PFG. It's the toughest, strongest drill rod for many applications that require maximum strength and impact.

Typical Analysis

- Carbon .50
- Molybdenum 1.40
- Manganese .70
- Silicon .25
- Chromium 3.25

MAXIMUM
STRENGTH

High Speed-2

AISI M-2

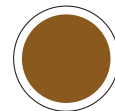
Ameralloy High Speed-2 is the most widely used type of high speed tool steel. It's higher carbon content and balanced analysis produce ideal properties for high speed use.

Typical Analysis

- Carbon .86
- Molybdenum 5.00
- Tungsten 6.35
- Chromium 4.15
- Vanadium 1.90

Ameralloy-5[®]

SHOCK RESISTANT STEEL AISI S-5



Color Code:
BROWN



Ameralloy-5 is formulated primarily for use in pneumatic and shock tools, and well suited to shock resistant parts in which a combination of great ductility and hardness is required. Carbon tool steels under Rockwell C 60 cannot compare in shock resistance to the alloyed grades. Ameralloy-5 is normally oil-quenched, particularly when machining intricate parts using Ameralloy-5. Quenching in water produces satisfactory results, but additional care should be taken if the part has drastic sectional changes or sharp corners.

Typical Analysis

- Carbon .60
- Manganese .85
- Vanadium .25
- Silicon 2.00
- Molybdenum .50

Features And Advantages

- Maximum shock resistance for hardness in the range of Rockwell C 58–60
- Good wear resistance
- Oil and water hardening

Heat Treatment

- **Forging** 1850°–1950°F, stop at 1650°F
- **Annealing** 1450°F, furnace-cool. Brinell 229 max.
- **Hardening** 1600°F, oil-quench or water-quench
- **Tempering** 400°–650°F, average hardness after heat treatment Rockwell C 57–61

Applications

- Asphalt cutters
- Beading tools
- Caulking tools
- Moil points
- Pavement breakers
- Pneumatic chipping chisels
- Punches
- Rivet busters
- Rivet sets
- Shear blades

General Instructions

- **Forging** Heat Ameralloy-5 to 1850°–1950°F and do not forge below 1650°F. Ameralloy-5 is subject to decarburization, and therefore should not be held at the forging temperature longer than necessary. After forging, the steel should be cooled slowly in a heat-insulating material such as dry ashes, dry lime, or vermiculite.

- **Annealing** Pack-annealing in sealed containers using inert material is preferable because of the decarburization tendency of this steel. Otherwise, controlled-atmosphere furnaces may be used. Heat slowly to 1450°F, and hold for 1 hour per inch of greatest thickness. To obtain optimal machining properties, Ameralloy-5 should be cooled slowly to 1000°F. Careful annealing should result in a hardness of Brinell 229 max.

- **Hardening** Ameralloy-5 is primarily an oil hardening grade, However, satisfactory results can be achieved with water-quenching when the design is not too intricate. Hardening temperature for both oil- and water-quenching is 1600°F. Holding time at hardening heat should be just sufficient for uniformity of temperature. Holding time should not exceed 1/2 hour per inch of greatest thickness because of the danger of excessive decarburization. Temper immediately after quenching.

Ameralloy-tested hardness and fracture grain ratings for various oil- and water-quenching temperatures. Specimen size 3/4" dia. x 5".

Quenching Temperature (°F)	OIL-QUENCH		WATER-QUENCH	
	Fracture Grain Size	Rockwell C	Fracture Grain Size	Rockwell C
1450°	8	49	8	51
1500°	9½	55	9	59
1550°	9½	61	9½	64
1600°	9½	64	9½	65
1650°	9	63	9½	65

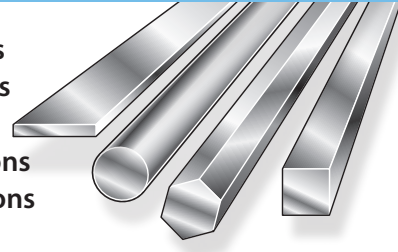
- **Tempering** Temperature should range between 400°–650°F, depending on the service desired. Normal tempering procedure for Ameralloy-5 is to hold at temperature for at least 2 hours per inch of greatest thickness.

Resulting Rockwell hardness for tempering oil- and water-quenched 3/4" dia. specimens at various temperatures

Tempering Temperature (°F)	1600°F Oil-Quench Rockwell C	1600°F Water-Quench Rockwell C
300°	63	63
400°	61	61
500°	60.5	60
600°	59	59
700°	57.5	57.5
800°	53	53.5
900°	51	51
1000°	49	48
1100°	47	45
1200°	40.5	40
1300°	33.5	33

Available Shapes And Sizes

Rounds
Squares
Flats
Octagons
Hexagons
Billets



Standard lengths 10'–12' R/L lengths. Other sizes available upon request. Prompt forging service also available

Rounds Decarb Free Or Hot Rolled Annealed

1/4	1	2	3	4
5/16	1-1/8	2-1/8	3-1/4	4-1/4
3/8	1-1/4	2-1/4	3-1/2	4-1/2
7/16	1-3/8	2-1/2	3-3/4	4-3/4
1/2	1-1/2	2-3/4		5
5/8	1-5/8			5-1/8
3/4	1-3/4			6
7/8	1-7/8			

Squares Octagons

3/8	2	1/4	1
1/2	2-1/2	3/8	1-1/8
5/8	3	7/16	1-1/4
3/4	4	1/2	
1		5/8	
1-1/4		3/4	
1-3/8		7/8	
1-1/2			
1-3/4			

Hexagons Billets

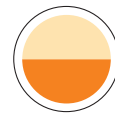
3/8	1	Round
1/2	1-1/8	CornerRadius
5/8	1-1/4	Square
3/4	1-1/2	4
7/8		6
		8
		10

Flats

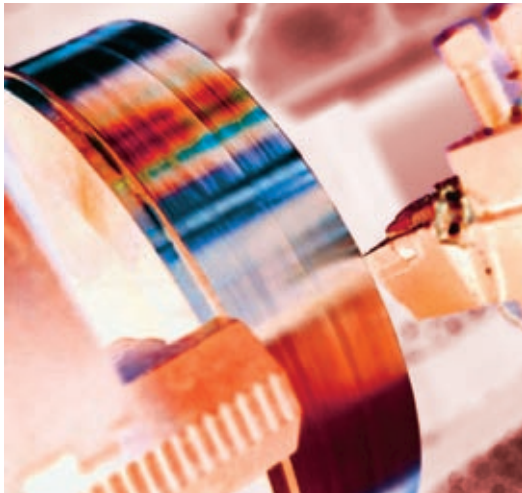
3/8	x 2-1/2	x 2-1/2	x 4-1/2	3
x 1	x 3	x 3	x 5	x 4
x 1-1/2	x 4	x 4	x 6	x 4-1/2
x 2	x 5	x 5	2	x 5
x 5	1	x 6	x 2-1/2	x 6
1/2	x 1-1/2	1-1/2	x 3	x 7
x 5/8	x 2	x 2	x 4	x 8
x 1	x 2-1/2	x 2-1/2	x 4-1/2	3-1/2
x 1-1/2	x 3	x 3	x 5	x 4
x 2	x 3-1/2	x 3-1/2	x 6	x 5
x 2-1/2	x 4	x 4	x 8	x 6
x 3	x 4-1/2	x 4-1/2	2-1/2	4
x 6	x 5	x 5	x 3	x 4-1/2
3/4	x 6	x 5-1/2	x 4	x 5
x 1	1-1/4	x 6	x 4-1/2	x 6
x 1-1/2	x 1-1/2	1-3/4	x 5	x 7
x 2	x 2	x 4	x 6	x 8

Ameralloy-7[®]

IMPACT RESISTANT STEEL AISI S-7



Color Code:
TAN & ORANGE



Ameralloy-7 is remarkably versatile. It is widely used for medium run cold-work tools and dies, plastic molding dies, shear blades, medium hot-work dies, master hobs, and component parts. Ameralloy-7 is a shock steel with exceptional impact properties, unnotched Charpy over 200 ft-lbs at 400°F temper. Since it hardens in air, Ameralloy-7 is safe and stable in heat treatment.

Ameralloy-7 Modified* is available in mill run quantities.

Typical Analysis

- Carbon .50
- Manganese .70
- Chromium 3.25 (3.75)*
- Silicon .25
- Molybdenum 1.40 (1.50)*

Features And Advantages

- Good machinability
- Maximum shock resistance
- Air hardening
- Medium hot-work characteristics

Heat Treatment

- **Forging** Preheat 1200°–1300°F, forge at 2000°–2050°F, stop at 1700°F and cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1500°–1550°F, cool slowly to 1000°F, air cool. Brinell 197 max.
- **Preheating** 1200°–1300°F prior to hardening
- **Hardening** 1725°F, quench in air if cross section is 2½" or smaller. Sections 2½–6" should be oil-quenched to black (1000°F) then air-cooled to 150°F. Larger cross sections should be oil-quenched to 150°F.
- **Tempering** 400°F minimum, double temper oil-quenched masses

Applications

- Hot and cold shock applications
- Rivet sets
- Chisels
- Punches
- Moil points
- Hot headers
- Gripper dies
- Cold Forming
- Blanking
- Bending
- Engraving dies
- Machined cavities
- Plastic-molding dies
- Die-casting dies
- Shear blades
- Master hobs

Characteristics

- **Machinability** When annealed to Brinell 197 max. Ameralloy-7 is rated at 95, as compared to a rating of 100 for a 1.00% carbon tool steel.
- **Dimensional stability** When quenched in air from the proper hardening temperature, Ameralloy-7 expands no more than 0.001 in./in. of cross section.

General Instructions

- **Maintain surface chemistry** Precautions should be taken to avoid excessive decarburization or carburization when heating Ameralloy-7 for forging, annealing, and hardening.
- **Forging** Preheat Ameralloy-7 at 1200°–1300°F before raising to a forging temperature of 2000°–2050°F. Discontinue forging at 1700°F and reheat rather than forge below this temperature. Ameralloy-7 is subject to decarburization and should not be held at the forging temperature longer than necessary. Following forging, cool slowly by burying in your choice of heat-insulating material to avoid cooling cracks.
- **Annealing** Anneal in a protective atmosphere. Heat rapidly to 1500°–1550°F and hold at temperature for 1½ hours per inch of greatest thickness. To obtain best machining properties, cool slowly to 1000° then air cool. Resulting hardness will be Brinell 197 max.
- **Hardening** To maintain surface chemistry, Ameralloy-7 should be hardened in a controlled neutral environment. Note that packing in cast-iron chips could impart a light carburized case. Unless such a case is considered desirable, make provisions for grinding it after treatment.

Ameralloy-7 should be preheated at 1200°–1300°F and raised to a hardening temperature of 1725°F. Hold at temperature 1 hour per inch of greatest thickness. Thicknesses 2½" or less should be quenched in still air. Upon reaching 150°F, temper without delay.

Thicknesses of 2½–6" should be oil-quenched until black (1000°F), then cooled in air. For massive sections larger than 6", it is advisable to oil-quench until the piece reaches 150°F then temper immediately. After oil-quenched sections have cooled to room temperature, temper again to insure complete transformation.

Ameralloy-tested Rockwell hardness and fracture grain ratings for specimens 1" round by 3" long, preheated to 1300°F. Various quenching methods and temperatures listed.

STILL AIR

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1550°	6½	43.5
1600°	7	48
1650°	8	57
1700°	9	60
1725°	8½	60
1750°	8	60
1800°	7	60
1850°	7	60

AIR-BLAST

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1550°	6½	52.5
1600°	7	57
1650°	8½	57.5
1700°	9	58
1725°	8½	60
1750°	8	60
1800°	7½	60
1850°	7	61

OIL-QUENCH

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1550°	8	52
1600°	8	54
1650°	9	57.5
1700°	9	61
1725°	8½	61
1750°	8	61.5
1800°	8	62
1850°	7	62

- **Carburizing** During heating for hardening to increase wear resistance, for some types of tools such as master hobs, striking dies, die stamps, and forming dies it is possible to increase wear resistance of Ameralloy-7 while retaining desirable shock resistance.

The best case depth for many applications is 0.010" or less. Hardness will be approximately Rc 60/62. A carburized case can be put on while heating for the hardening operation, by packing the tool in carburizing compound instead of inert material. A low activity carburizer such as wood charcoal is recommended to avoid the possibility of excessively deep or extremely high-carbon cases, which can produce "austenitic soft skin."

Avoid using cyanide cases due to brittleness.

General Instructions (continued)

- **Tempering** Ameralloy-7 is normally tempered 1½ to 2 hours per inch of greatest thickness. Tempering temperature varies according to intended use. For cold-work and similar applications, a temperature of 400°F is recommended. For hot-work applications, temper at 900°–1000°F. Never temper at less than 400°F.

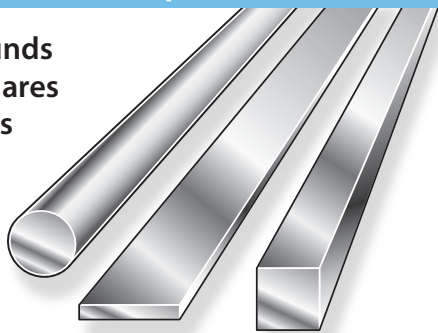
When interrupted oil-quench (to 1000°F) or full oil-quench (150°F) has been utilized in hardening, always temper immediately. After cooling down to room temperature, temper again to insure complete transformation.

Rockwell hardness for specimens 1" round by 3" long, air hardened from 1725°F and tempered at various temperatures for 2 hours.

Tempering Temperature (°F)	Rockwell C
As quenched	60
300°	59
400°	58
500°	56
600°	55
700°	54
800°	53
900°	52
1000°	51
1100°	47
1200°	38
1300°	31

Available Shapes And Sizes

Rounds
Squares
Flats



ROUNDS: Standard lengths 8'–10' R/L. **FLATS & SQUARES:** Standard lengths 8'–12' R/L. Specify O.D. and I.D. Ameralloy-7 Modified and special sizes available upon request. Prompt forging service available.

Rounds Hot Rolled Annealed & Pre-Machined

1/2	1-1/2	2-1/2	3-3/4	7
5/8	1-5/8	2-5/8	4	7-1/2
3/4	1-3/4	2-3/4	4-1/4	8
7/8	1-7/8	2-7/8	4-1/2	9
1	2	3	5	10
1-1/8	2-1/8	3-1/4	5-1/2	11
1-1/4	2-1/4	3-1/2	6	12
1-3/8	2-3/8	3-5/8	6-1/2	

Flats & Squares Decarb-Free Plus .015/.035

1/2	5/8	3/4	7/8	1
x 1/2	x 5/8	x 3/4	x 7/8	x 1
x 1	x 3/4	x 1	x 1	x 1-1/2
x 1-1/2	x 1	x 1-1/2	x 1-1/2	x 2
x 2	x 1-1/2	x 2	x 2	x 2-1/2
x 2-1/2	x 2	x 2-1/2	x 2-1/2	x 3
x 3	x 2-1/2	x 3	x 3	x 3-1/2
x 3-1/2	x 3	x 3-1/2	x 3-1/2	x 4
x 4	x 3-1/2	x 4	x 4	x 5
x 5	x 4	x 5	x 5	x 6
x 6	x 5	x 6	x 6	x 8
x 8	x 6	x 8	x 8	x 10
x 10	x 8	x 10	x 10	x 12
x 12	x 10	x 12	x 12	
	x 12			

1-1/4	1-1/2	1-3/4	2	2-1/2
x 1-1/4	x 1-1/2	x 1-3/4	x 2	x 2-1/2
x 1-1/2	x 2	x 2	x 2-1/2	x 3
x 2	x 2-1/2	x 2-1/2	x 3	x 3-1/2
x 3	x 3	x 3	x 3-1/2	x 4
x 4	x 3-1/2	x 4	x 4	x 4-1/2
x 5	x 4	x 5	x 5	x 5
x 6	x 5	x 6	x 6	x 6
x 8	x 6	x 8	x 8	x 8
x 10	x 8	x 10	x 10	x 10
x 12	x 10	x 12	x 12	x 12
	x 12			

3	3-1/2	4	5	6
x 3	x 3-1/2	x 4	x 5	x 6
x 3-1/2	x 4	x 5	x 6	x 8
x 4	x 5	x 6	x 7	x 10
x 4-1/2	x 6	x 8	x 8	x 12
x 5	x 8	x 10	x 10	
x 6	x 10	x 12	x 12	
x 8	x 12			
x 10				
x 12				

Ameralloy-13[®]

HOT WORK DIE STEEL
VACUUM DEGASSED

AISI H-13



Color code:
MAROON-13

Ameralloy-13 is a chromium-molybdenum-vanadium hot work steel with high vanadium content which increases its wash resistance. In addition, the alloy content minimizes heat checking at high operating temperatures.

Ameralloy-13 is best used for long run zinc and magnesium die casting dies; also in

forging, heading, and extruding applications where toughness, impact, strength and hot work steel qualities are essential.

Ameralloy-13 requires a relatively simple heat treatment and can be quenched in air with a minimum of distortion. It may also be quenched in oil with satisfactory results.

Typical Analysis

- Carbon .40
- Manganese .40
- Chromium 5.25
- Silicon 1.10
- Molybdenum 1.50
- Vanadium 1.10

Features And Advantages

- High resistance to heat checking
- Good red hardness
- Good shock resistance
- Good machinability
- Good dimensional stability
- Excellent hardenability

Heat Treatment

- **Forging** 2050°–2150°F, stop at 1650°F and cool slowly
- **Annealing** 1600°F, then furnace-cool. Brinell 207 max.
- **Preheating** 1350°F, soak before heating for hardening
- **Hardening** 1850°F, air-quench
- **Tempering** 1050°–1150°F, avg. Rockwell C 38/46, die casting dies should be hardened to Rockwell C 44/48

Applications

Die Casting

(aluminum, long run zinc, magnesium)

- Cylinder liners
- Die casting nozzles (aluminum)
- Cams (die casting machines)
- Plunger and tip
- Dies
- Cores
- Ejector pins
- Sleeves

Forging And Heading

(steel, brass, and aluminum)

- Cold heading dies, hot press dies
- Drop forging die inserts
- Forging machine dies and plungers
- Hot heading dies, hot trim dies
- Hot work rolls
- Bolt dies, rivet dies, bull dies, gripper dies, bending dies, swagging dies
- Shear blades, punches, nut piercers

Extrusion

- Extrusion dies
- Extrusion press liners
- Extrusion rams
- Rolls
- Dummy blocks, backer blocks
- Cylinders

Ameralloy-13

HOT WORK DIE STEEL
VACUUM DEGASSED

AISI H-13

Characteristics

- **Machinability** In the thoroughly annealed condition Ameralloy-13 may be machined without difficulty. Where a 1% carbon steel is rated at 100, Ameralloy-13 has a rating of 75.
- **Dimensional stability** When air-quenched from proper hardening temperature, Ameralloy-13 generally expands .001 in./in. of cross section.
- **Critical points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1600° to 1665°F
Cooling – Ar range 1460° to 1350°F

- **Surface Chemistry** This grade does not decarburize as readily as other types of tool steels having higher carbon content. However, care must be taken to maintain surface chemistry during heat treatment, since either carburization or decarburization are possible and would affect the steel's resistance to heat checking.

When heat treating Ameralloy-13, maintain as near a neutral atmosphere as possible, preferably by vacuum heat treating or by wrapping the piece in stainless steel foil. If this is not possible, working surfaces should be ground after heat treatment.

General Instructions

- **Forging** Large pieces of Ameralloy-13 should be preheated slowly to 1300°–1500°F, and thoroughly soaked before heating rapidly to the forging temperature of 2050°–2150°F. The steel should be thoroughly heated before beginning the forging operation. Do not forge below 1650°F, but reheat as many times as necessary. After forging is completed, the steel should be slowly cooled by burying in a heat-insulating material such as dry ashes, lime, or vermiculite.
- **Annealing** Ameralloy-13 may be annealed by heating to 1600°F. Soak 1 hour per inch of greatest thickness, and furnace cool at 30°F per hour to 900°F. Then air cool. Proper annealing procedure includes packing in a steel container using a neutral inert material. Maximum Brinell hardness of 207.
- **Hardening** In a controlled atmosphere, preheat thoroughly to 1300°–1400°F. Then heat to 1850°F and hold for 1 hour per inch of greatest cross section. Quench in still air and temper immediately.

When maximum hardness is the primary requirement, Ameralloy-13 may be oil-quenched. But keep in mind that when oil-quenched this grade is as vulnerable to cracking as and has the same distortional characteristics as an oil hardening tool steel.

Ameralloy-tested Rockwell hardness and fracture grain ratings for specimens 1" round by 3" long, preheated to 1350°F. Various quenching methods and temperatures listed.

Quenching Temperature (°F)	Fracture Grain Size	Rockwell C
1750°	8½	46
1800°	8¾	52
1850°	9	54
1900°	9	54
1950°	9	55
2000°	8½	56

- **Tempering** For hot work applications, Ameralloy-13 is used in the hardness range of HRC 38–48. The usual hardness range for die casting dies is HRC 44–48, requiring a temper at approximately 1100°F. For improved shock resistance, the steel is often tempered at temperatures approaching 1150°F, resulting in a hardness range of HRC 40–44. The steel should be held at tempering temperature for at least 2 hours per inch of greatest cross section. All hot work steel should be tempered at a minimum of 50°F above the expected maximum operating temperature of the tool or die. Double tempering, with the second temper 25°–50°F lower than the first temper, is always advisable, particularly where heat checking is a problem.

Resulting Rockwell hardness for various tempering temperatures. Obtained from 1" round quenched from 1850°F and tempered for 2 hours.

Tempering Temperature (°F)	Rockwell C
400°	54
500°	53
600°	53
700°	53
800°	53
900°	54
1000°	52
1100°	46
1200°	36

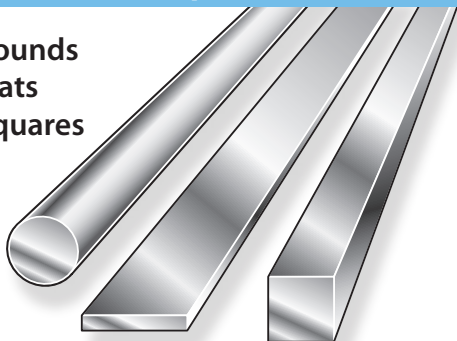
Above results on 1" diameter specimens may be used as a guide in tempering tools to desired hardness. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

Ameralloy-13

HOT WORK DIE STEEL AISI H-13
VACUUM DEGASSED

Available Shapes And Sizes

Rounds
Flats
Squares



ROUNDS: Standard lengths 8'-10' R/L. **FLATS & SQUARES:** Standard lengths 8'-12' R/L. Specify O.D. and I.D. Modified and special sizes available upon request. Prompt forging service available.

Flats Pre-machined / Annealed

3/4	x 3	3-1/4	x 18	x 30
x 1-1/4	x 3-1/2	x 3-1/2	x 20	x 36
1	2-1/2	3-1/2	5-1/2	10-1/4
x 4	x 2-3/4	x 6	x 20	x 24
x 6	x 3	x 10	6	11
x 8	x 4	x 12	x 12	x 25
x 16	x 5	x 14	x 14	x 28
1-1/2	x 6	x 16	x 16	11-1/2
x 2	x 8	4	x 18	x 26-1/2
x 3	x 10	x 5	x 20	12
x 4	x 12	x 8	x 25	x 25
x 5	x 14	x 10	x 28	x 36
x 6	x 18	x 12	7	x 40
x 8	2-3/4	x 14	x 18	13
x 12	x 3	x 16	x 25	x 28
x 14	x 4	x 18	8	14
2	3	x 20	x 16	x 28
x 3	x 3-1/2	x 25	x 20	x 28-1/2
x 4	x 4	4-1/2	x 25	14-7/8
x 5	x 6	x 14	x 28	x 19
x 6	x 7	x 16	x 30	15
x 8	x 8	x 18	9	x 28
x 10	x 10	x 24	x 12	x 30
x 12	x 12	5	x 25	16
x 16	x 14	x 10	x 36	x 24
2-1/4	x 16	x 12	10	
x 2-1/2	x 18	x 14	x 20	
x 2-3/4	x 20	x 16	x 25	

Rounds Hot Roll/Annealed/Decarb Free/Oversize

1/2	2	4	7	11
5/8	2-1/8	4-1/8	7-1/2	11-5/8
3/4	2-3/16	4-1/4	7-3/4	12
7/8	2-1/4	4-1/2	8	12-1/2
1	2-3/8	4-3/4	8-1/2	13
1-1/8	2-1/2	5	8-3/4	13-1/2
1-1/4	2-5/8	5-1/4	9	14-18
1-3/8	2-3/4	5-1/2	9-1/4	20
1-7/16	3	5-3/4	9-1/2	22
1-1/2	3-1/8	6	9-3/4	
1-5/8	3-1/4	6-1/4	10	
1-3/4	3-1/2	6-1/2	10-7/16	
1-7/8	3-3/4	6-3/4	10-1/2	

Centerless Ground Rounds Annealed

.250	1.506	2.1935	3-1/4	4-1/2
.3125	1.5685	2-1/4	3-1/2	4-3/4
.820	1.631	2-1/2	3.506	5
.881	1.756	2.506	3.990	5-1/2
1.006	1.881	2.756	4	5-3/4
1.256	2.010	3	4.006	6
1.3185	2.131	3.006	4-5/16	7.795

Squares Annealed

2-1/4	3	6
2-1/2	3-1/4	8
2-3/4	4	10
	5	

Billets

6	12
8	14
10	16

Ameralloy[®]-20

CHROME-MOLY STEEL

AISI P-20



Color code:
TAN WITH
ORANGE STRIPE



Ameralloy-20 is a chrome-moly tool steel made specifically to fill the requirements for machined cavities and forces used in zinc die casting and plastic molding. Ameralloy-20 is delivered fully quenched and tempered to approximately Brinell 300. Other hardness levels may be obtained through additional heat treatment.

Typical Analysis

- Carbon .35
- Manganese .80
- Chromium 1.70
- Silicon .50
- Molybdenum .45

Features And Advantages

- Usually eliminates heat treating by customer
- Mold quantity – electric furnace melted, vacuum degassed and ultrasonically inspected
- Good machinability
- Available in a wide range of sizes
- Deep hardening
- Uniform mechanical properties

Applications

- Cavities and cores of zinc die casting dies
- Plastic molding dies
- Compression and transfer molds

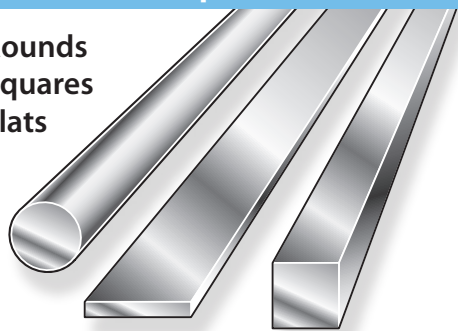
Heat Treatment

For most zinc die casting and plastic molding operations, no further heat treatment is required. However, if the material is committed to reforging, if higher hardness is required, or if stress relieving is necessary after heavy machining, the following cycles are suggested:

- **Stress relieving** 1000°F, air cool
- **Forging** Heat to 2000°F, stop at 1700°F and cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1450°–1500°F, furnace cool. Brinell 207 max.
- **Hardening** 1550°F, oil-quench to 150°F.
- **Tempering** Temper at 300°–400°F for Rockwell C-54/55
- **Nitriding** 1000°–1025°F for 25 hours produces 0.025" case depth
- **Carburizing** 1700°F for 8 hours produces approximately 0.05" case depth

Available Shapes And Sizes

Rounds
Squares
Flats



ROUNDS: Standard lengths 8'–10' R/L. **FLATS & SQUARES:** Standard lengths 8'–12' R/L. Specify O.D. and I.D. Modified and special sizes available upon request. Prompt forging service available.

Rounds

3/4
1
1-1/4
1-1/2
1-3/4
2
2-1/8
2-1/4
2-1/2
2-3/4
3
3-1/4

3-1/2
4
4-1/4
4-1/2
5
5-1/2
6
6-1/2
7
7-1/2
8
8-1/2

9
10
11
12
14
14-1/2
16
18
20
24

Squares

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

Centerless ground rounds, heat treated & rough turned.

Flats Machine Oversize / Allowance to finish

1	x 16	x 12	x 10	x 14	x 34	x 20	x 40
x 2-1/4	x 18	x 14	x 12	x 16	x 36	x 25	x 48
x 6	x 20	x 16	x 14	x 18	x 38	x 26	x 60
x 8	x 36	x 25	x 16	x 20	x 40	x 30	17
x 12	2-1/4	x 27-1/2	x 18	x 22	x 45	x 32	x 48
x 18	x 12	4	x 20	x 25	10	x 34	18
x 36	x 14	x 6	x 22	x 26	x 12	x 36	x 23
1-1/4	2-1/2	x 7	x 25	x 28	x 14	x 38	x 24
x 10	x 6	x 8	x 28	x 30	x 20	x 40	x 40
x 12	x 8	x 10	x 36	x 36	x 22	x 48	x 48
x 16	x 10	x 12	5-1/2	x 40	x 23	x 60	x 60
1-1/2	x 12	x 14	x 16	8	x 25	14	20
x 3	x 14	x 16	x 40	x 10	x 26	x 23	x 22
x 6	x 16	x 18	6	x 12	x 28	x 25	x 24
x 7	x 20	x 20	x 9	x 16	x 30	x 30	x 34
x 8	x 36	x 24	x 12	x 18	x 32	x 32	x 40
x 10	3	x 25	x 14	x 20	x 36	x 34	x 48
x 12	x 5	x 27-1/2	x 16	x 22	x 38	x 36	x 60
x 14	x 6	4-1/4	x 18	x 25	x 40	x 38	22
x 16	x 6-1/2	x 5-1/4	x 20	x 28	x 48	x 40	x 24
x 18	x 8	4-1/2	x 22	x 30	x 60	x 48	x 48
x 20	x 10	x 8	x 25	x 32	11	x 60	23
x 36	x 12	x 10	x 26	x 34	x 25	15	x 48
2	x 14	x 12	x 28	x 36	x 30	x 23	24
x 4	x 16	x 14	x 30	x 40	x 32	x 25	x 48
x 6	x 18	x 16	x 32	9	x 34	x 30	
x 7	x 20	x 18	x 34	x 20	x 36	x 40	
x 8	x 25	x 28	x 36	x 22	x 40	x 48	
x 10	x 27-1/2	5	x 40	x 25	x 48	x 60	
x 12	3-1/2	x 6	7	x 26	x 60	16	
x 14	x 10	x 8	x 12	x 30	12	x 20	

Amera-Mold™

PRE-HARDENED STEEL



Color code:
LIGHT TAN



Amera-Mold is engineered expressly for the plastics molding industry. Amera-Mold is a pre-hardened alloy steel delivered at Rockwell C 28–32 (special hardness upon request). As a result of its fine grain structure (95% of 8), close chemistry, and quality control, Amera-Mold assures our customers of excellent machinability and high lustrous finish unequalled in the industry.

Typical Analysis

- Carbon .50
- Manganese 1.00
- Chromium 1.05
- Silicon .32
- Molybdenum .20
- Nickel .61
- Vanadium .28

Features And Advantages

- Usually eliminates the cost of heat treating by the customer
- Excellent machinability
- High lustrous (mirror-like) finish
- Deep hardening
- Good compressive strength
- Retains high strength at operating temperatures as high as 900°F

Applications

- Injection or compression molding of plastics requiring high sheen on the finished product
- Plastic film extrusion dies
- Zinc casting dies

Heat Treatment

For most plastic molding operations, no further heat treatment is required. However, if the material is committed to reforging, if higher hardness is required, or if stress relieving is necessary after heavy machining, the following cycles are suggested:

- **Stress relieving** Approximately 1000°F
- **Forging** Heat to 2100°F, stop at 1800°F and cool slowly
- **Normalizing** 1600°F, air cool
- **Annealing** 1525°F, cool 20° per hour to 1195°F, air cool, Brinell 207 max.
- **Hardening** 1525°F, oil-quench
- **Tempering** Temper at 1150°F (depending on size and desired properties)
- **Nitriding** 1000°–1025°F for 25 hours produces 0.025" case depth
- **Carburizing** 1700°–1750°F for Rockwell C 63–64 surface hardness

General Instructions

Amera-Mold is delivered fully quenched and tempered to a hardness range of Brinell 285 to 321. For most operations, no further heat treatment is required. Where heat treatment is required, refer to the following procedures.

- **Stress relieving** Stress produced by cold work operations such as hobbing, straightening, deep stamping, grinding, and heavy machining continue to add distortion during heat treatment and should be removed prior to hardening. Heat to 1000°–1100°F, holding until all parts are heated uniformly, and cooling to room temperature. If the stresses are produced after machining in the heat-treated condition, the maximum stress-relieving temperature is 100°F below the tempering temperature.
- **Forging** Heat Amera-Mold to approximately 2100°F, and hold until the piece is thoroughly heated before forging. Stop forging at 1800°F and reheat if necessary. After forging, the piece should be buried in an inert, heat-insulating material and slow cooled. Then normalize and anneal.

- **Normalizing** Heat to approximately 1600°F and hold at temperature 1 hour per inch of greatest thickness. The piece should then be cooled to room temperature in still air.

- **Annealing** Heat the piece in a protective atmosphere to 1525°F and soak 1 hour per inch of greatest thickness. Maintain atmosphere control and cool at a rate of 20°F per hour to 1195°F and then air cool. This procedure should produce a hardness of Brinell 212 maximum.

- **Hardening** Heat to a temperature of 1525°F and hold for 1 hour per inch of greatest thickness. Quench in oil to 150°F and temper immediately.

- **Tempering** Temperature will vary with the size of the piece and the application. Use the chart below to achieve desired tempering properties.

Results of tests performed on 1" round specimen. For larger sections, the mechanical properties may be somewhat lower. It may be necessary to adjust the tempering temperature to obtain the same properties as those shown:

Tempering Temperature (°F)	Yield Point (psi)	Tensile Strength (psi)	Elongation (%)	Reduction (%)	Hardness (Brinell)
400°	247,500	301,500	10.25	33.95	578
500°	249,500	283,250	10.0	37.25	555
600°	240,500	268,500	10.5	40.65	534
700°	224,250	243,000	10.25	39.6	495
800°	212,000	223,500	9.5	38.8	444
900°	201,000	214,000	11.0	44.0	429
1000°	184,500	198,000	11.5	40.1	401
1050°	170,000	182,000	14.0	48.3	375
1100°	162,000	157,000	14.5	49.5	363
1150°	160,000	174,000	15.0	49.5	363
1200°	147,000	158,000	17.0	56.2	331
1250°	130,000	142,500	18.5	58.6	292
1300°	117,000	128,000	20.0	59.1	262

Rounds				Squares		Flats					
1/4	2-5/8	5-1/4	10-1/2	1/2	4-1/2	3/4	x 12	x 12	x 5	x 18	x 20
3/8	2-3/4	5-1/2	11	5/8	5	x 1	1-1/4	1-3/4	x 6	3-1/2	5
1/2	2-7/8	5-3/4	11-1/2	3/4	5-1/2	x 1-1/2	x 4	x 6	x 7	x 4	x 10
5/8	3	6	12	1	6	x 2	x 5	2	x 8	x 5	x 12
3/4	3-1/8	6-1/4	12-1/2	1-1/8	8	x 3	x 6	x 3	x 10	x 6	x 14
7/8	3-1/4	6-1/2	13-1/4	1-1/4	9	x 4	x 7	x 4	x 12	x 8	x 18
1	3-3/8	6-3/4	14-1/4	1-3/8	10	x 5	x 8	x 5	x 14	x 10	6
1-1/8	3-1/2	7	15-1/4	1-1/2	11	x 6	x 10	x 6	x 16	x 12	x 10
1-1/4	3-5/8	7-1/4	16-1/4	1-5/8	12	x 8	1-1/2	x 7	x 18	x 14	x 12
1-3/8	3-3/4	7-1/2	17-1/4	1-3/4	14	1	x 2	x 8	3	4	x 16
1-1/2	3-7/8	7-3/4		2	16	x 1-1/2	x 3	x 10	x 4	x 5	x 18
1-5/8	4	8		2-1/4		x 2	x 3-1/2	x 12	x 5	x 6	x 20
1-3/4	4-1/8	8-1/4		2-1/2		x 3	x 4	x 14	x 6	x 8	8
2	4-1/4	8-3/4		2-3/4		x 4	x 5	x 16	x 8	x 10	x 12
2-1/8	4-3/8	9		3		x 5	x 6	x 18	x 10	x 12	x 14
2-1/4	4-1/2	9-1/4		3-1/4		x 6	x 7	2-1/2	x 12	x 14	x 16
2-3/8	4-3/4	9-1/2		3-1/2		x 8	x 8	x 3	x 14	x 16	x 20
2-1/2	5	10		4		x 10	x 10	x 4	x 16	x 18	

Amera-Mold sizes available for immediate shipment. Hot rolled, cold drawn, and decarb-free.

Ameralloy-6[®]

OIL HARDENING STEEL **AISI L-6**



Color Code:
RED & ORANGE



Ameralloy-6 is in the general class of oil hardening alloy tool steels. Due to its lower carbon content, it has slightly better shock resistance than more highly alloyed types, and should be used in applications where some wear resistance may be sacrificed for increased toughness.

Typical Analysis

- Carbon .75
- Manganese .75
- Chromium .90
- Nickel 1.75
- Molybdenum .35

Features And Advantages

- Oil hardening
- Low distortion in heat-treatment
- Good toughness at lower hardness levels
- Good wear resistance at high hardness levels

Heat Treatment

- **Forging** 2100°–2175°F, stop at 1700°F, cool slowly
- **Normalizing** Do not normalize
- **Annealing** 1400°F, furnace-cool. Brinell 217 max.
- **Hardening** 1500°–1550°F, oil-quench
- **Tempering** 400°F, average hardness after heat treatment Rockwell C 60–61

Applications

- Forming rolls
- Punches
- Blanking dies
- Forming dies
- Clutch parts
- Pawls
- Knuckle pins
- Clutch pins
- Shear blades
- Spindles

General Instructions

- **Forging** Heat Ameralloy-6 slowly and uniformly to 2100°–2175°F, and do not forge below 1700°F. If a preheater is available, hold at 1200°F until uniformly heated before increasing temperature to the forging heat. Because of its air-hardening properties, for slow cooling bury in dry lime, silocel, or other insulating medium immediately after forging.
- **Annealing** Heat to 1400°F and hold 1 hour per inch of greatest thickness. Cool at 20°F per hour to 900°F then air-cool. A maximum hardness of Brinell 217 will be obtained following this treatment. Because of its air-hardening ability, Ameralloy-6 should not be normalized.

- **Hardening** Ameralloy-6 should be preheated at 1200°F, soaked, then raised to a hardening temperature of 1500°–1550°F and held for 1 hour per inch of greatest thickness. Oil-quench to 150°F and temper immediately. Tools made of Ameralloy-6 in sections less than 1" thickness may be air-quenched from 1500°F, providing safer hardening of intricate sections. Air-quenching also results in less distortion.

Ameralloy-tested hardness and fracture grain ratings for air-blast and oil-quenching temperatures. Specimen size 1" round x 5":

Quenching Temperature (°F)	AIR-BLAST		OIL-QUENCH	
	Fracture Grain Size	Rockwell C	Fracture Grain Size	Rockwell C
1400°	9¾	61	9¾	63
1450°	9¾	63	9¾	64
1500°	9½	63	9¾	64.5
1525°	9½	63	9¾	64.5
1550°	8¾	63	9¼	64
1600°	8½	63	8½	63
1650°	8¼	63	7½	63
1700°	8	62.5	7¼	62
1750°	8	62.5	7¼	61.5
1800°	7	62	7	61

- **Tempering** Temper Ameralloy-6 at 400°. Some hardness may be sacrificed in favor of increased toughness by using higher tempering temperatures.

Unlike many die steels, Ameralloy-6 does not become brittle when tempered in the range of 450°–800°F. Hold a minimum of 1 hour per inch of greatest thickness when tempering at 400°F. To minimize the possibility of cracking, temper immediately after hardening by heating slowly to the desired tempering temperature.

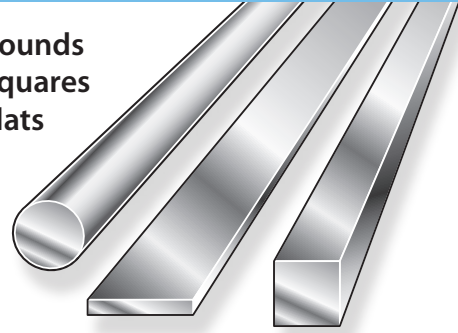
Resulting Rockwell hardness for tempering air-blast and oil-quenched specimens 7/8" round x 2-1/2" long at various temperatures:

Tempering Temperature (°F)	AIR-BLAST	OIL-QUENCH
	1500°F Rockwell C	1525°F Rockwell C
No draw	63	65
300°	59.5	62
400°	57.5	61
500°	56.5	58
600°	55	56
700°	51	53
800°	49	50
900°	47.5	48
1000°	43.5	46

Above results on 7/8" diameter specimens may be used as a guide in tempering tools to desired hardness. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

Available Shapes And Sizes

**Rounds
Squares
Flats**



Standard lengths 10'–12' R/L lengths. Larger rounds available upon request.

Rounds Hot Rolled Annealed

1/4	5/8	1	1-1/2	2-1/4
5/16	11/16	1-1/16	1-5/8	2-3/8
3/8	3/4	1-1/8	1-3/4	2-1/2
7/16	13/16	1-1/4	1-7/8	2-5/8
1/2	7/8	1-5/16	2	2-3/4
9/16	15/16	1-3/8	2-1/8	2-7/8

Rough Turned Rounds 5" And Over

3	3-3/4	5	6-1/4	7-1/2
3-1/8	4	5-1/4	6-1/2	
3-1/4	4-1/4	5-1/2	6-3/4	
3-3/8	4-1/2	5-3/4	7	
3-1/2	4-3/4	6	7-1/4	

Squares

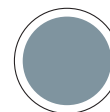
1/2	3/4	1-1/4	1-3/4	2-1/4
5/8	1	1-1/2	2	2-1/2

Flats Hot Rolled Annealed

1/4	x 2	x 2-1/2	x 3	x 8
x 1-1/4	x 2-1/2	x 3	x 3-1/2	x 10
x 2-1/4	x 3	x 3-1/2	x 4	2-1/4
3/8	x 4	x 4	x 5	x 4
x 1	x 5	x 4-1/2	x 6	x 6
x 1-1/4	3/4	x 5	x 8	2-1/2
x 1-1/2	x 1	x 6	x 10	x 3
x 2	x 1-1/4	x 8	1-3/4	x 3-1/2
x 3	x 1-1/2	1-1/4	x 2	x 4
x 4	x 1-3/4	x 1-1/2	x 2-1/2	x 4-1/2
1/2	x 2	x 1-3/4	x 3	x 5
x 1	x 2-1/2	x 2	x 3-1/2	x 6
x 1-1/4	x 3	x 2-1/2	x 4	3
x 1-1/2	x 3-1/2	x 3	x 4-1/2	x 4
x 1-3/4	x 4	x 4	x 5	x 5
x 2	x 5	x 5	2	x 6
x 3	x 6	x 6	x 2-1/2	3-1/2
x 4	x 8	x 8	x 3	x 4
x 6	1	x 10	x 3-1/2	4
5/8	x 1-1/4	1-1/2	x 4	x 5
x 1	x 1-1/2	x 1-3/4	x 4-1/2	x 6
x 1-1/4	x 1-3/4	x 2	x 5	
x 1-1/2	x 2	x 2-1/2	x 6	

Ameralloy[®]-FH

FLAME HARDENING DIE STEELS



Color code:
GRAY

Ameralloy-FH was specially developed to withstand severe wear and resist galling. The application of Ameralloy-FH will result in a more uniform section after hardening, without shrinking. Ameralloy-FH can be hardened by quenching and tempering, flame hardening, or carburizing.

Ameralloy-FH was engineered to produce a perfect hand tool with inexperienced help, or where there is a lack of adequate heat-treating facilities. Ameralloy-FH can be reworked at the forge without cracking or changing physical properties.

Typical Analysis

- Carbon .30
- Manganese .75
- Chromium 1.10
- Silicon .45
- Molybdenum .35
- Copper .50

Features And Advantages

- Minimum decarburization
- Safe—will not mushroom or chip
- Wider range of hardness
- Shock resistant
- Extremely tough
- No tempering required

Heat Treatment

- **Forging** 1900°–2150°F, stop at 1700°F
- **Annealing** 1400°F, slow furnace cool, Brinell 197
- **Hardening** 1500°–1850°F, water or oil-quench
- **Tempering** 300°–1300°F, Brinell 534–241

General Instructions

- **Annealing** If machining is to follow forging, anneal by heating to 1400°F (cherry-red), cool to 900°F, then air cool.
- **Hardening** Allow tool to cool after forging. Reheat to 1550°–1850°F (salmon-to-orange range) and quench in water.
- **Toughen striking end** In the as-forged condition, the striking end should be tapered and heated to 1325°F (cherry-red), and quenched in water. This insures elimination of mushrooming.
- **Forging** Forge at 1800°–2000°F. Discontinue operation when temperature falls below 1800°F and reheat again. After forging, the piece should be air cooled. Ameralloy-FH will have the following physical properties:
 - Yield point: 96,000 lbs. psi
 - Tensile strength: 152,000 lbs. psi
 - Elongation in 2": 18%
 - Reduction of area: 46%
 - Brinell hardness: 320

Rounds			Squares		Hexagons		Flats				
1/2	2	4-1/4	1/2	2-1/4	3/8	1-3/4	3/4	x 2	x 6	x 7	x 7
5/8	2-1/8	4-1/2	5/8	2-1/2	1/2	1-7/8	x 1	x 3	x 7	x 8	x 8
3/4	2-1/4	4-3/4	3/4	2-3/4	5/8	2	x 1-1/2	x 4	x 8	x 10	x 10
7/8	2-3/8	5	7/8	3	3/4	2-1/8	x 2	x 5	x 10	x 12	x 12
1	2-1/2	5-1/2	1	3-1/2	7/8	2-1/4	x 3	x 6	1-1/2	1-3/4	x 14
1-1/8	2-3/4	6	1-1/8	4	1	2-3/8	x 4	x 8	x 2	x 6	x 16
1-1/4	3	6-1/2	1-1/4		1-1/8	2-1/2	x 5	x 10	x 3	2	x 18
1-3/8	3-1/4	7	1-3/8		1-1/4	2-3/4	x 6	x 12	x 3-1/2	x 3	2-1/2
1-1/2	3-1/2	7-1/2	1-1/2		1-3/8	3	x 8	1-1/4	x 4	x 4	x 3
1-5/8	3-3/4	8	1-3/4		1-1/2		1	x 4	x 5	x 5	x 4
1-3/4	4		2		1-5/8		x 1-1/2	x 5	x 6	x 6	x 5

Ameralloy-FH sizes for immediate shipment. Lengths: 18-20'. Custom sizes by request.

Ameralloy[®] HIGH SPEED-2

HIGH CARBON STEEL

AISI M-2



Color code:
ORANGE WITH
BLACK STRIPE



Ameralloy High Speed-2 is the most widely used type of high-speed steel. It is generally used for the same applications as T-1 high speed. Ameralloy High Speed-2 has higher carbon content and balanced analysis producing properties applicable to all general-purpose high speed uses.

Typical Analysis

- Carbon .86
- Chromium 4.15
- Tungsten 6.35
- Molybdenum 5.00
- Vanadium 1.90

Applications

- Lathe tools
- Planer tools
- Drills
- Taps
- Reamers
- Broachers
- Milling cutters
- Form cutters
- Wood knives
- Gear cutters
- End mills

Features And Advantages

- Balanced abrasion and shock resistance
- Good red-hardness
- Weighs 6% less than T-1 high speed
- Can be hardened at 100° below T-1 high speed

Heat Treatment

- **Forging** 2050°–2100°F, stop at 1800°F and cool slowly
- **Annealing** 1600°F, cool slowly. Brinell 241 max.
- **Preheating** 1550°F, soak before hardening
- **Hardening** 2250° to 2275°F, oil-quench
- **Tempering** 1000°–1050°F, Rockwell C 65-66

Characteristics

- **Machinability** Like all highly alloyed steels, High Speed-2 machines with somewhat more difficulty than the lower alloyed steels. It is rated at 65 as compared to a 1% carbon tool steel, which is rated at 100.
- **Critical points** Critical points obtained by dilatometer tests when heating at a rate of 400° per hour and cooling at 30° per hour are as follows:

Heating – Ac range 1530° to 1610°F

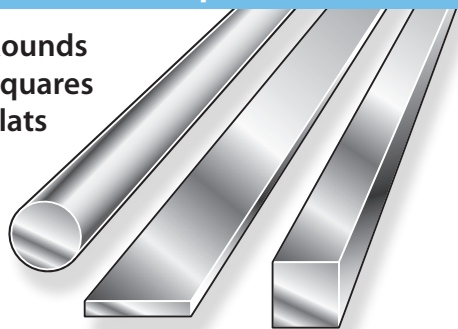
Cooling – Ar range 1430° to 1380°F

Ameralloy[®] High Speed-2

HIGH CARBON STEEL AISI M-2

Available Shapes And Sizes

Rounds
Squares
Flats



Standard lengths 10'–12' or cut to specified length.
Modified and special sizes available upon request.
Prompt forging service available.

Rounds Decarb Free

1/16	5/8	1.515	2-17/64	3-11/16
5/64	21/32	1-9/16	2-5/16	3-3/4
3/32	11/16	1-19/32	2-3/8	3-13/16
7/64	3/4	1.610	2-7/16	3-7/8
1/8	5/32	1-5/8	2-1/2	3-15/16
9/64	13/16	1.650	2-17/32	4
5/32	7/8	1-11/16	2.515	4-1/32
11/64	15/16	1.700	2-9/16	4-1/16
3/16	31/32	1-3/4	2.610	4-1/8
13/64	1	1.765	2-5/8	4-1/4
7/32	1.015	1-49/64	2-11/16	4-3/8
15/64	1.055	1-25/32	2-3/4	4-1/2
1/4	1-1/16	1-13/16	2-13/16	4-5/8
17/64	1-1/8	1.860	2-7/8	4-3/4
9/32	1.160	1-7/8	2-15/16	4-25/32
5/16	1-3/16	1.890	3	4-7/8
21/64	1.192	1-15/16	3.015	5
11/32	1-7/32	1-31/32	3-1/16	5-1/4
3/8	1-1/4	2	3-1/8	5-1/2
25/64	1.275	2.015	3-1/4	5-3/4
13/32	1-5/16	2-1/64	3-5/16	6
7/16	1.360	2-1/32	3-3/8	6-1/4
15/32	1-3/8	2-1/16	3-7/16	6-1/2
1/2	1-7/16	2-1/8	3-1/2	7
17/32	1.450	2-3/16	3-9/16	7-1/2
9/16	1-1/2	2-1/4	3-5/8	8

Flats & Squares Decarb-Free Plus .015/.030

1/4	1/2	5/8	3/4	7/8
x 1/4	x 1/2	x 5/8	x 3/4	x 1-1/2
x 1	x 3/4	x 1-1/4	x 1	x 1-3/4
x 1-1/2	x 1	x 1-1/2	x 1-1/2	x 2
3/8	x 1-1/2	x 2	x 2	x 3
x 3/8	x 2	x 2-1/4	x 2-1/2	x 4
x 1	x 2-1/2		x 3	x 5
x 1-1/4	x 3		x 4	x 6
x 1-1/2	x 4		x 5	x 8
x 2	x 6		x 6	x 10
x 3	x 8		x 8	x 12
	x 10		x 10	
	x 12		x 12	
1	1-1/4	1-1/2	1-3/4	2
x 1	x 1-1/4	x 1-1/2	x 1-3/4	x 2
x 1-1/4	x 1-1/2	x 2	x 2	x 2-1/2
x 1-1/2	x 2	x 2-1/2	x 2-1/2	x 3
x 2	x 2-1/2	x 3	x 3	x 3-1/2
x 2-1/2	x 3	x 4	x 4	x 4
x 3	x 4	x 6	x 5	x 5
x 4	x 5	x 8	x 6	x 6
x 5	x 6	x 10	x 8	x 8
x 6	x 8	x 12	x 10	x 10
x 8	x 10		x 12	x 12
x 10	x 12			
x 12				
2-1/2	3			
x 2-12	x 3			
x 3	x 4			
x 4	x 6			
x 6	x 8			
x 8	x 10			
x 10	x 12			
x 12				

Ameralloy-T[®]

TUNGSTEN BASE STEEL AISI T-1



Ameralloy-T is the best known tungsten base type of high speed steel. Ameralloy-T is used for general purpose cutting operations.

Typical Analysis

- Carbon .75
- Chromium 4.00
- Tungsten 18.00
- Vanadium 1.10

Features And Advantages

- Balanced combination of abrasion and shock resistance for cutting tools
- High red-hardness
- Least decarburization of the standard high speed steels.

Heat Treatment

- **Forging** 2050°–2150°F, stop at 1800°F
- **Annealing** 1650°F, furnace-cool, Brinell 241 max.
- **Preheating** 1600°F, prior to hardening
- **Hardening** 2350° oil-quench
- **Tempering** 1000°–1050°F, Rockwell C 65

Applications

- Lathe tools
- Planer tools
- Boring mill tools
- Slotter tools
- Shaper tools
- Tool bits
- Flat and twist drills
- Hobs
- Milling cutters
- Chasers
- Taps
- Reamers
- File-cutting chisels
- Gear cutters
- Form cutters
- End mills
- Broaches
- Threaders
- Punches
- Piercers
- Crowning tools

Characteristics

- **Machinability** Like all highly alloyed steels, Ameralloy-T machines with somewhat more difficulty than steels containing lower alloy content. Ameralloy-T has a machinability of 60, as compared with a 1% carbon tool steel rated at 100.
- **Critical points** Critical point ranges obtained by dilatometer test when heating and cooling at a rate of 400°F/hour:

Heating – Ac range 1540° to 1630°F
Cooling – Ar range 1550° to 735°F

- **Decarburization** Ameralloy-T is not as highly susceptible to decarburization as the molybdenum base high speed steels. However, reasonably good heat treating equipment is required, otherwise the tools must be ground to remove decarburization after hardening.

General Instructions

- **Forging** Preheat Ameralloy-T and soak at approximately 1300°F before transferring to the high temperature furnace. Heat slowly to the forging range of 2050°–2150°F. Discontinue forging as soon as the piece has cooled to about 1800°F, and reheat before resuming forging. Pieces should be cooled slowly after the forging operation is completed.
- **Annealing** Ameralloy-T should always be annealed after forging. To prevent decarburization, use a controlled atmosphere furnace or pack in a sealed container using inert material. Heat slowly to 1650°F and hold at this temperature for approximately 1 hour per inch of greatest thickness. Cool at a rate of 25°F per hour to 900°F. Resulting hardness after proper annealing is Brinell 241 max.
- **Hardening** Preheat Ameralloy-T slowly to 1600°F and hold at this temperature until thoroughly soaked. Then heat to the quenching temperature of 2350°F. Tools should be heated to the quenching temperature rapidly and not held

at this temperature any longer than necessary for proper solution of carbides. If held too long, grain growth with accompanying brittleness may result. Total heating time in the furnace or bath varies from a few minutes to 10–15 minutes, depending on the size of the tool. Temper as soon as the tool has reached a quenching temperature of 150° to 200°F.

Ameralloy-tested fracture grain size & Rockwell C hardness of Ameralloy-T specimens 1" round x 5" long, quenched in oil and quenched in still air:

Quenching Temperature (°F)	OIL-QUENCHED		AIR-QUENCHED	
	Fracture Rating	Rockwell C	Fracture Rating	Rockwell C
1900°	8½	59	8½	56
2000°	8¾	61	9	61
2100°	9	63	9¼	63
2200°	9¼	65	9¼	64
2300°	9¼	65	9¼	64
2350°	9½	66	9¼	64
2400°	8¾	66	8¾	64

- **Tempering** The best combination of cutting ability, strength, hardness, shock resistance, and toughness for all types of tools is developed by tempering in the secondary hardness range. For Ameralloy-T that range is approximately 1000°–1050°F. Tools are tempered by heating to 1025°–1050°F, at a minimum holding time of 2 hours per inch of greatest cross section. Then cool to room temperature. It is customary to use a double-tempering operation carried out with a secondary heating at 25°–50°F below the primary tempering temperature. Shock resisting and hot work parts are usually tempered within a range of 1100°–1200°F.

Rockwell C hardness of specimens 1" round x 2-1/2" long, hardened in oil vs. still air at temperatures ranging from 2100°–2400°F. The specimens were then tempered for 2 hours at temperatures ranging from 300°–1400°F:

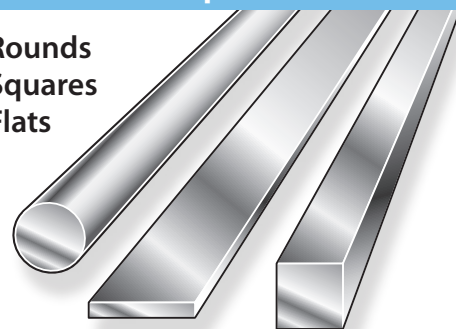
OIL-QUENCH	Quenching Temperature (°F)				
	2100°	2200°	2300°	2350°	2400°
Tempering Temperature (°F)	Rockwell C				
As quenched	63	65	65	66	66
300°	63	65	65	65	65
400°	62	63	64	64	64
500°	60	61	62	62	63
600°	60	61	61	61	62
700°	59	60	61	61	61
800°	59	60	61	61	61
900°	60	61	62	63	63
1000°	61	62	64	65	65
1050°	61	62	64	65	65
1100°	61	62	64	64	64
1200°	53	55	57	57	58
1300°	44	45	47	47	47
1400°	33	36	36	37	37

AIR-QUENCH	Quenching Temperature (°F)				
	2100°	2200°	2300°	2350°	2400°
Tempering Temperature (°F)	Rockwell C				
As quenched	63	64	64	64	64
300°	63	64	64	64	64
400°	62	63	64	64	64
500°	59	60	61	63	63
600°	59	61	61	62	62
700°	59	61	62	62	62
800°	59	61	61	62	62
900°	59	61	62	62	62
1000°	59	62	63	63	63
1050°	59	60	62	63	63
1100°	57	60	61	62	62
1200°	52	55	55	55	56
1300°	43	45	43	43	43
1400°	26	28	31	31	31

Above results on 1" diameter specimens may be used as a guide in tempering tools to desired hardness. Tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

Available Shapes And Sizes

Rounds
Squares
Flats



Standard lengths 10'–12' or cut to specified length.
Modified and special sizes available upon request.
Prompt forging service available.

Rounds Decarb-Free

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

Squares Hot Rolled Finish–Tolerance Standard

1-1/4	1-1/2	2
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Flats Hot Rolled Finish–Tolerance Standard

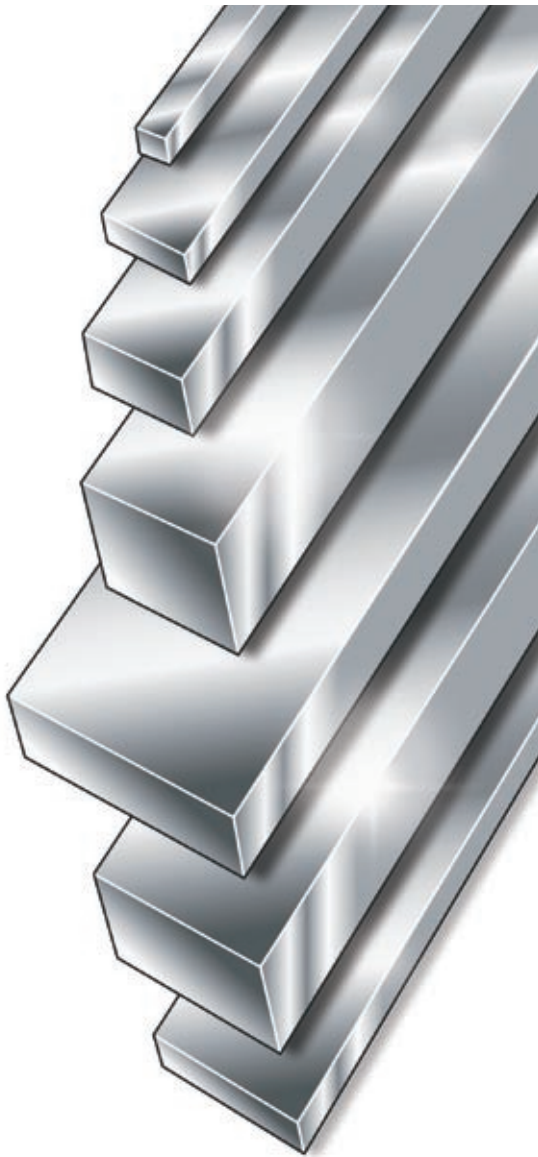
3/8 x 1-1/4	3/4	1-1/2
1/2 x 2-1/2	x 1-1/4	x 2
5/8 x 1-1/4	x 1-1/2	x 2-1/2
11/16 x 1-5/16	1	
	x 1-1/4	
	x 1-1/2	
	x 1-3/4	
	x 2	
	x 3	

Durelloy-PM™

HEAT TREATED ALLOY



Color Code:
ENDS RED



Durelloy pre-machined is a fine grained, stress relieved, electric furnace alloy. It is heat treated to Rockwell C 28–32, Blanchard ground top and bottom $+.020/.030 - .000$, width $+1/8" - .000$.

A machinability rating of 80% means Durelloy-PM is ready for use in most tooling applications with no further heat treating. Durelloy-PM can be flame-hardened to 578/698 BHN for applications in which a higher hardness is required at wear points.

Applications

- Base plates
- Backup plates
- Bolsters
- Fixtures
- Guides
- Holder blocks
- Peenable dies
- Punch pads
- Strippers
- Jigs
- Molds

Available Sizes

- **Thickness** 1/2"–5" custom grinds to 20"
- **Widths** 2"–24" custom grinds to 96"
- **Lengths** 60"–72" custom grinds to 120" and 144"
- **Custom sizes** Available upon request