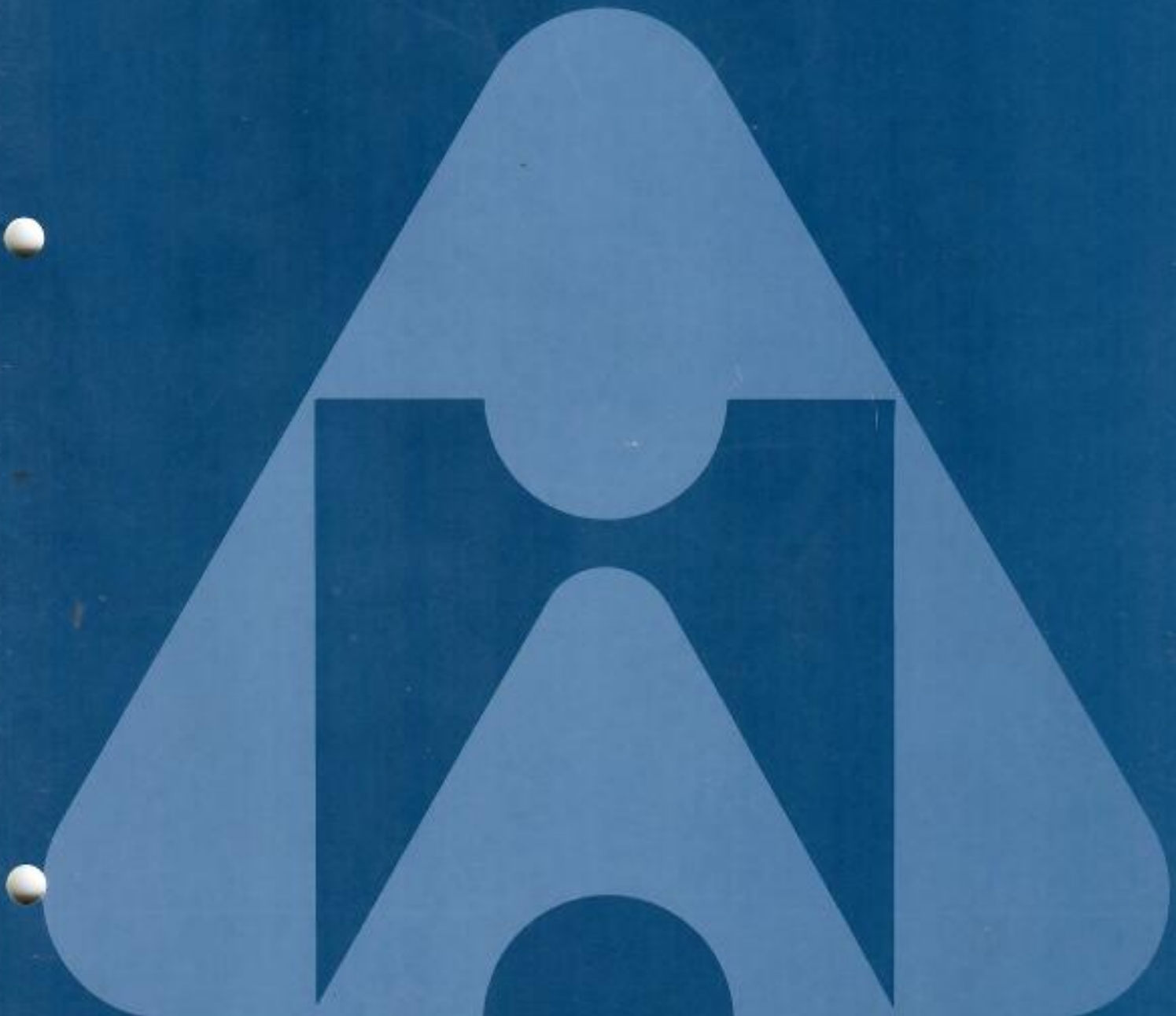
HUNTINGTON ALLOYS

MONEL alloys



CONTENTS

Second Edition, 1972.

MONEL
nickel-copper alloys

Nickel and copper, mutually soluble in all proportions, form a series of alloys used as engineering materials. MONEL nickel-copper alloy 400 was the first of these to be developed.

Also included in this bulletin are MONEL alloys 401 and 404, used for specialized electronic applications; MONEL alloy R-405, a machinable grade of alloy 400; MONEL alloy K-500, an age-hardenable, high-strength nickel-copper alloy; and MONEL alloy 502, a version of alloy K-500 especially developed for good machining characteristics.

All values shown are typical of the performance of the materials but should not be used for specification purposes. Unless stated otherwise, values shown represent tests at room temperature.

MONEL
alloy 400

MONEL nickel-copper alloy 400 is a solid-solution alloy that can be hardened only by cold working. It has high strength and toughness over a wide temperature range and excellent resistance to many corrosive environments. Composition is shown in Table 1.

Alloy 400 is widely used in many fields, especially marine and chemical processing. Typical applications are valves and pumps; pump and propeller shafts; marine fixtures and fasteners; electrical and electronic components; springs; chemical processing equipment; gasoline and fresh water tanks; crude petroleum stills, process vessels and piping; boiler feedwater heaters and other heat exchangers; and deaerating heaters.

Table 1—Limiting Chemical Composition, %, of MONEL Alloy 400

Nickel (plus Cobalt)	63.00-70.00
Carbon	0.30 max.
Manganese	2.00 max.[a]
Iron	2.50 max.
Sulfur	0.024 max.
Silicon	0.50 max.
Copper	Bal.

[a] Strip and sheet are furnished to 1.25% max.

PHYSICAL CONSTANTS AND THERMAL PROPERTIES

The physical constants and thermal properties of MONEL alloy 400 are shown in Tables 2 and 3. The effect of temperature on modulus of elasticity in tension is in Figure 1.

It will be noted in Table 2 that the Curie temperature lies within the ambient range. It is affected by variations in chemical composition. The values shown represent the range which can be expected from normal production; therefore, some heats will be magnetic at room temperature and others not. If there is a strong requirement for nonmagnetic characteristics, other MONEL alloys should be considered.

Table 2—Physical Constants of MONEL Alloy 400 [a]

Density	
gram/cc	8.83
lb/cu in.	0.319
Melting Range, °F	2370-2460
Modulus of Elasticity, 10^6 psi	
Tension	26.0
Compression	26.0
Torsion	9.5
Poisson's Ratio	0.32
Curie Temperature, °F	20-50

[a] These values also apply to MONEL alloy R-405.

Table 3—Thermal Properties of MONEL Alloy 400 *

Temperature, °F	Mean Linear Expansion,[b] in./in./°F × 10^{-6}	Thermal Conductivity,[c] Btu/in./hr/sq ft/°F	Specific Heat,[d] Btu/lb/°F	Electrical Resistivity,[e] ohm/circ mil/ft
−320	—	—	—	206
−300	6.1	113	0.050	—
−200	6.4	130	0.078	—
−100	6.7	139	0.088	—
70	—	151	0.102	307
200	7.7	167	0.105	322
400	8.6	193	0.110	337
600	8.8	215	0.114	346
800	8.9	238	—	355
1000	9.1	264	—	367
1200	9.3	287	—	379
1400	9.6	311	—	391
1600	9.8	335[f]	—	403
1800	10.0[f]	360[f]	—	415
2000	10.3[f]	—	—	427

* These values also apply to MONEL alloy R-405. See also Table 38.
[b] Annealed material. Between 70°F and temperature shown. Results are in good agreement with those obtained at the Bureau of Standards by Hidnert[1]. Values below 0°F are taken from Corruccini[2] as found in Eldridge and Deem[3].
[c] Values above 0°F from Powell[4]. These results appear to match other data better than the lower values published by Silverman[5] as found in Eldridge and Deem[3]. Subzero data are from Esterman and Zimmerman[6] as found in Reference 3.
[d] Values below 0°F from Hampton and Monnie[7] as found in Corruccini and Gniewek[8]. Above 0°F the data are from Douglas and Victor[9].
[e] Annealed material.
[f] Extrapolated.

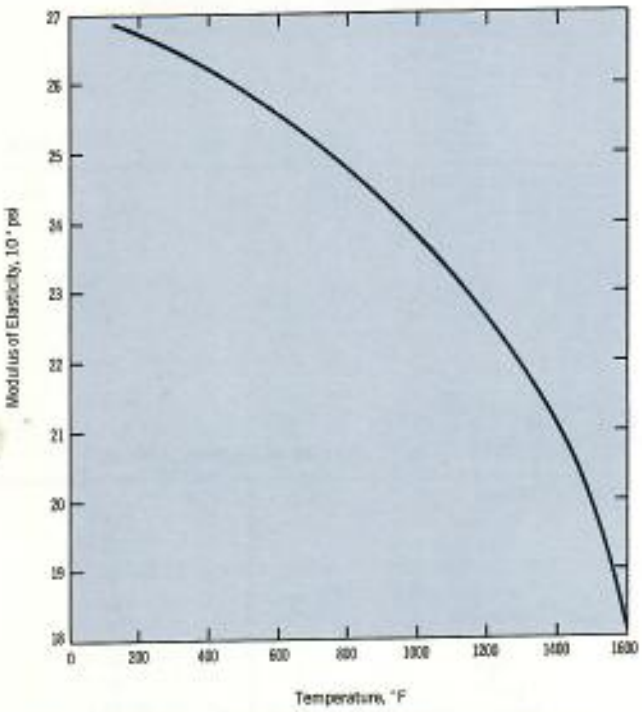


Figure 1—Effect of temperature on modulus of elasticity in tension of MONEL alloy 400 (determined by dynamic method).

MECHANICAL PROPERTIES

Tensile Properties and Hardness

The nominal room-temperature tensile properties of MONEL alloy 400 are shown in Table 4. Additional data on hardness of various tempers of sheet and strip are in Table 5.

Figures 2 and 3 are based on typical data that show relationships between properties of rods and forgings and sheet and strip.

Short-time high-temperature properties of hot-rolled annealed material are shown in Figure 4.

MONEL alloy 400 has excellent mechanical properties at subzero temperatures. Strength and hardness increase with only slight impairment of ductility or impact resistance. The alloy does not undergo a ductile-to-brittle transition even when cooled to the temperature of liquid hydrogen. This is in marked contrast to many ferrous materials which are brittle at low temperatures despite their increased strength. Table 6 shows mechanical properties of the alloy at low temperatures.

Table 4—Nominal Room-Temperature Tensile Properties of MONEL Alloy 400 [a]

Form and Condition	Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Elongation, %	Hardness	
				Brinell (3000-kg)	Rockwell B
Rod and Bar					
Annealed	75–90	25–50	60–35	110–149	60–80
Hot-Finished (except Hexagons over 2½ inches and Angles)	80–110	40–100	60–30	140–241	75–100
Hot-Finished Hexagons over 2½ inches and Angles	75–100	30–55	50–30	130–184	72–90
Cold-Drawn, Stress-Relieved	84–120	55–100	40–22	160–225	85–20C
Plate					
Hot-Rolled, As-Rolled	75–95	40–75	45–30	125–215	70–96
Hot-Rolled, Annealed	70–85	28–50	50–35	110–140	60–76
Sheet					
Annealed	70–85	25–45	50–35	—	73 max.[a]
Cold-Rolled, Hard	100–120	90–110	15–2	—	93 min.[a]
Strip, Cold-Rolled					
Annealed	70–85	25–45	55–35	—	68 max.[a]
Spring Temper	100–140	90–130	15–2	—	98 min.[a]
Tube and Pipe, Seamless					
Cold-Drawn, Annealed	70–85	25–45	50–35	—	75 max.[a]
Cold-Drawn, Stress-Relieved	85–120	55–100	35–15	—	85–100[a]
Heat-Exchanger, Annealed	70–85	28–45	50–35	—	75 max.[a]
Heat-Exchanger, Stress-Relieved	85–105	55–90	35–20	—	85–97[a]
Hot-Extruded	—[b]	—[b]	—[b]	—	—[b]
No. 1 Temper (Annealed)	85 max.	30–45	45–30	—	73 max.[a]
No. 2 Temper (Half-Hard)	85–105	55–80	30–10	—	75–97[a]
No. 3 Temper (Full-Hard)	110–130	90–110	10–3	—	95–27C
Wire, Cold Drawn[c]					
Annealed	70–95	30–55	45–25	—	—
No. 1 Temper	85–100	50–75	30–20	—	—
Quarter-Hard	95–120	65–95	25–15	—	—
Half-Hard	110–135	85–120	15–8	—	—
Three-Quarter-Hard	125–150	100–135	8–5	—	—
Full-Hard—Spring-Temper	145–180	125–170	5–2	—	—

[a] The ranges shown are composites for various product sizes and therefore are not suitable for specification purposes. Hardness values are suitable for specification purposes providing tensile properties are not also specified.
[b] Properties on request.
[c] Properties shown are for sizes from 0.032 to 0.250-in. diameter. Properties for other sizes may vary from these.

Torsional Strength

Some torsional properties of alloy 400 are shown in Table 7.

Compressive Strength

Compressive properties, determined in triplicate on single typical melts, are shown in Table 8 along with the corresponding tensile properties and hardness. The modulus of elasticity in compression is the same as that in tension. More detailed information may be found elsewhere.[11]

Table 5—Hardness of Cold-Rolled MONEL Alloy 400 Sheet and Strip

Temper	Rockwell B Hardness	
	Sheet	Strip
Deep-Drawing and Spinning Quality	68 max.	68 max.[a]
Annealed	73 max.[b]	68 max.[b]
Skin-Hard	—	68-73
Quarter-Hard	73-83	73-83
Half-Hard	82-90	82-90
Three-Quarter-Hard	—	89-94
Hard	93 min.	93-98
Spring	—	98 min.

[a] 70 max. 0.015 to 0.024 in. inclusive, 68 max. over 0.024 in. to 0.125 in. inclusive. Hardness values for strip under 0.050 in. are based on Rockwell Superficial readings and converted to Rockwell.
[b] Hardness for information only where tensile requirements apply.

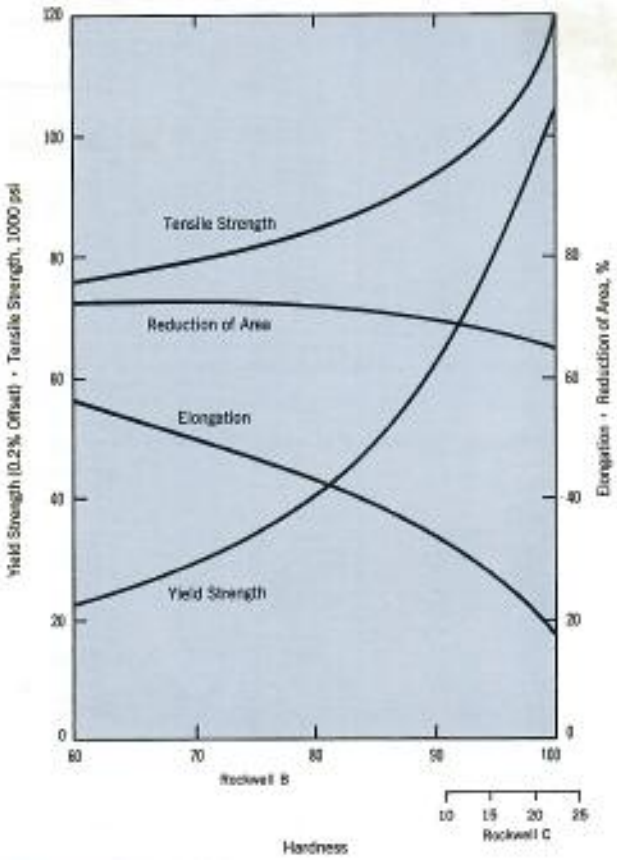


Figure 2—Approximate relationships between tensile properties and hardness of hot-rolled and cold-drawn MONEL alloy 400 rods and forgings.

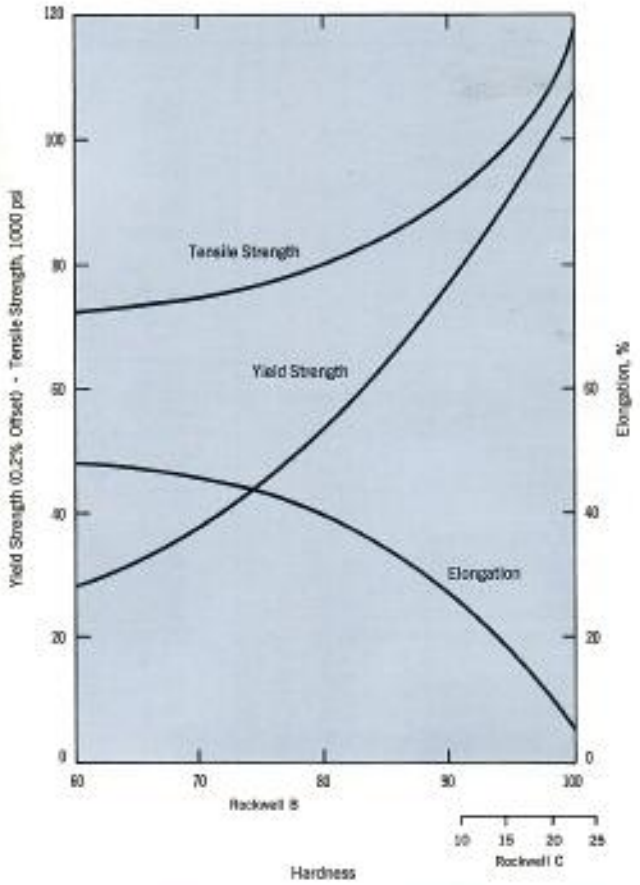


Figure 3—Approximate relationships between tensile properties and hardness of MONEL alloy 400 sheet and strip.

Table 6—Tensile Properties of MONEL Alloy 400 at Low Temperatures

Temper	Temperature, °F	Tensile Strength, psi	Yield Strength, (0.2% Offset), psi	Elongation, %	Reduction of Area, %
Cold-Drawn[10]	Room	103,800	93,700	19.0	71.0
	−110	117,450	100,850	21.8	70.2
	Room[a]	103,400	93,300	17.3	72.5
Forged	70	92,000	67,000	31.0	72.7
	−297	128,250	91,500	44.5	71.8
	−423	142,000	96,400	38.5	61.0
Annealed	70	78,650	31,300	51.5	75.0
	−297	115,250	49,500	49.5	73.9

[a] Held at −110°F for several hours prior to testing at room temperature.

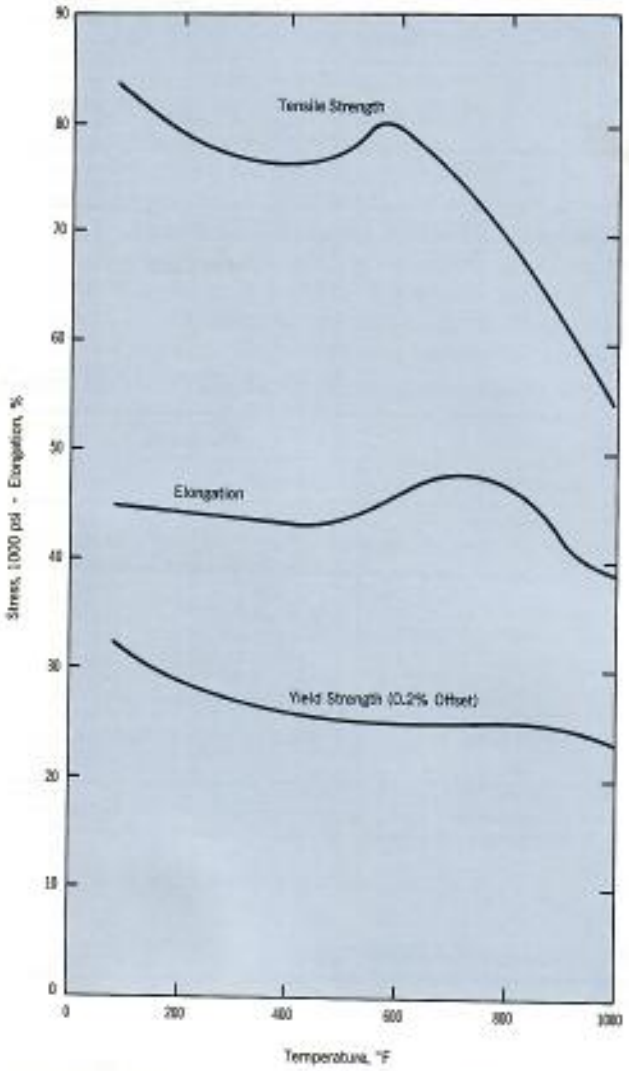


Figure 4—High-temperature properties of annealed MONEL alloy 400.

Shear Strength

Room-temperature shear strength of MONEL alloy 400 sheet is shown in Table 9. The values are the averages of several tests. The shear strength of rivet wire at various temperatures is given in Table 10. Shear properties were determined on ⅛-in. diameter wire in double shear.

Lismer[12] conducted U.S. Navy tear tests at temperatures down to −320°F. The material showed excellent ductility and tough fracture characteristics over this temperature range with the maximum load increasing considerably with decrease in temperature. The data appear in Table 11.

Bearing Strength

It is possible, in riveted joints, for failure to occur by tearing out a segment of sheet instead of by shearing the rivet. The resistance of sheet metal to this deformation is known as bearing strength. It can be evaluated by using a hard pin or rivet to enlarge or tear a hole in a sample of sheet metal.

The data shown in Table 12 were determined[13] with samples 0.062 × 1.25 × 2.5 in. in size having a 3/16-in. hole located so that its center was ⅜-in. from the edge. A snugly fitted pin was placed in the hole. The maximum load for tearing out the hole and the load required for a permanent enlargement of the hole diameter by 2% were determined and calculated as ultimate and yield strengths, respectively, in bearing.

Table 7—Torsional Properties of MONEL Alloy 400

Form and Condition	Dia., in.	Tensile Properties		Torsional Properties		Ratio		
		Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Breaking Strength, 1000 psi	Proportional Limit, 1000 psi	Breaking Strength Torsional/ Tensile Strength	Torsional Proportional Limit/ Tensile Strength	Torsional Proportional Limit/ Torsional Breaking Strength
Wire								
Cold-Drawn, 75%	0.148	157	—	110	68	0.700	0.433	0.618
Cold-Drawn, 75% Stress-Relieved	0.148	160	—	105	65	0.656	0.404	0.619
Rod								
Hot-Rolled	1	86	38	66	23	0.768	0.267	0.349
Cold-Drawn, 20%	1	115	107	72	47	0.626	0.408	0.653
	1½	113	102	71	45	0.628	0.398	0.634

Table 8—Compressive Properties of MONEL Alloy 400

Temper	Compression		Tension			
	Yield Strength (0.01% Offset), psi	Yield Strength (0.2% Offset), psi	Tensile Strength, psi	Yield Strength (0.01% Offset), psi	Yield Strength (0.2% Offset), psi	Elongation, %
Hot-Rolled	33,000	38,000	84,000	37,000	41,000	39.5
Cold-Drawn[a]	58,000	81,000	97,000	75,000	87,000	27.0
Annealed[b]	19,000	28,000	78,000	28,000	33,000	44.0

[a] Stress-equalized at 525°F after cold drawing.
[b] Cold-drawn +1450°F/3 hr, F.C.

Table 9—Shear Strength of MONEL Alloy 400 Sheet[a]

Temper	Thickness, in.	Shear Strength, psi	Tensile Strength, psi	Hardness, Rb	Ratio, Shear Strength/ Tensile Strength
Hot-Rolled, Annealed	0.042	48,750	73,000	65	0.67
Cold-Rolled, Annealed	0.029	49,500	76,800	60	0.65

[a] Double-shear tests at room temperature.

Table 10—Shear Strength of MONEL Alloy 400 Rivet Wire

Property	Condition	
	Annealed	B&S No. 1[a]
Shear Strength, psi		
Room	48,500	54,500
600[b]	45,000	52,000
800[b]	37,000	47,500
1000[b]	29,000	38,000
800[c]	38,500	49,500
1000[c]	30,500	38,500
Tensile Strength, psi	78,500	88,000
Yield Strength, (0.2% Offset), psi	46,000	75,500
Elongation, %	41	18

[a] Corresponds to the approximate strength of the shank of a headed rivet.
[b] 30 min at temperature before testing.
[c] 24 hr at temperature before testing.

Table 11—U. S. Navy Tear Tests on MONEL Alloy 400 Hot-Rolled Plate[a]

Temperature, °F	Maximum Load, lb	Corrected Energy Values, ft-lb			Reduction of Thickness, %
		Initiation	Propagation	Total	
Room	32,340	715	2008	2723	57.0
−184	39,000	649	2402	3051	50.0
−238	42,000	795	2408	3203	51.0
−320	47,800	899	2802	3701	46.0
−320[b]	41,300	676	2138	2814	45.0

[a] In all cases, appearance of fracture was double-cup shear.
[b] Tested with jeweler's-saw notch.

Table 12—Bearing Strength of MONEL Alloy 400 Sheet

Temper	Tensile Properties			Bearing Strength		Ratio, Bearing Strength/	
	Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Elongation, %	Yield Strength,[a] 1000 psi	Ultimate Strength,[b] 1000 psi	Yield Strength	Ultimate Strength
Annealed	70.0	27.2	42.5	58.0	145.0	2.13	2.07
Half-Hard	75.8	56.2	32.0	98.1	166.0	1.75	2.19
Full-Hard	117.8	110.0	5.0	162.0	211.5	1.47	1.79

[a] 2% enlargement of hole diameter in sheet.
[b] Tearing out of sheet.

Impact Strength

MONEL alloy 400 is notable for its toughness, which is maintained over a considerable range of temperatures. Table 13 shows room-temperature Charpy and Izod impact strength values as determined on typical material from production melts. Tension and torsion impact data from Catlin and Mudge[11] appear in Tables 14 and 15. Complete fractures occurred in the tension impact test specimens whereas the torsion specimens remained intact. Attempts to produce fractures in the torsion specimens by reducing the minimum area by 75% were not successful because of the toughness of the material.

Table 13—Impact Strength of MONEL Alloy 400 *

Temper	Impact Strength, ft-lb	
	Izod	Charpy U Notch
Hot-Rolled	100-120+	220
Forged	75-115	—
Cold-Drawn	75-115	150
Annealed	90-120+	215

* Tested at room temperature. None of the specimens was completely fractured.

Table 14—Tension Impact Strength of MONEL Alloy 400 Rod

Temper	Tension Impact			Tensile Properties				
	Impact Strength, ft-lb	Elongation in 3.54 in., %	Reduction of Area, %	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation in 2 in., %	Reduction of Area, %	Hardness, Brinell (3000-kg)
Cold-Drawn 24%, Stress-Relieved	96*	15.0	63.7	97,250	86,650	27.0	66.4	199
Annealed 1450°F/3 hr	129*	29.5	68.0	78,350	33,350	44.0	65.9	123

*Specimen completely broken.

Table 15—Charpy Torsion Impact Strength of MONEL Alloy 400 Rod

Temper	Impact Strength		Angle of Twist,* Degree	Hardness, Brinell (3000-kg)
	ft-lb	ft-lb/sq in.		
Hot-Rolled	34	694	101.5	145
Cold-Drawn 24%, Stress-Relieved	39	788	98.0	199
Annealed 1450°F/3 hr	30	599	102.0	123

* Gage length about 3/16 in.; specimen described in Reference 11.

The effect of decrease of temperature on impact strength appears in Table 16. Impact tests conducted on hot-finished plate at liquid-hydrogen[14] and liquid-helium[15] temperatures are summarized in Table 17. Tests were conducted on samples representing both longitudinal and transverse orientation in the plate, and on welded samples. No evidence of brittle fractures was shown. The welded specimens all fractured in the weld. No significant amount of anisotropy was evidenced.

Table 16—Impact Strength of MONEL Alloy 400 (Charpy V-Notch)

Temper	Impact Strength, ft-lb			
	75°F	−20°F	−112°F	−310°F
Hot-Rolled	219	—	213	196
Cold-Drawn, Annealed	216	212	219	212
Weld, As-Welded	78	—	—	73

Table 17—Charpy Impact Strength of Hot-Finished MONEL Alloy 400 Plate

Temperature, °F	Notch	Orientation	Impact Strength, ft-lb
−423[a]	V	Long.	141–219
−423[a]	V	Trans.	121–216
−423[a]	Keyhole	Long.	81–87
−423[a]	Keyhole	Trans.	72–75
−440[b]	V	Long.	Unbroken
−440[b]	V	Trans.	171–193
−440[b]	Keyhole	Long.	123–146
−440[b]	Keyhole	Trans.	91–116

[a] Range for 5 tests at liquid-hydrogen temperature.
[b] Range for 4 tests at liquid-helium temperature.

Fatigue Strength

Fatigue strength of various tempers of alloy 400 is given in Table 18. Values for sheet and strip are in Table 19 and for wire in Figure 5.

Table 18—Fatigue Strength [a] of MONEL Alloy 400 Rod

Temper	Fatigue Strength (10^8 cycles), 1000 psi	Tensile Strength, 1000 psi	Ratio, Fatigue Strength/ Tensile Strength
Annealed	33.5	82.0	0.41
Hot-Rolled	42.0	88.0	0.48
Cold-Drawn, As-Drawn	40.5	105.0	0.39
Cold-Drawn, Stress-Equalized[b]	44.0	104.0	0.42
Cold-Drawn, Stress-Relieved[c]	37.0	96.5	0.38

[a] Rotating-beam tests of polished specimens in air at room temperature and 10,000 rpm.
[b] 525°F/3 hr.
[c] 1000°F/3 hr.

Table 19—Fatigue Strength of MONEL Alloy 400 Sheet and Strip [a]

Temper	Fatigue Strength (10^8 Cycles), psi	Tensile Strength, psi	Ratio, Fatigue Strength/ Tensile Strength
Annealed	21,000	74,700	0.28
Quarter-Hard	24,500	76,500	0.32
Half-Hard	28,500	84,150	0.34
Full-Hard	39,000	126,000	0.31
Full-Hard, Stress-Equalized (525°F/21 hr)	41,000	133,000	0.31

[a] As-rolled surface. Tested in air at room temperature. Specimen length parallel to direction of rolling. Completely reversed stress.

Spring Properties

MONEL nickel-copper alloy 400 springs are used in corrosive environments at temperatures up to 450°F. Recommended stresses for safe design of springs cold-coiled from spring-temper wire stress-equalized after coiling are

	Max. Shearing Stress, psi
Up to 400°F	60,000
400° to 450°F	40,000

Only where experience indicates that they are conservative should higher values be used. Where insufficient information concerning service is available, a suitable safety factor should be included.

The recommended heat treatment after cold coiling is stress equalizing at 575°–650°F for ½–1 hr, followed by air cooling. Cleaning of springs after heat treatment is not recommended.

Alloy 400 has a good combination of strength without brittleness at low temperature, and springs of this material can be used to −320°F or lower. Room-temperature properties should be used as the basis of design.

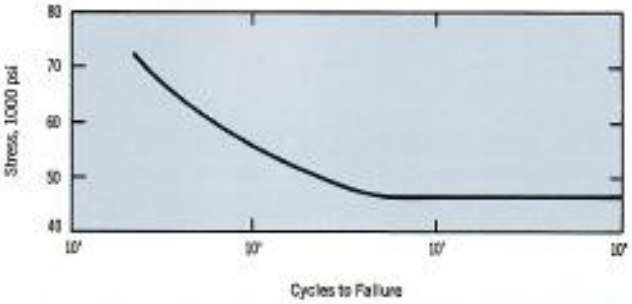


Figure 5—Fatigue strength of commercially produced MONEL alloy 400 wire (0.0375-in. diameter, cold-drawn 75% after final anneal). Tested in processed condition. Data determined with a rotating-wire (5000 rpm) arc-fatigue machine.

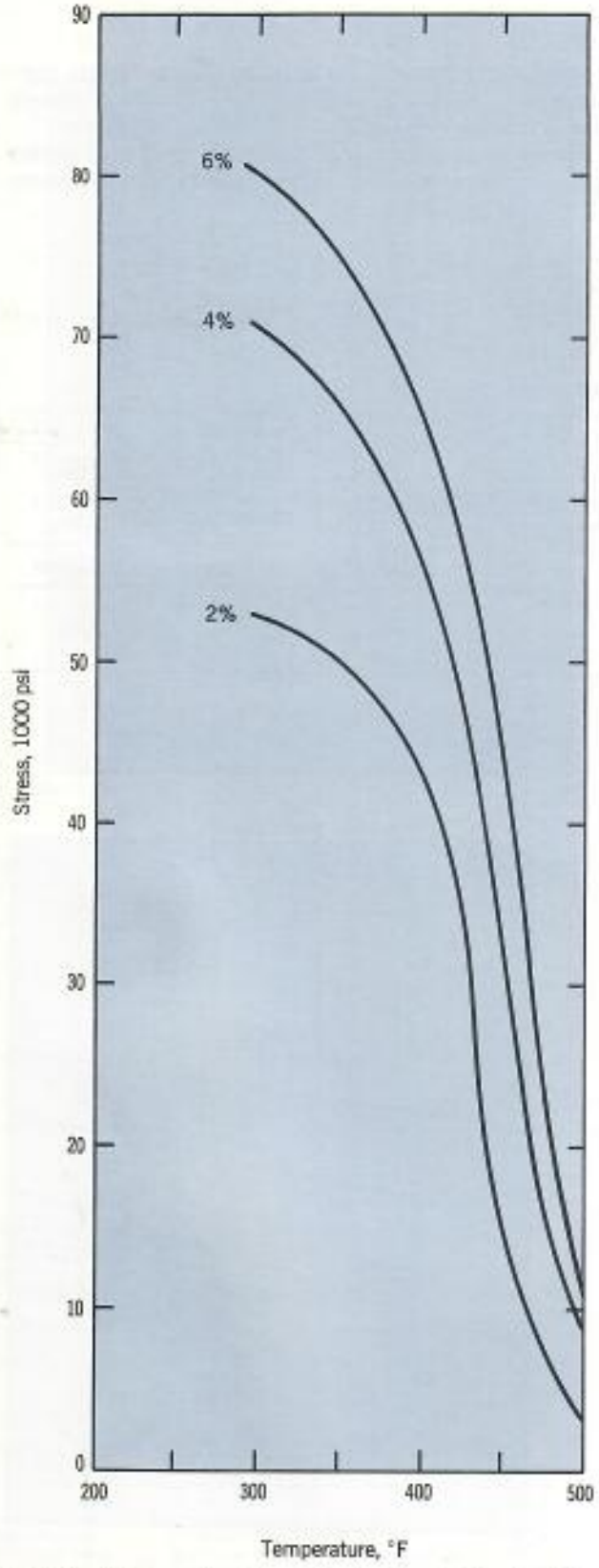


Figure 6—Stress required to produce 2, 4, and 6% relaxation of MONEL alloy 400 (stress-equalized 575°F/1 hr) in 7 days. All stresses corrected for curvature; modulus corrected for temperature.

Relaxation data are shown in Figure 6. They show that 450°F is the limiting service temperature based on a criterion of 5–6% relaxation in 7 days.

Some mechanical properties of MONEL alloy 400 springs determined in air at room temperature are shown in Table 20. The springs were coiled on standard automatic equipment, cold-pressed to solid height several times, and heat-treated. Their dimensions were 1¼-in. O.D., 0.148-in. wire diameter, 2¾-in. free height, and 6¼ total turns. The wire had been reduced 75%.

Creep and Rupture Properties

MONEL nickel-copper alloy 400 is useful at temperatures up to and including 1000°F in oxidizing atmospheres. Higher temperatures may be employed if the alloy is in a reducing environment.

Creep-rupture properties have been studied by the Huntington laboratory and by other investigators. Grant and Bucklin[16] have reported on creep-rupture and recrystallization characteristics of the alloy in various tempers. Shahinian and Lane[17] discuss the influence of grain size on the high-temperature properties of a nickel-copper alloy quite similar in composition to MONEL alloy 400 except for the iron content.

Creep and rupture properties are shown in Figures 7–11.

Applications under Boiler and Pressure Vessel Code

Table 21 lists the maximum allowable design stresses as given by Table UNF-23 in Section VIII (Pressure Vessels—Division 1) of the ASME Boiler and Pressure Vessel Code. The Code permits a maximum temperature of 900°F for annealed material. Cold-drawn, stress-relieved tubing has a maximum allowable temperature of 800°F. Cold-drawn and cold-drawn stress-equalized bolting values are permitted up to 500°F. These lower allowable temperatures have been established to prevent the loss of the strengthening effect of cold work through recrystallization during long-time exposure at temperature.

The user is also referred to Section VIII—Division 2 of the Code, "Guide to Alternative Rules for Pressure Vessels." As stated in Division 2, its intent "is to provide rules for the design and construction of pressure vessels which will take full advantage of techno-

logical progress with no sacrifice of safety. More specifically, this means the use of higher design stresses resulting in thinner materials of construction."

This objective is accomplished in part by using a higher percentage of the metal's properties to establish design stresses. Stringent rules pertaining to almost every phase of material selection, design, construction, and testing ensure that Division 2 vessels are as safe (or even safer) than Division 1 vessels.

Design stress intensity values which appear in the Code (Section III) for nuclear applications are given in Tables 22 and 23.

Table 20—Properties of MONEL Alloy 400 Springs

Thermal Treatment After Cold Coiling	Properties of Wires			Fatigue Strength or Stress Range of Springs, 1000 psi (Curvature Correction Factor Included) Initial Stress—10,000 psi		
	Tensile Strength, psi	Torsional Breaking Strength, psi	Torsional Proportional Limit, psi	10^6 Cycles	10^7 Cycles	10^8 Cycles
As-Drawn	156,800	110,300	67,900	—	—	—
Stress-Equalized 525°F/3 hr	175,000	110,100	61,100	45,000	35,500	34,500
575°F/1 hr	167,000	104,900	64,700	—	—	—

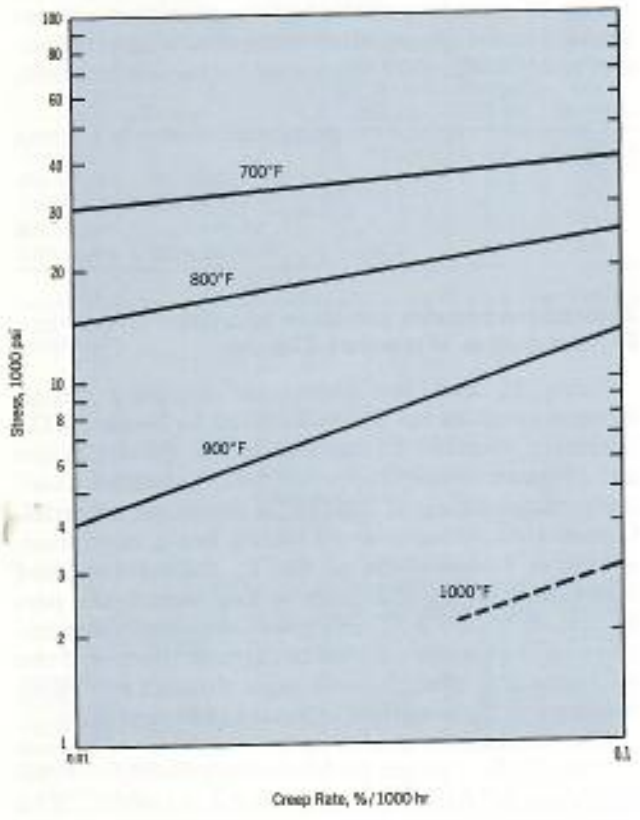


Figure 7—Creep properties of hot-rolled MONEL alloy 400.

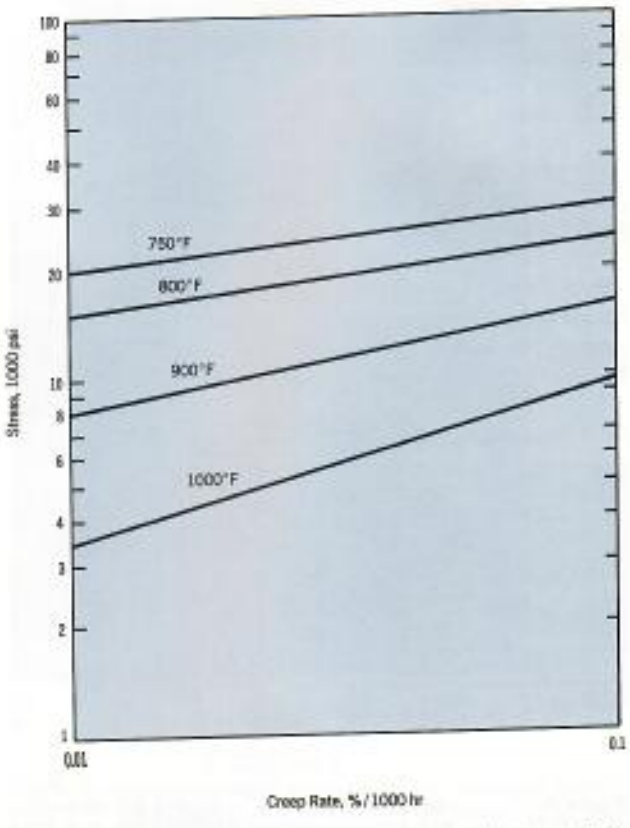


Figure 8—Creep properties of cold-drawn annealed (1500°F/3 hr) MONEL alloy 400.

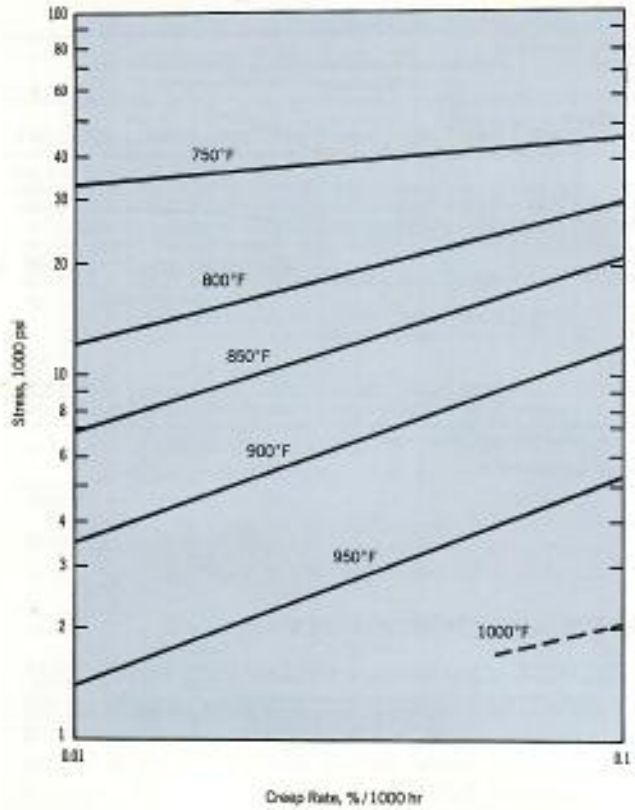


Figure 9—Creep properties of 20% cold-drawn stress-relieved (1000°F/8 hr) MONEL alloy 400.

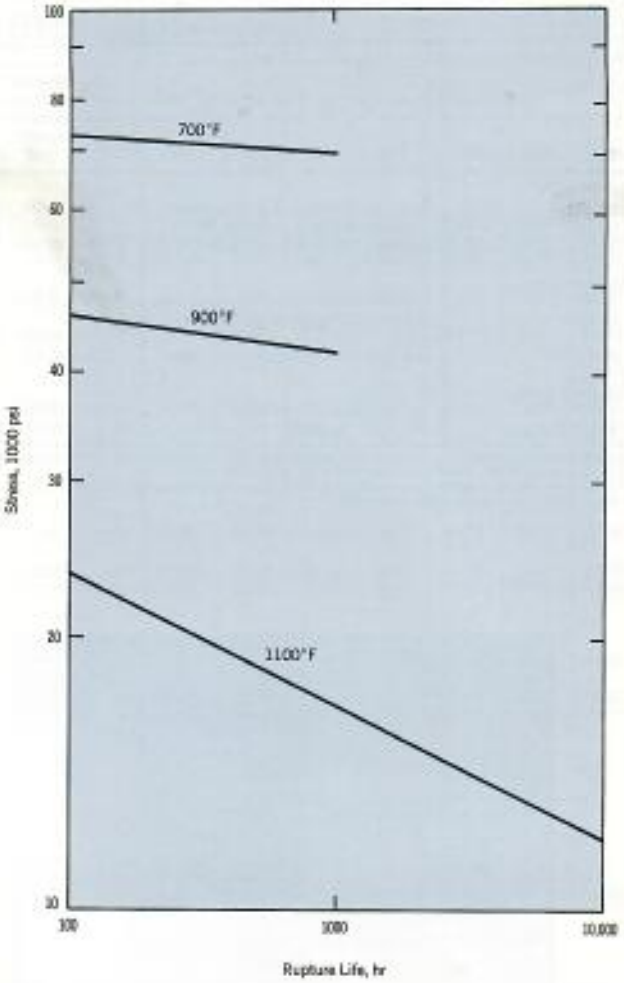


Figure 10—Rupture properties of cold-drawn annealed (1500°F/30 min) MONEL alloy 400.

Table 21—ASME Design Stresses [a]

Form and Specification [b]	Condition	Minimum Specification Tensile Strength, psi	Minimum Specification Yield Strength (0.2% Offset), psi	Maximum Allowable Working Stress Values in Tension, psi, For Metal Temperatures Not Exceeding 100°F	200°F	300°F	400°F	500°F	600°F	700°F	800°F	900°F
Bars, Rods, Shapes and Forgings												
SB-164 (Class A and B)	Hot- or Cold-Worked—Annealed—All Sizes, All Products	70,000	25,000	16,600	14,600	13,600	13,200	13,100	13,100	13,100	13,100	8,000
SB-164 (Class A only)	Hot-Finished—All Sizes except Hex. over 2½ in.	80,000	40,000	20,000	18,500	18,400	18,200	18,200	18,200	17,600	14,500	4,000
SB-164 (Class A only	Hot-Finished—Hex. over 2½ in.	75,000	30,000	18,700	17,700	17,200	17,100	17,100	17,100	16,300	14,500	4,000
SB-164 (Class B only)	Hot-Finished Rounds to 3 in., incl.	75,000	35,000	18,700	17,700	17,200	17,100	17,100	17,100	16,300	14,500	4,000
SB-164 (Class A only)	Hot-Finished—Stress-Relieved—4 in. to 12 in. Diam. incl.	80,000	40,000	20,000	18,500	18,400	18,200	18,200	18,200	17,600	14,500	4,000
SB-164 (Class A only)	Hot-Finished—Stress-Relieved—over 12 in. Diam.	75,000	40,000	18,700	17,700	17,200	17,100	17,100	17,100	16,300	14,500	4,000
Bolting												
SB-164 (Class A and B)	Annealed—All Products, All Sizes	70,000	25,000	6,100	5,700	5,200	5,000	4,900	4,900	4,900	4,900	4,700
SB-164 (Class A only)	Hot-Finished—All Sizes except Hex. over 2½ in.	80,000	40,000	10,000	9,600	9,400	9,000	8,500	8,500	8,500	8,300	4,000
SB-164 (Class A only)	Hot-Finished—Hex. over 2½ in.	75,000	30,000	7,500	7,400	7,300	6,800	6,500	6,500	6,400	6,200	4,000
SB-164 (Class B only)	Hot-Finished Rounds to 3 in. Diam. incl.	75,000	35,000	8,800	8,500	8,300	7,900	7,600	7,600	7,500	7,300	4,000
SB-164 (Class A only)	Cold-Drawn—Stress-Relieved—All Sizes[c]	84,000	50,000	12,500	11,900	11,500	11,300	11,200	—	—	—	—
SB-164 (Class A only)	Cold-Drawn—Stress-Equalized—Rounds to 3½ in. incl.[c]	90,000	70,000	17,400	16,500	16,200	15,500	15,400	—	—	—	—
SB-164 (Class A only)	Cold-Drawn—Stress-Equalized—Other Sizes and Shapes[c]	85,000	55,000	13,700	13,000	12,600	12,400	12,300	—	—	—	—
SB-164 (Class A only)	Cold-Drawn—As-Drawn—All Sizes[c]	85,000	55,000	13,700	13,000	12,600	12,400	12,300	—	—	—	—
SB-164 (Class B only)	Cold-Drawn—As-Drawn—All Sizes[c]	85,000	50,000	12,400	12,000	11,500	11,100	11,100	—	—	—	—

Table 21— (continued

Form and Specification[a]	Condition	Minimum Specification Tensile Strength, psi	Minimum Specification Yield Strength (0.2% Offset), psi	Maximum Allowable Working Stress Values in Tension, psi, For Metal Temperatures Not Exceeding 100°F	200°F	300°F	400°F	500°F	600°F	700°F	800°F	900°F
Pipe or Tube												
SB-165	Seamless—Annealed—5 in. OD and under	70,000	28,000	17,500	16,500	15,500	14,800	14,700	14,700	14,700	14,500	8,000
SB-165	Seamless—Annealed—Over 5 in. OD	70,000	25,000	16,600	14,600	13,600	13,200	13,100	13,100	13,100	13,100	8,000
SB-165	Seamless—Stress-Relieved, All Sizes[c]	85,000	55,000	21,200	20,200	19,500	19,200	19,200	—	—	—	—
Condenser Tube												
SB-163	Seamless—Annealed—All Sizes to 3 in., incl.	70,000	28,000	17,500	16,900	15,900	14,800	14,700	14,700	14,700	14,500	8,000
SB-163	Seamless—Stress-Relieved—½ in. to ⅝ in. Diam., incl.	90,000	55,000	22,500	21,200	20,700	20,500	20,500	20,500	19,500	15,000	4
SB-163	Seamless—Stress-Relieved—Other Sizes	85,000	55,000	21,200	20,200	19,500	19,200	19,200	19,200	18,900	15,000	4
Plate, Sheet or Strip												
SB-127	Hot- or Cold-Rolled—Annealed	70,000	28,000	17,500	16,500	15,500	14,800	14,700	14,700	14,700	14,500	8,000
SB-127 (Plate only)	Hot-Rolled—As-Rolled	75,000	40,000	18,700	17,500	17,000	17,000	17,000	17,000	16,500	14,500	4,000

[a] From Table UNF-23 of ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels—Division 1." Published by The American Society of Mechanical Engineers, 1968.
[b] Class A material is MONEL alloy 400, and Class B material is MONEL alloy R-405.
[c] The maximum operating temperature is arbitrarily set at 550°F, because harder temper adversely affects design stress in the creep-rupture temperature range.
[d] 2000 psi at 900°F. Use annealed condition above 800°F.

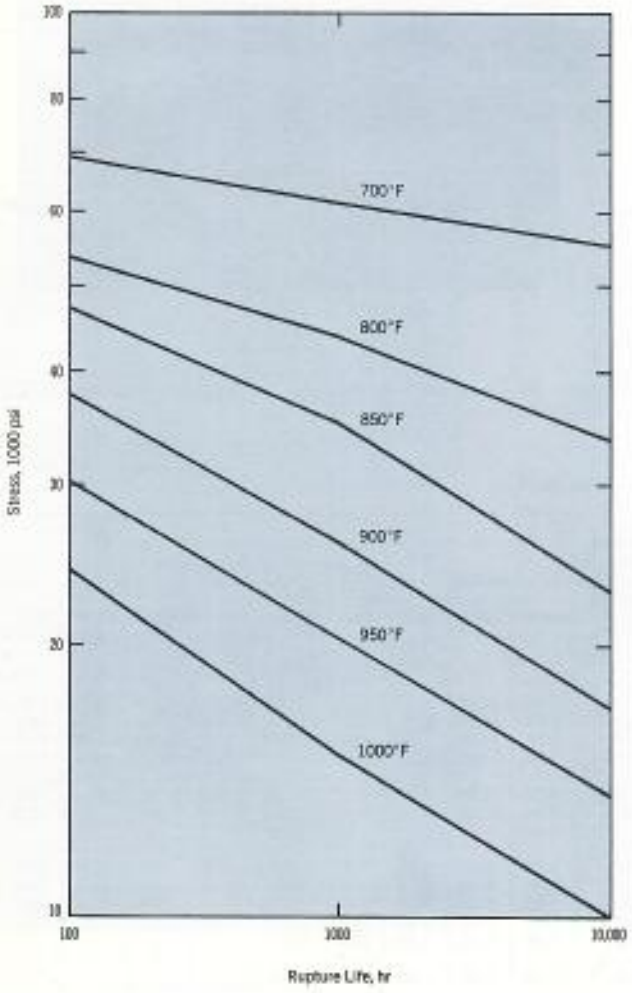


Figure 11—Rupture properties of cold-drawn, stress-relieved (1000°F/8 hr) MONEL alloy 400.

METALLOGRAPHY

MONEL alloy 400 is a solid-solution binary alloy. As nickel and copper are mutually soluble in all proportions, it is a single-phase alloy. It has a face-centered cubic lattice structure with a lattice parameter of 3.534 A. Figure 12 shows the typical microstructure of the material.

In the unetched condition, a polished specimen of MONEL alloy 400 will exhibit only randomly dispersed nonmetallic inclusions. These consist of metal sulfides or silicates. Under some conditions, graphite particles may also be present.

Directions for preparing and etching macro- and microspecimens may be found in the HANDBOOK OF HUNTINGTON ALLOYS.[18]

Figure 12—Longitudinal section of cold-drawn MONEL alloy 400 rod. Etchant: Sodium cyanide—ammonium persulfate. 100X

Table 22—Design Stress Intensity Values Excluding Bolting Material [a]

Form and Specification[b]	Condition	Minimum Specification Tensile Strength, psi	Minimum Specification Yield Strength (0.2% Offset), psi	Welding P-No.	Design Stress Intensity Value, psi, For Metal Temperatures Not Exceeding 100°F	200°F	300°F	400°F	500°F	600°F	650°F	700°F	750°F	800°F
Bars, Rods, Shapes, and Forgings														
SB-164 (Class A)	Hot-Finished	80,000	40,000	42	26,700	23,500	21,900	21,900	21,200	21,200	21,200	21,200	20,900	20,300
SB-164 (Class A)	Hot-Finished	75,000	30,000	42	20,000	17,600	16,500	15,900	15,500	15,900	15,900	15,500	15,600	15,200
SB-164 (Class B)	Hot-Finished Rounds	75,000	35,000	42	23,300	20,600	19,200	18,500	18,500	18,500	18,500	18,500	18,200	17,900
SB-164 (Class A)	Hot-Finished—Stress-Relieved	80,000	40,000	42.	26,700	23,500	21,900	21,200	21,200	21,200	21,200	21,200	20,900	20,300
SB-164 (Class A)	Hot-Finished—Stress-Relieved	75,000	40,000	42	25,000	23,500	21,900	21,200	21,200	21,200	21,200	21,200	20,900	20,300
Pipe or Tube														
SB-165	Annealed—5 in. OD and Under	70,000	28,000	42	18,700	16,400	15,400	14,800	14,800	14,800	14,800	14,800	14,600	14,200
SB-165	Annealed—Over 5 in. OD	70,000	25,000	42	16,700	14,700	13,700	13,200	13,200	13,200	13,200	13,200	13,000	12,700
SB-165	Stress-Relieved	85,000	55,000	42	28,300	28,300	28,300	28,300	28,300	28,300	28,100	27,900	26,600	25,600
Condenser Tube														
SB-163	Annealed—Up to 3 in. Dia.	70,000	28,000	42	18,700	16,400	15,400	28,000	14,800	14,800	14,800	14,800	14,600	14,200
SB-163	Stress-Relieved—½ to ¾ in. Dia.	90,000	55,000	42	30,000	30,000	30,000	29,100	28,100	29,100	29,100	29,100	28,200	27,100
SB-163	Stress-Relieved	85,000	55,000	42	28,300	28,300	28,300	28,300	28,300	28,300	28,100	27,900	26,600	25,600
Plate, Sheet or Strip														
SB-127	Hot- or Cold-Rolled—Annealed	70,000	28,000	42	13,700	16,400	15,400	18,000	14,800	14,800	14,800	14,800	14,600	14,200
SB-127 (Plate Only)	Hot-Rolled—As-Rolled	75,000	40,000	42	25,000	23,500	21,900	21,200	21,200	21,200	21,200	21,200	20,900	20,300

[a] From Table N-423, ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Vessels." Published by The American Society of Mechanical Engineers. 1968.
[b] Class A material is MONEL alloy 400, and Class B material is MONEL alloy R-405.

Table 23—Design Stress Intensity Values for Bolting Materials [a]

Form and Specification[b]	Condition	Minimum Specification Tensile Strength, psi	Minimum Specification Yield Strength (0.2% Offset), psi	Design Stress Intensity Value, psi, For Metal Temperatures Not Exceeding 100°F	200°F	300°F	400°F	500°F	600°F	700°F	800°F
SB-164 (Class A and B)	Annealed	70,000	25,000	8,300	7,300	6,900	6,600	6,600	6,600	6,600	6,300
SB-164 (Class A)	Hot-Finished	80,000	40,000	13,300	11,700	11,000	10,600	10,600	10,600	10,600	10,100
SB-164 (Class A)	Hot-Finished	75,000	30,000	10,000	8,800	8,200	7,900	7,900	7,900	7,900	7,600
SB-164 (Class B)	Hot-Finished	75,000	35,000	11,700	10,300	9,600	9,300	9,300	9,300	9,300	8,900
SB-164 (Class A)	Cold-Drawn—Stress-Relieved	84,000	50,000	16,600	14,600	13,800	13,200	13,200	—	—	—
SB-164 (Class A)	Cold-Drawn—Stress-Equalized Rounds	90,000	70,000	23,300	20,500	19,200	18,500	18,500	—	—	—
SB-164 (Class A)	Cold-Drawn—Stress-Equalized	85,000	55,000	18,300	16,100	15,100	14,600	14,600	—	—	—
SB-164 (Class A)	Cold-Drawn—As-Drawn	85,000	55,000	18,300	16,100	15,100	14,600	14,600	—	—	—
SB-164 (Class B)	Cold-Drawn—As-Drawn	85,000	50,000	16,600	14,600	13,800	13,200	13,200	—	—	—

[a] From Table N-422, ASME Boiler and Pressure Vessel Code, Section III, "Nuclear Vessels." Published by The American Society of Mechanical Engineers. 1968.
[b] Class A material is MONEL alloy 400, and Class B material is MONEL alloy R-405.

CORROSION RESISTANCE

MONEL alloy 400 is more resistant than nickel to corrosion under reducing conditions and more resistant than copper to corrosion under oxidizing conditions. Hence, it is in general, more corrosion-resistant than either of its two principal constituents. Being a single-phase, solid-solution alloy, it is free from such types of corrosion which sometimes result from local galvanic action between phases of multiphase alloys.

An important consideration in the use of MONEL alloy 400 in corrosive environments is its general freedom from stress-corrosion cracking. Because it is not subject to chloride-ion stress-corrosion cracking, it is eminently satisfactory for use in equipment covered with chloride-containing thermal insulation or in heat exchangers or condensers utilizing brackish or saline cooling water.

Stress-corrosion cracking has been observed in a few specific corrosive media. Fraser[19] cites cases involving mercury and solutions of its salts, fluosilicic acid and fluosilicates, and concentrated caustic soda and caustic potash. Cracking in these media was prevented by stress relieving or annealing prior to use and by minimizing service stresses. Copson and Cheng[20] discuss circumstances under which hydrofluoric acid vapors can cause cracking in MONEL alloy 400.

Equipment for use in environments where cracking may occur should be heat-treated after fabrication to remove all stresses set up by forming and welding, and operating stresses should be kept to a minimum.

More information on performance of MONEL alloy 400 in corrosive environments may be found in RESISTANCE OF HUNTINGTON ALLOYS TO CORROSION.[21]

Atmospheric Corrosion

MONEL alloy 400 is highly resistant to atmospheric corrosion. Indoor exposure produces a very light tarnish which is easily removed by occasional wiping. Outdoor-exposure rates are extremely low.[22] Surfaces that are exposed to rain develop a thin gray-green patina. Protected surfaces accumulate a coating of corrosion products which are hygroscopic enough to become moist on humid days. These surfaces may require periodic washing so that they have the same appearance as exposed areas.

In sulfurous atmospheres the alloy retains only a thin film, smooth, brown, and adherent. In marine atmospheres a smooth gray-green film is developed. In rural atmospheres only a light tarnish occurs. The corrosion rates under any of these environments are extremely low, as shown by the 20-year exposure data plotted in Figure 13. Experience has shown the alloy to be free from season cracking and other forms of stress-corrosion cracking in atmospheric exposure.

Corrosion by Water

The two major problems in industrial use of water are pitting and stress-corrosion cracking (many common alloys having good resistance to general corrosion by water). Alloy 400, however, does not pit or stress-corrosion-crack under most conditions.

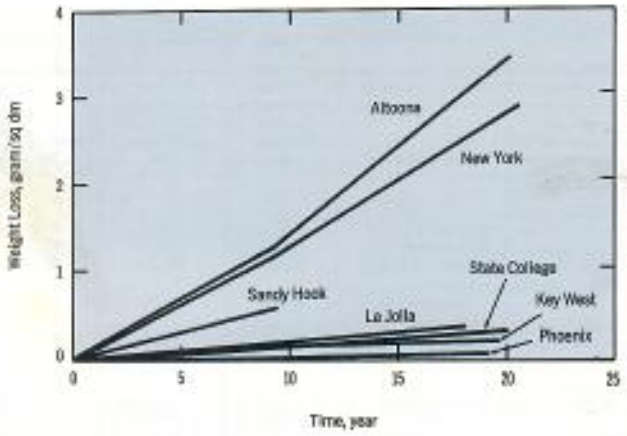


Figure 13—Weight loss of MONEL alloy 400 during 20 years of atmospheric exposure in various locations.

FRESH WATER. The alloy is highly resistant to distilled water and natural waters, both hard and soft. In distilled and fresh waters, rates of corrosion are usually less than 1 mpy under the most severe conditions of temperature, flow, and aeration. In acid mine waters that contain oxidizing salts, attack may be accelerated. See Reference 21 for data on corrosion in coal-mine waters.

HIGH-PURITY WATER. MONEL alloy 400 has been evaluated for service in pressurized water-type nuclear reactors.[23] Corrosion rates in hydrogenated primary water were 3 to 4 times greater than those of INCONEL nickel-chromium alloy 600 or Type 347 stainless steel under the same test conditions, but were not considered to be excessive for the application.

STEAM. In steam/hot-water systems such as condensers, appreciable corrosion may occur if noncondensables (carbon dioxide and air) in the steam exist in certain proportions.

In steam condensate at 160°F where the vapor phase contains as noncondensable gases 70% carbon dioxide and 30% air at 35 psi, MONEL alloy 400 had a high corrosion rate of 60 mpy in a short-time test.[21] The corrosion rate was lower for other ratios of carbon dioxide and air. Deaeration of the feed or venting of the noncondensable gases will prevent this attack.

SALT WATER. The alloy gives excellent service in sea water or brackish waters under high-velocity conditions, as in propellers, propeller shafts, pump shafts, impellers, and condenser tubes, where resistance to cavitation-erosion is important. Another important application is splash-zone sheathing of offshore structures. Corrosion rates in strongly agitated and aerated sea water usually do not exceed 1 mpy.

Conditions of stagnant exposure to sea water are less favorable because marine organisms may accumulate and induce local oxygen-concentration-cell action followed by pitting. Such pitting tends to slow down after fairly rapid initial attack, however, and rarely exceeds 50 mils in depth even after exposure for several years.

Gases

MONEL alloy 400 is resistant to corrosion by all common dry gases at room temperature. It is not resistant to such gases as chlorine, bromine, nitric oxides, ammonia, and sulfur dioxide in the presence of appreciable amounts of water.

Moist hydrogen sulfide is moderately corrosive. A sample of MONEL alloy 400, suspended over 150°F water through which hydrogen sulfide was bubbled, corroded at a rate of 30 mpy.

The alloy is attacked by mixtures of nitrogen and hydrogen under the temperature and pressure conditions encountered in ammonia synthesis. Mixtures of air and ammonia as used in ammonia-oxidation processes are not corrosive, and the material has been used for gas filters in ammonia-oxidation equipment.

Alloy 400 has excellent resistance to fluorine, even at elevated temperatures. Data and suggestions for assuring the metal will retain the protective fluoride film that ensures satisfactory service are given in Reference 21.

Where exposure is to only dry chlorine, MONEL alloy 400 is used for trim on chlorine cylinder and tank car valves, for orifice plates in chlorine pipe lines and various parts of chlorine-dispensing equipment. Wet hydrogen chloride and chlorine at temperatures below the dew points or aqueous solutions containing considerable amounts of chlorine are very corrosive. Suggested upper temperature limits (based on laboratory data)[51] for continuous service of alloy 400 are

800°F in dry chlorine
450°F in dry hydrogen chloride

Corrosion by Acids

SULFURIC ACID. MONEL alloy 400 is widely used for handling sulfuric acid solutions under reducing conditions, but aeration increases its corrosion rate. Figure 14 shows the effect of both acid concentration and aeration on corrosion rate at room temperature. These curves show that at up to 85% concentration, the maximum corrosion rate is at 5% concentration. Above 85%, the acid becomes oxidizing, and there is a sharp increase in rate which is

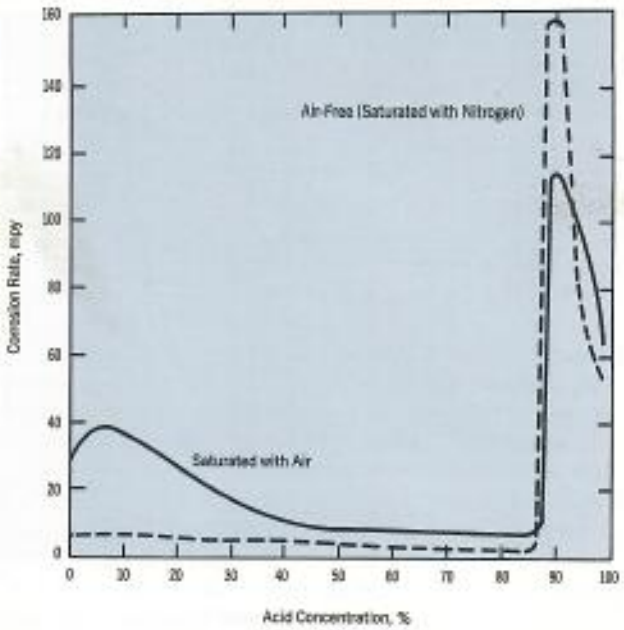


Figure 14—Corrosion of MONEL alloy 400 in sulfuric acid. (Temperature 86°F; Velocity, 17 fpm).

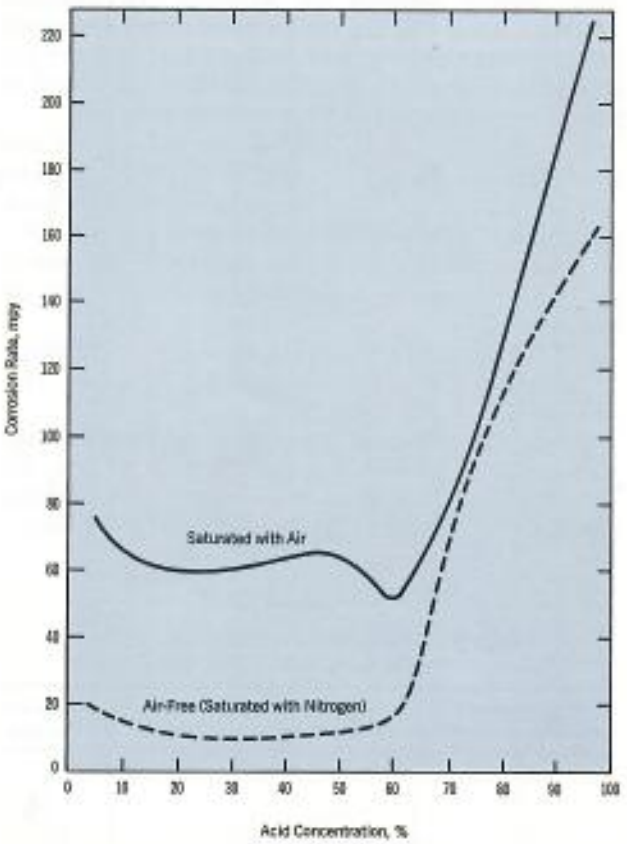


Figure 15—Corrosion of MONEL alloy 400 in sulfuric acid. (Temperature, 203°F; Velocity, 16.5 fpm).

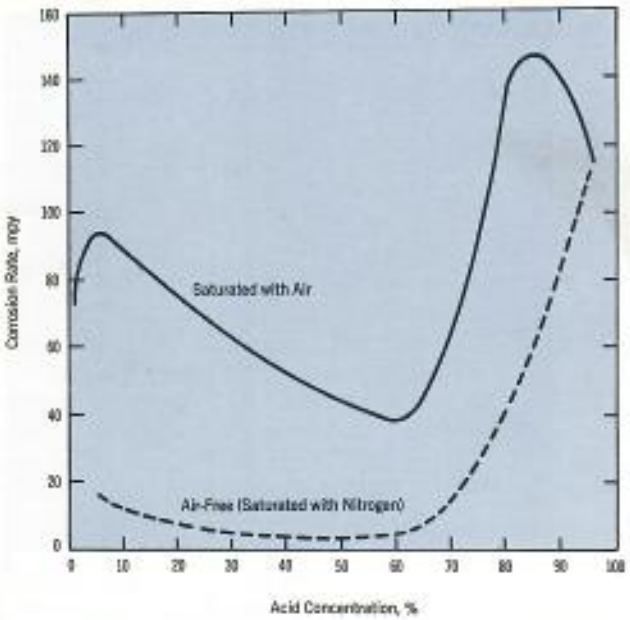


Figure 16—Corrosion of MONEL alloy 400 in sulfuric acid. (Temperature, 140°F; Velocity 16.5 fpm).

only slightly affected by aeration. In practice, MONEL alloy 400 has shown satisfactory resistance in the storage of 80% acid at room temperature but should not be used continuously with pure acid of higher concentration without preliminary tests.

Higher temperatures increase corrosion rate and accelerate the effect of air saturation. Data in Figures 15 and 16 show that maximum concentration of pure, air-free acid solutions for useful service is about 65%. In most applications, corrosion rate will be close to air-free rates because continuous air saturation is uncommon.

MONEL alloy 400 has shown suitable resistance to boiling sulfuric acid solutions up to about 15% concentration (See Table 24).

The usual effect of increasing velocity between metal and liquid is an increase in corrosion rate. Abnormally high velocities, especially when abrasive solids are suspended in solution, should be avoided.

Table 24—Corrosion of MONEL Alloy 400 by Boiling Sulfuric Acid Solutions

Acid Concentration, $\%H_2SO_4$, by weight	Boiling Temperature, °F	Duration of Test, hr	Corrosion Rate, mpy
5	214	23	3.4
10	216	23	2.4
19	219	23	7.5
50	253	20	650
75	360	20	2300
95	560	3	3300

In sulfuric acid solutions MONEL alloy 400 is often used in contact with other metals. When in contact with most materials of construction (other than lead, high-silver silver brazing alloys, and in some cases carbon), alloy 400 is either cathodic (protected) or neutral. For example, it is used in pickling of steel. Operating conditions are favorable, as action of the hot dilute sulfuric acid on steel evolves hydrogen, thus maintaining strongly reducing conditions. In addition, the crates, chains, and baskets are galvanically protected by contact with the steel.

In acid concentrations above about 80%, the good corrosion resistance of steel usually makes it the most economical material to use. In some cases, however, such as the handling of oil-refinery acid sludges, alloy 400 may be the preferred material. In this application, the oil present serves to inhibit corrosion.

Properly heat-treated MONEL alloy 400 is not susceptible to stress-corrosion cracking in sulfuric acid solutions, except those containing mercury salts or considerable amounts of hydrofluoric or fluosilicic acid. Before being placed in this type of service, fabricated alloy 400 equipment should be stress-relieved (1000°–1200°F/1 hr and slow cooling).

SULFUROUS ACID. Sulfurous acid is often very corrosive to MONEL alloy 400; for example, it cannot be used to handle the solutions of sulfurous acid and calcium bisulfite used to cook sulfite paper pulp. However, in dilute solutions, such as exist in spent cooking liquor or in the pulp itself, resistance to corrosion is very good and considerable quantities of alloy 400 are used for pulp washers, thickeners and screens in sulfite pulp mills.

The concentrations of sulfurous acid that develop in condensed moisture from flue gases from heating equipment and smelting operations may be appreciably corrosive. Caution should be exercised in applying the alloys in flue-gas handling systems.

In smoke-scrubbing systems, where the concentration of sulfurous acid is kept low and where an opportunity for oxidation to the less corrosive sulfuric acid is provided, MONEL alloy 400 is often useful and is one of the few strong, malleable metals worthy of consideration for such service.

HYDROCHLORIC ACID. MONEL alloy 400 is one of the few materials that may be used to handle hydrochloric acid. Corrosion rate in solutions of 10% concentration at room temperature has been found to be less than 10 mpy. For practical use at room temperature its application should be limited to concentrations under 20% in air-free solutions and 10% in aerated solutions.

Effect of increasing temperature on corrosion rate in 5% acid is shown in Figure 17. Alloy 400 is commonly used in acids of lower concentrations at higher temperatures. In most processes in which hydrochloric acid is formed as a result of hydrolysis of chlorides or chlorinated solvents, acid concentrations are less than 0.5%; alloy 400 can withstand these concentrations satisfactorily at temperatures up to 300° or 400°F. Table 25 shows the results of tests in boiling acids where it can be used with concentrations below 1%.

In air-saturated hydrochloric acid above room temperature, applications are usually limited to concentrations under 3 or 4%. For instance, it is being used to handle aerated acid of 2% concentration at 120°F and of 1% concentration at 180°F.

If oxidizing salts are present in any but very small amounts, corrosion can be greatly accelerated.

Alloy 400 has good resistance to corrosion by chlorinated solvents even at boiling temperatures and is used for dry cleaning equipment and solvent distillation and reclamation units.

HYDROFLUORIC ACID. Few compounds are more corrosive than hydrofluoric acid, yet MONEL alloy 400 is an outstanding metallic material of construction for hydrofluoric acid service. Aeration or the presence of oxidizing salts increases corrosion rate, but in unaerated acid it resists all concentrations up to the boiling point. Its resistance to attack

Table 25—Corrosion of MONEL Alloy 400 in Boiling Hydrochloric Acid (Velocity, none; Aeration, none. Duration of tests, 10 days)

Acid Concentration, % HCl by wt	Corrosion Rate, mpy
0.5	29
1.0	42
5.0	44

is shown in Figure 18. The presence of small amounts of reducing sulfur compounds or sulfuric acid is not detrimental. The alloy is also comparatively insensitive to velocity effects in hydrofluoric acid media.

Alloy 400 is widely used in the manufacture and purification of hydrofluoric acid. It has been found to be the most suitable material for such purposes if precautions are taken to exclude air.[24-26] It is widely used for critical parts such as bubble caps or valves that are in contact with flowing acid.

For service in moist, aerated hydrofluoric or hydrofluosilicic acid vapor, MONEL alloy 400 components should be in the stress-relieved condition (1000°–

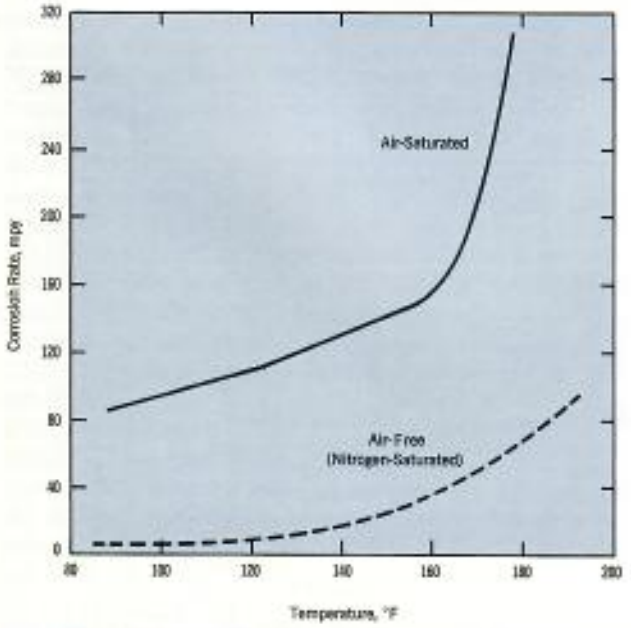


Figure 17—Effect of temperature on corrosion of MONEL alloy 400 in 5% hydrochloric acid.

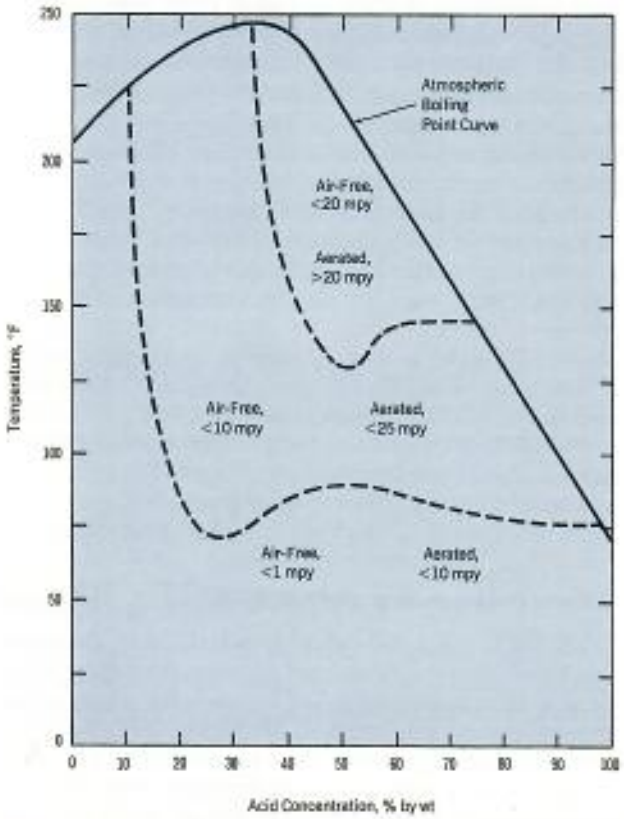


Figure 18—Isocorrosion chart of MONEL alloy 400 in hydrofluoric acid.

1200°F/1 hr, followed by slow cooling). Otherwise, the alloy will be subject to stress-corrosion cracking in these media. Exposure to moist aerated HF vapor is the most dangerous condition for stress-corrosion cracking. It also causes the highest corrosion rates.[20]

Complete immersion in the acid or elimination of aeration are other steps helpful in preventing cracking.

Corrosion tests in hydrofluoric acid solutions are described in Table 26. More data are in Reference 21.

PHOSPHORIC ACID. MONEL alloy 400 has useful resistance to pure phosphoric acid. Rates are below 10 mpy for all concentrations at temperatures up to approximately 200°F. Higher temperatures and aeration rapidly increase corrosion. For example, a test in agitated 53% acid at 240°F showed a rate of 500 mpy.

Corrosion rates in crude phosphoric acid are likely to be high because oxidizing salts may be present. As little as 0.4% ferric ion may increase corrosion by an order of magnitude.

Table 26—Corrosion of MONEL Alloy 400 in Plant Solutions of Hydrofluoric Acid

Condition	Temperature, °F	Corrosion Rate, mpy
Anhydrous Hydrogen Fluoride	932	48
	1022	48
	1112	72
Hydrofluoric Acid Diluted from 60 to 40% in Storage Tank. Test Specimens Immersed in Solution	Room	3
Commercial 60-65% Hydrofluoric Acid, Containing 1.5-2.5% Fluosilicic Acid, 0.3-1.25% Sulfuric Acid, and 0.01-0.03% Iron. Test Specimens Immersed in Solution in Storage Tank.	60–80	22
12% Hydrofluoric Acid, Containing 0.2% Fluosilicic Acid and 1 gram/liter Ferric Oxide as Ferric Salts. Test Specimens Immersed in Solution Resulting from Water Absorption of Fluorine from Chemical Process. Velocity, 3.2 fpm.	182	12

NITRIC AND NITROUS ACIDS. MONEL alloy 400 is severely attacked by nitric and nitrous acid except in solutions of 0.5% or less at room temperature. Because these chemicals are most successfully resisted by metals that develop passive oxide films, chromium-containing INCOLOY alloys 800 and 825 should be considered for such applications.

ORGANIC ACIDS. MONEL alloy 400 has useful resistance to corrosion by all the common organic acids. As with other non-oxidizing acids, aeration and temperature usually increase corrosion.

In air-free acetic acid at room temperature, rates are less than 4 mpy for all concentrations. The most corrosive concentration for aerated acetic acid is about 50%; above that, corrosion rate begins to fall.

The alloy is highly resistant to glacial acetic acid. In a test at 230°F, corrosion rate was 13 mpy.

MONEL alloy 400 has been used for distillation of fatty acids at temperatures of up to 500°F.

Corrosion by Alkalies

MONEL alloy 400 is highly satisfactory for handling most alkalies. It is resistant to corrosion by caustic soda throughout most of the concentration range (but not quite as resistant as Nickel 200 and 201). Some representative test data are shown in Table 27.

Alloy 400 is resistant to anhydrous ammonia and to ammonium hydroxide solutions of up to 3% concentration.

Corrosion by Salts

When salts are dissolved in water, they increase its conductivity and thereby enable it to carry a higher corrosion current. Therefore galvanic effects are more pronounced in salt solutions than in pure water. Some corrosion test data in such media are given in Table 28.

Table 27—Corrosion of MONEL Alloy 400 in Alkalies

Test Condition	Temperature, °F	Corrosion Rate, mpy
Laboratory Tests in 4% Sodium Hydroxide	Room	
Quiet Immersion		0.16
Air-Agitated		0.21
Continuous Alternate Immersion		0.07
Intermittent Alternate Immersion		0.15
Spray		0.01
Plant Test in 14% Caustic Soda in First Effect of Multiple-Effect Evaporator	190	0.05
Plant Test in 23% Caustic Soda in Tank Receiving Liquor from Evaporator	220	0.20
Plant Test in Single-Effect Evaporator Concentrating Caustic Soda from 30 to 50%	179	0.19
Laboratory Test in Caustic Soda during Concentration from 32 to 52%. Vacuum, 640-685 mm Mercury.	185–196	0.20
Test in 49-51% Caustic Soda in Storage Tank	131–167	0.08
Plant Test in 70% Electrolytic Caustic in Receiving Tank	194–239	1.1
Plant Test in 75% Caustic in Receiving Tank	275	1.7

Table 28—Corrosion of MONEL Alloy 400 in Salt Solutions

Test Condition	Temperature, °F	Corrosion Rate, mpy
Plant Test in Evaporation of Ammonium Chloride from 28 to 40%. Test Spool Immersed in Liquor.	216	12
Plant Test in Mixture of 72-100% Arsenic Trichloride and 0-28% Sulfur Monochloride with Small Amount of Moisture. Test Spool Located in Top of First Pass of Vertical Condenser Subject to Vapor and Some Condensate.	248–266	3.8
Plant Test in Evaporation of 37% Manganous Chloride Solution. Test Spool Half Submerged at Liquor Level in Open Pan into which Atmospheric Drum Dryer Drum Dips.	210–225	19
Laboratory Test in Phosphorus Pentachloride	169	0.4
Plant Test in Mixture of Phosphoric, Hydrochloric, and Cresylic Acids with Phosphorus Oxychloride. Test Spool at Liquid Line in Reaction Kettle.	180	74
Plant Test in Distillation of Crude Tin Tetrachloride. Test Spool Located in Still, above Steam Coil and below Liquid Level.	220–240	3.2
Plant Test in Double-Effect Zinc Chloride Evaporator		
Weak Liquor Effect, 7.9-21% Zinc Chloride. Vacuum, 26-28 in. Mercury	90–100	4.5
Strong Liquor Effect, 21-69% Zinc Chloride. Vacuum, 15-18 in. Mercury	230–240	16
Plant Test in Evaporator Concentrating a Mixture of Magnesium and Calcium Chloride Brines to 50% Chlorides. Vacuum.	Boiling	2

MONEL alloy 400 is not subject to stress-corrosion cracking in any of the chloride salts and has excellent general resistance to all of the non-oxidizing halides.

NEUTRAL AND ALKALINE SALTS. Solutions of neutral or alkaline salts such as chlorides, carbonates, sulfates, nitrates, and acetates have little corrosive action. Corrosion rates are usually less than 1 mpy and seldom more than 5 mpy. Tests in hot saturated brine in a salt grainer showed a corrosion rate of 2 mpy.

ACID SALTS. The alloy has useful resistance to solutions of acid salts such as zinc chloride, ammonium sulfate, aluminum sulfate and ammonium chloride. Tests in zinc chloride being concentrated from 30 to 70% showed a corrosion rate of only 13 mpy. MONEL alloy 400 is used successfully for coils in open zinc chloride evaporators and for tubes in vacuum evaporators. The observed rate of corrosion in an aluminum sulfate concentrator was 6 mpy. It is also used for coke by-product ammonium sulfate saturators, pumps, ejectors and centrifugal driers. Plant corrosion tests in saturators or crystallizers have shown rates of 5 mpy or less.

OXIDIZING ACID SALTS. Alloy 400 is not resistant to oxidizing acid salts such as ferric chloride, ferric sulfate, cupric chloride, stannic chloride, mercuric chloride and silver nitrate except in very dilute solutions. This also applies to acids containing chromates, dichromates, nitrates, peroxides, and other oxidizing compounds except in a few specific cases, such as acid tanning and textile solutions containing chromates where the presence of glucose or other organic materials may have an inhibiting effect.[26]

OXIDIZING ALKALINE SALTS. Hypochlorites are the only common alkaline salts that are definitely corrosive. For continuous exposure, use is generally limited to the dilute solutions, containing less than 500 ppm available chlorine, frequently used for sterilizing. The limiting concentration of available chlorine which can be used in intermittent service is 3 gram/liter. The chlorine solution should be followed by rinsing and souring (acid) solutions, as in cyclic bleaching operations.

MONEL alloy 400 is useful in contact with alkaline peroxide bleaching solutions. Wire cloth of this material is a most satisfactory material for filters and cylinder molds used for the washing of paper pulp that has been bleached with hypochlorites, in which the solution often contains small amounts of free chlorine.

Corrosion by Mercury

MONEL alloy 400 resists amalgamation by mercury at moderate temperatures. (In 15-day tests at 750°F, however, amalgamation has been noted.)

The alloy is subject to stress cracking in the presence of mercury or mercury salts if not annealed prior to exposure.[19] Suggested heat treatment is 1000°-1200°F/1 hr followed by slow cooling. It is also advisable to oxidize the surface slightly during annealing and leave the oxide film on the surface to increase resistance to amalgamation.

WORKING INSTRUCTIONS

MONEL alloy 400 can be readily joined and fabricated. By proper control of the amount of hot or cold work and by the selection of appropriate thermal treatments, finished fabrications can be produced to a rather wide range of mechanical properties.

Heating and Pickling

THERMAL TREATMENTS. General procedures and precautions for heating alloy 400 either in preparation for hot working or for achievement of desired mechanical properties may be found in HEATING AND PICKLING HUNTINGTON ALLOYS.[27] The material will remain bright and free from discoloration when heated and cooled in a reducing atmosphere or quenched in an alcohol-water solution. Rate

of cooling will have no significant effect. Alloy 400 will form an adherent oxide film if allowed to cool in air after heating.

Both cold-worked and hot-worked MONEL alloy 400 requires thermal treatment to develop the optimum combination of strength and ductility and to minimize distortion during subsequent machining. How thermal treatment affects properties is shown in Figure 19.

Stress equalizing of cold-worked material causes an increase in the yield strength at 0.00% offset without marked effects on other properties (see Figure 19). Stress equalizing is done by holding for about 3 hr at a temperature of 575°F.

Stress relieving will reduce stresses without producing a recrystallized grain structure. This treatment is recommended to obtain minimum "walking" or distortion after metal removal. Heating for 1 to 2 hr at 1000° to 1050°F will relieve strains in either hot- or cold-worked products. As discussed in the section on corrosion, stress relief (1000°–1200°F/1 hr, followed by slow cooling) is strongly recommended as a precaution against stress-corrosion cracking in certain environments. As shown in Figure 19, stress relieving slightly decreases tensile strength, yield strength, and hardness and slightly increases elongation.

Annealing can completely soften work-hardened material. Time and temperature required depend on the amount of previous cold work. In general, alloy 400 is annealed by the open heating method by holding at 1600° to 1800°F for 2–10 min, whereas box annealing is done most satisfactorily at 1400° to 1500°F for 1–3 hr at temperature.

The effects of heating on properties of cold-drawn and hot-rolled material are compared in Figures 19 and 20.* In these tests, the cold-drawn rod developed an annealed temper after 3 hr at temperature at 1300°F, and the hot-rolled plate, after 3 hr at about 1470°F. More data on time-temperature-hardness relationships are shown in Figure 21. They may be used as guides for establishing procedures for specific applications.

Grain growth occurs when material is heated in the upper portion of the annealing temperature range. Figure 22 indicates grain sizes which may be expected from open annealing of cold-rolled strip.

PICKLING. Pickling can produce bright, clean surfaces on MONEL alloy 400. Procedures and precautions are described in the publication, HEATING AND PICKLING HUNTINGTON ALLOYS.

Fabricating

MONEL alloy 400 is readily fabricated by standard processes. Special recommendations may be found in FABRICATING HUNTINGTON ALLOYS.[29]

HOT FORMING. With respect to its resistance to hot deformation, MONEL alloy 400 is softer than many steels. It can, therefore, be hot-formed into almost any shape.

The use of proper temperatures during hot forming is important. The range of hot-forming temperatures is 1200° to 2150°F. For heavy reductions, recommended metal temperature is 1700° to 2150°F. Light reductions may be taken down to 1200°F. Working at the lower temperatures produces higher mechanical properties and smaller grain size.

Prolonged soaking at hot-working temperatures is detrimental. If a delay occurs during processing, the furnace should be cut back to 1900°F and not brought to temperature until operations are resumed. In no case should the alloy be heated above 2150°F; permanent damage may result.

Heavy forging should not be carried out so rapidly that the metal becomes overheated from working. The use of an optical pyrometer is recommended.

*Data in Figure 20 derived from Reference 28.

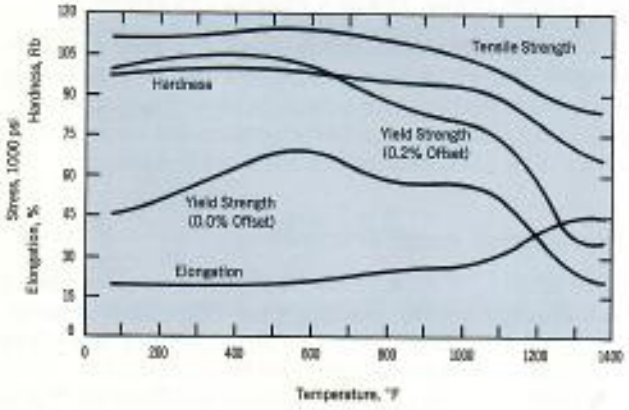


Figure 19—Effect of annealing (3 hr) on room-temperature properties of MONEL alloy 400 cold-drawn rod.

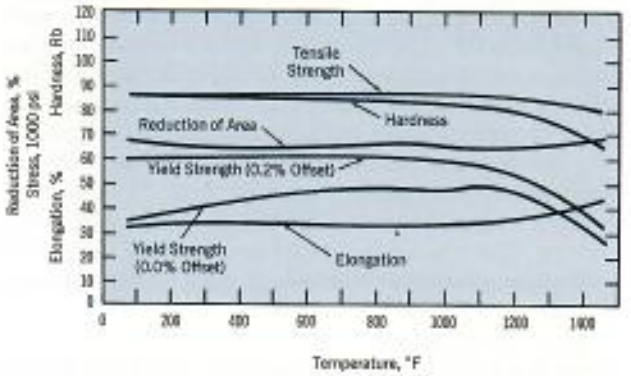


Figure 20—Effect of annealing (3 hr) on room-temperature properties of hot-rolled MONEL alloy 400 plate. At 1470°F, material is fully annealed. (Hardness converted from BHN.).

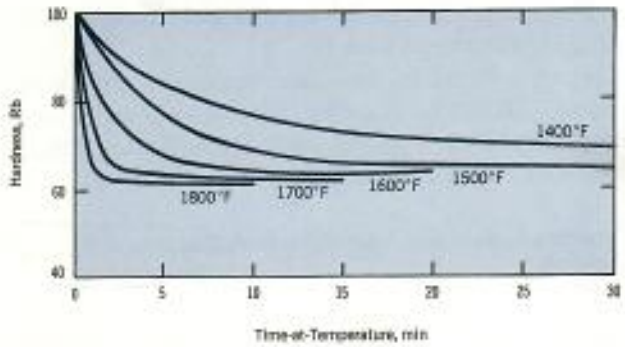


Figure 21—Approximate time required at various temperatures to produce different hardness levels in MONEL alloy 400 cold-rolled strip by open annealing.

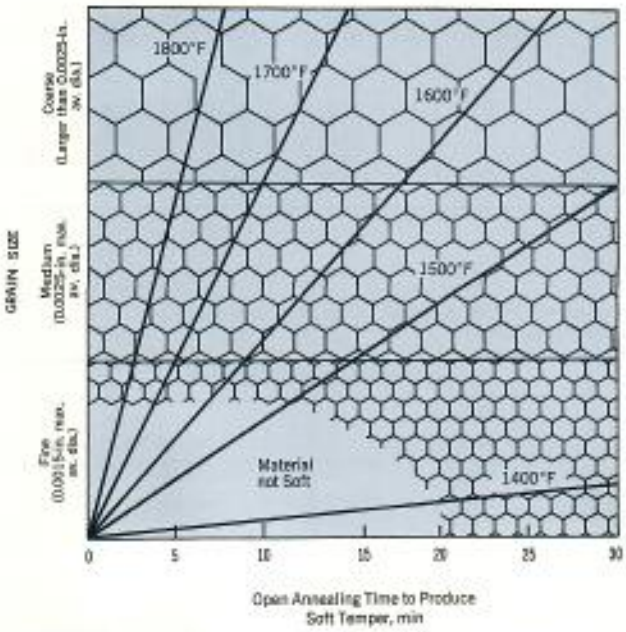


Figure 22—Approximate time required at various temperatures to produce different grain sizes in MONEL alloy 400 cold-rolled strip by open annealing.

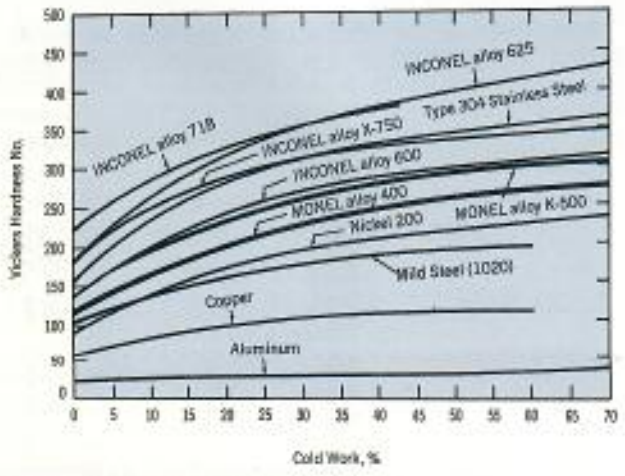


Figure 23—Effect of cold work on hardness.

In hot-bending operations the metal should be worked as soon as possible after removal from the furnace.

Preheating tools and dies to about 500°F is helpful to prevent chilling the material while working.

A controlled forging procedure is necessary to meet the requirements of some specifications for forged, hot-finished parts. Both the amount of reduction and the finishing temperature must be controlled in order to develop the desired properties.

One procedure for producing forgings to such specifications consists of taking 30–35% reduction following the final reheat.

This is accomplished as follows:

1. Reheat.
2. Forge to a section having about 5% larger area than the final shape (take at least 25% reduction).
3. Cool to 1300°F.
4. Finish to size (5% reduction).

High-tensile forgings, as described in certain military specifications, also require a minimum of 30–35% reduction following the last reheat. This is taken in the following manner:

1. Reheat.
2. Forge to a section having an area about 25% larger than the final shape (take about 5% reduction).
3. Cool to 1300°F.
4. Finish to size (25% reduction).

Grain refinement is achieved by using a temperature of 2000°F for the final reheat and by increasing the amount of reduction taken after the last reheat.

COLD FORMING. MONEL alloy 400 is adaptable to virtually all methods of cold fabrication. The forces required and the rate of work hardening are intermediate between those of mild steel and Type 304 stainless steel (see Figure 23).

Machining

Alloy 400 can be machined at satisfactory rates with machine tools generally employed by industry. The best tool materials and design, speeds, coolants, and other factors are discussed in MACHINING HUNTINGTON ALLOYS.[30] In general, cold-drawn or cold-drawn, stress-relieved material is recommended for best machinability and smoothest finish.

Joining

MONEL alloy 400 is readily welded, brazed, and soldered. Procedures and recommendations are outlined in JOINING HUNTINGTON ALLOYS.[31]

Alloy 400 may be welded by:

The oxyacetylene process using matching-composition filler metal,

The gas tungsten-arc or gas metal-arc process using MONEL Filler Metal 60,
The shielded metal-arc process using MONEL Welding Electrode 190, or
The submerged-arc process using MONEL Filler Metal 60 and INCOFLUX 5 Submerged Arc Flux.

(For more information see the publication, Joining Huntington Alloys.[32])

When welding to low-alloy or carbon steel is required, MONEL Welding Electrode 190 is used. Properties of alloy 400-to-alloy 400 and alloy 400-to-steel welds are shown in Tables 29 and 30.

Table 29—High-Temperature Tensile Properties of MONEL Alloy 400 Welds Made with MONEL Welding Electrode 190 [a]

Temperature, °F	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %	Reduction of Area, %
		All-Weld Metal		
Room	74,350	46,650	41.0	66.4
200	72,250	46,050	39.0	56.5
400	68,600	43,100	33.5	64.2
600	69,250	43,150	34.0	59.9
800	66,100	43,000	32.5	47.4
1000	55,950	38,700	22.0	24.5
		Transverse Across Weld[b]		
Room	76,200	48,500	24.0	48.0
400	69,600	45,000	24.0	58.3
600	68,500	45,800	21.0	56.5
800	69,000	41,000	28.0	44.2

[a] Butt joints—½-in. MONEL alloy 400.
[b] All breaks occurred in weld.

Table 30—Room-Temperature Properties of Butt Joint Weld of 1 ¼-in. MONEL Alloy 400 and Steel Using MONEL Welding Electrode 190

Property	As-Welded		Heat-Treated 1150°F/100 hr, A.C.	
	All-Weld Metal	Transverse Across Weld[a]	All-Weld Metal	Transverse Across Weld[a]
Tensile Strength, psi	71,000	78,000	70,500	76,400
Yield Strength, psi	48,300	51,500	45,300	36,700
Elongation, %	38	21	38	31
Reduction of Area, %	63.3	60.5	63.3	59.3

[a] Break occurred in weld.

AVAILABLE PRODUCTS AND SPECIFICATIONS

MONEL alloy 400 is furnished in a wide range of standard mill forms including sheet, strip, rod, bar, plate, tube, shapes, and forgings. Popular forms and sizes are available from stock; many specialty products may be obtained from converters. Inquire for complete information from any of the offices listed on the back cover of this bulletin.

Specifications for welding products may be found in the HANDBOOK OF HUNTINGTON ALLOYS.[18]

Applicable specifications are:

Product	ASME	ASTM	Federal	Military	SAE
Plate, Sheet, Strip	SB–127	B 127	QQ–N–281	MIL–N–894 MIL–T–842	AMS–4544
Bar, Rod, Forgings	SB–164	B 164	QQ–N–281	MIL–N–24106, MIL–N–894	AMS–4675
Pipe and Tube	SB–165	B 165	QQ–N–281	MIL–T–23520 MIL–T–1368	—
Condenser Tube	SB–163 SB–395	B 163 B 395	—	MIL–T–1368	—
Wire	—	—	QQ–N–281	MIL–N–894	AMS–7233

MONEL
alloys 401 and 404

MONEL copper-nickel alloy 401 and MONEL nickel-copper alloy 404 are used primarily in specialized electrical and electronic applications.

Composition of MONEL alloy 401 is shown in Table 31. Some typical constants and properties are given in Table 32. Alloy 401 is readily autogenously welded, in the thin sections in which it is most often used, by the gas tungsten-arc process. Resistance welding is a very satisfactory method for joining the material. It also exhibits good brazing characteristics.

Alloy 401 is normally furnished as strip and wire; other forms may be obtained on request. Inquire for complete information.

Table 31—Limiting Chemical Composition, %, of MONEL Alloy 401

Nickel	40.0-45.0	Cobalt	0.25 max.
Carbon	0.10 max.	Sulfur	0.015 max.
Manganese	2.25 max.	Silicon	0.25 max.
Iron	0.75 max.	Copper	Bal.

Table 32—Typical Constants and Properties [a] of MONEL Alloy 401

Density, lb/cu in.	0.321
Thermal Expansion, in./in./°F x 10^{-6}	
−320° – 70°F	7.0
70° – 200°F	7.6
70° – 500°F	8.5
70° – 1000°F	9.2
70° – 1500°F	9.8
70° – 2000°F	10.6
Thermal Conductivity, Btu/sq ft/hr/°F/in. at 70°F	133
Electrical Resistivity, ohm/circ mil/ft at 70°F	294
Temperature Coefficient of Resistance, ppm	±20
Curie Temperature, °F	< −320
Tensile Strength, psi	64,000
Yield Strength (0.2% Offset), psi	19,500
Elongation, %	51
Hardness, Rb	43

[a] Tensile properties determined for hot-rolled annealed rod.

Composition of MONEL alloy 404 (see Table 33) is carefully adjusted to provide a very low Curie temperature, low permeability, and good brazing characteristics. Its permeability (measured at 27°F with a field strength of 0.5 oersted) will not exceed 1.1. Because its low permeability is not significantly affected by processing and fabrication, the alloy is particularly suitable for electronic parts.

Also, much of the strength of alloy 404 is retained at out-gassing temperatures. Its thermal expansion characteristics are sufficiently close to those of many other alloys to permit the firing of composite metal tubes with negligible distortion.

Some physical constants and thermal properties of MONEL alloy 404 are shown in Table 34. Magnetic properties are in Table 35. Effect of temperature on modulus of elasticity is shown in Table 36. Figure 24 shows high-temperature tensile properties of annealed material.

MONEL alloy 404 can be fabricated by the same procedures used for MONEL alloy 400. It can be joined to itself by the gas tungsten-arc welding process without the addition of filler metal. Joints exhibit good ductility and strength, but care must be taken to avoid porosity.[31] The alloy may also be joined by the same processes and welding products used for alloy 400.* Brazing characteristics are very good; successful triple brazes have been made in hydrogen with a dew point of approximately +75°F.

MONEL alloy 404 is available in standard mill forms including sheet, strip, rod and bar, shapes, tube, and plate. Popular forms and sizes are available from stock; specialty products are available from converters. Inquire for complete information.

*See the section of this publication on MONEL alloy 400.

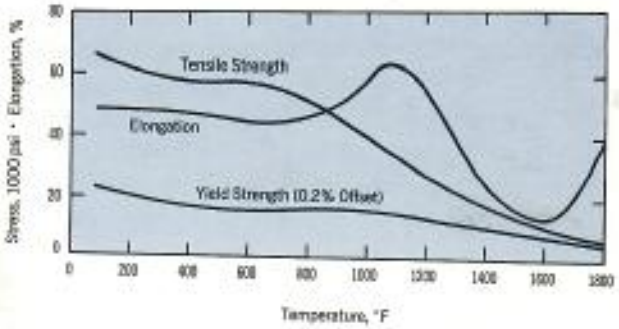


Figure 24—High-temperature tensile properties of cold-drawn MONEL alloy 404 rod annealed (1400°F/1 hr).

Table 33—Limiting Chemical Composition, %, of MONEL Alloy 404

Nickel (plus Cobalt)	52.0–57.0	Sulfur	0.024 max.
Carbon	0.15 max.	Silicon	0.10 max.
Manganese	0.10 max.	Copper	Bal.
Iron	0.50 max.	Aluminum	0.05 max.

Table 34—Physical Constants and Thermal Properties of MONEL Alloy 404

Density, lb/cu in.	0.321
Specific Heat, Btu/lb/°F, at 70°F	0.099
Thermal Expansion, in./in./°F x 10^{-6}	
70° – 200°F	7.4
70° – 500°F	8.5
70° – 1000°F	9.2
70° – 1500°F	9.8
Thermal Conductivity, Btu/sq ft/hr/in./°F, at 70°F	146
Electrical Resistivity, ohm/circ mil/ft, at 70°F	300

Table 35—Magnetic Properties of MONEL Alloy 404

Condition	Permeability at 78°F, 200 Oersted	Curie Temperature, °F
As-Forged	1.0047	−121
Annealed and Furnace-Cooled	1.0017	−110

Table 36—Modulus of Elasticity of MONEL Alloy 404

Temperature, °F	Modulus in Tension, 10^6 psi	Shear Modulus, 10^6 psi	Poisson's Ratio
78	24.5	9.44	0.295
100	24.4	9.44	0.291
200	24.0	9.25	0.298
300	23.7	9.10	0.300
400	23.3	8.95	0.301
500	23.9	8.79	0.301

MONEL alloy R-405

MONEL nickel-copper alloy R–405 is the free-machining grade of alloy 400. Its greater sulfur content enhances machinability. It has essentially the same corrosion resistance and physical properties as alloy 400 but a slightly different range of mechanical properties. Alloy R–405 is used chiefly for automatic-screw-machine stock and is not generally recommended for other applications. Composition is shown in Table 37.

Thermal expansion of alloy R–405 is shown in Table 38. The values for physical constants and other thermal properties of MONEL alloy 400 (Tables 2 and 3) may be used for MONEL alloy R-405.

Table 37—Limiting Chemical Composition, %, of MONEL Alloy R-405

Nickel (plus Cobalt)	63.0-70.0	Sulfur	0.025-0.060
Carbon	0.30 max.	Silicon	0.50 max.
Manganese	2.0 max.	Copper	Bal.
Iron	2.5 max.		

Table 38—Thermal Expansion of MONEL Alloy R-405

Temperature, °F	Mean Linear Expansion,* in. /in. /°F x 10^{-6}
200	7.6
400	8.4
600	8.7
800	9.0
1000	9.2
1200	9.4
1400	9.7
1600	9.9
1700	10.0
1800	10.1
2000	10.4

* Between 70°F and temperature shown.

MECHANICAL PROPERTIES

The ranges of nominal mechanical properties of MONEL alloy R-405 rod and bar are shown in Table 39.

Fatigue strength of alloy R-405 in various conditions is shown in Table 40. Toughness of the material is shown by the impact data in Tables 41, 42, and 43. The tension and torsion data are from Catlin and Mudge.[11] Table 44 gives compressive properties found for the alloy.

Table 39—Nominal Mechanical Property Ranges of MONEL Alloy R-405 Rod and Bar [a]

Condition	Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Elongation, %	Hardness	
				Brinell (3000-kg)	Rockwell B
Annealed	70–85	25–40	50–35	110–140	60–76
Hot-Finished	75–90	35–60	45–30	130–170	72–86
Cold-Drawn, As-Drawn	85–115	50–105	35–15	160–245	85–23C

[a] The ranges shown are composites for various product sizes and therefore are not suitable for specification purposes.

Table 40—Fatigue Strength of MONEL Alloy R-405 Rod [a]

Condition	Fatigue Strength (10^8 Cycles), 1000 psi	Tensile Strength, 1000 psi	Ratio, Fatigue Strength/ Tensile Strength
Annealed	30.0	75.5	0.40
Hot-Rolled	36.0	80.0	0.45
Cold-Drawn, As-Drawn	36.5	90.5	0.40
Cold-Drawn, Stress-Equalized[b]	40.0	95.0	0.42

[a] Rotating-beam tests of polished specimens in air at room temperature and 10,000 rpm.
[b] 525°F/3 hr.

Alloy R-405 is approved as a material of construction under Section VIII (Pressure Vessels—Division 1) of the ASME Boiler and Pressure Vessel Code. Maximum allowable design stresses for alloy R-405 (designated Class B material) are shown with those for alloy 400 in Table 21 of this bulletin. Design stress intensity values for use in connection with Section III, Nuclear Vessels, of the Code, are included in Tables 22 and 23.

Table 41—Impact Strength [a] of MONEL Alloy R-405 Rod

Condition	Impact Strength, ft-lb	
	Izod	Charpy U Notch
Hot-Rolled	96	187
Cold-Drawn	99	140
Annealed	120+	196

[a] Tested at room temperature. None of the specimens was completely fractured.

Table 42—Tension Impact Strength of MONEL Alloy R-405 Rod

Condition	Tension Impact			Tensile Properties				
	Impact Strength,[a] ft-lb	Elongation in 3.54 In., %	Reduction of Area, %	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation in 2 In., %	Reduction of Area, %	Hardness, Brinell (3000-kg)
Cold-Drawn 24%, Stress-Relieved	90	17.0	64.7	83,150	74,350	28.0	66.6	180
Annealed 1450°F/3 hr	148	35.0	69.1	73,350	28,000	44.5	70.1	116

[a] Specimens completely broken.

Table 43—Charpy Torsion Impact Strength of MONEL Alloy R-405 Rod

Temper	Impact Strength		Angle of Twist,[a] degree	Hardness, Brinell (3000-kg)
	ft-lb	ft-lb/sq in.		
Hot-Rolled	30	605	100.5	121
Cold-Drawn 24%, Stress-Relieved	34	687	100.5	180
Annealed 1450°F/3 hr	30	606	102.0	116

[a] Gage length about 5/16 in.; specimen described in Reference 11.

Table 44—Compressive Properties of MONEL Alloy R-405 Rod

Temper	Compression		Tension			
	Yield Strength (0.01% Offset), psi	Yield Strength (0.2% Offset), psi	Tensile Strength, psi	Yield Strength (0.01% Offset), psi	Yield Strength (0.2% Offset), psi	Elongation, %
Hot-Rolled	26,000	34,000	76,000	33,000	36,000	39.5
Cold-Drawn[a]	51,000	66,000	83,000	62,000	74,000	28.0
Annealed[b]	23,000	26,000	73,000	25,000	28,000	44.5

[a] Stress-equalized at 525°F after cold drawing.
[b] Cold-drawn + 1450°F/3 hr, F.C.

METALLOGRAPHY

The typical microstructure of MONEL alloy R–405 is shown in Figure 25. Because its composition contains sulfur, the structure of the alloy displays a considerable number of nickel-copper sulfides. These sulfides, which promote machinability, appear as elongated stringers in Figure 25.

Directions for preparing and etching macro- and microspecimens are given in the HANDBOOK OF HUNTINGTON ALLOYS.[18]

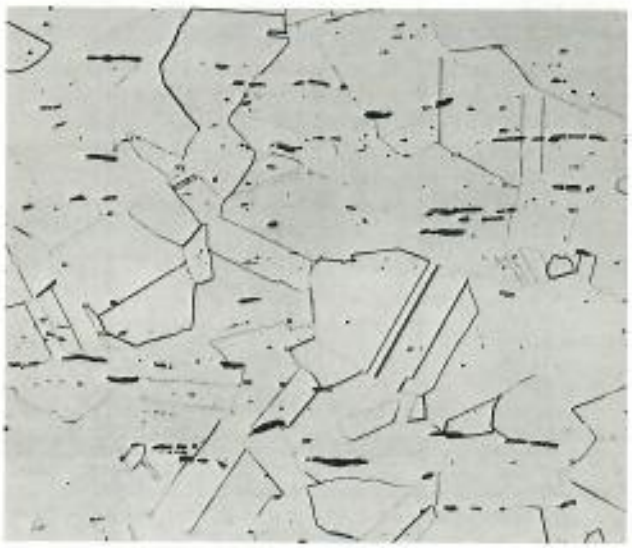


Figure 25—Longitudinal section of MONEL alloy R-405 rod, showing sulfide stringers. Etchant: Sodium cyanide—ammonium persulfate. 250X

WORKING INSTRUCTIONS

MONEL R–405 is fabricated, pickled, and heat-treated by the same procedures as for alloy 400. The alloy is not recommended for forging.

MACHINING. MONEL alloy R–405 was especially developed for good machinability and is recommended for use with automatic screw machines. The nickel-copper sulfides resulting from the sulfur in its composition act as chip breakers. Because of these inclusions the surface finish of the alloy is not as smooth as that of MONEL alloy 400.

Some results obtained in actual production runs in commercial screw machines are shown in Table 45. For more data and recommendations on procedures and tool design, see MACHINING HUNTINGTON ALLOYS.[30]

JOINING. MONEL alloy R-405 may be joined by standard welding, brazing, and soldering techniques. Technical Service, Huntington Alloy Products Division, can provide specific recommendations. In general, processes and procedures are the same as for MONEL alloy 400.

AVAILABLE PRODUCTS AND SPECIFICATIONS

MONEL alloy R-405 is normally furnished only in the form of rod and bar. Standard sizes of these products are available from stock. Wire and specialty products are available from converters. Inquire from any of the offices listed on the back cover for full information.

Applicable specifications (rod and bar) are:

ASME	SB-164	ASTM	B 164
Federal	QQ-N-281	SAE	AMS-4674, 7234
Military	MIL-N-894		

Table 45—Automatic Screw Machining of MONEL Alloy R-405

Operation	Test I: Size of Material—⅝-in. Dia. Tooling—High-Speed Steel Lubricant—Sulfurized Chlorinated Cutting Oil				Test II: Size of Material—⅛-in. Hexagon Tooling—High-Speed Steel Lubricant—Sulfurized Mineral-Base Sperm Oil		Test III: Size of Material—⅝-in. Hexagon Tooling—High-Speed Steel Lubricant—Sulfurized Mineral-Base Sperm Oil	
			Surface Finish, microinch					
	Speed sfpm	Feed, ipr	First Piece	Last Piece	Speed, sfpm	Feed, ipr	Speed, sfpm	Feed, ipr
Box Turning	143	0.004	—	—	—	—	—	—
Spot Drilling	65	0.0035	—	—	—	—	—	—
Forming	143	0.001	25-45	100	161	0.0007	176	0.005
Drilling								
0.261 in. Dia.	60	0.003	8-20	30-60	—	—	—	—
0.199 in. Dia.	46	0.0025	45	—	—	—	—	—
⅜ in. Dia.	—	—	—	—	84	0.004	—	—
9/32 in. Dia.	—	—	—	—	62	0.0035	—	—
½ in. Dia.	—	—	—	—	—	—	112	0.005
⅝ in. Dia.	—	—	—	—	—	—	84	0.0045
Reaming								
⅝ to ½ in. Step	—	—	—	—	21	0.0075	—	—
1 1/32 in. Dia.	—	—	—	—	—	—	38	0.018
Tapping								
⅜ in.-20 TPI	—	—	—	—	—	—	41	0.050
Threading								
⅜ in.-14 TPI	33	0.071	Smooth	Smooth	—	—	—	—
⅜ in.-21 TPI	—	—	—	—	25	0.050	—	—
Cut-Off	143	0.001	40-80	30	100	0.0008	140	0.0008
Results	575 parts were produced in 75 sec machine time per piece. Tools were not excessively worn after 11.8 hr.				495 parts were produced in 60 sec machine time per piece. Tools were not excessively dulled after 8.2 hr. Surface finish was equal or better than that in Test I.		543 parts were produced in 46 sec machine time per piece. Tools required regrinding after 6.7 hr. Surface finish was equal to or better than in Test I.	

MONEL alloy K-500

MONEL nickel-copper alloy K–500 combines the excellent corrosion resistance characteristic of MONEL alloy 400 with the added advantages of greater strength and hardness. The increased properties are obtained by adding aluminum and titanium to the nickel-copper base, and by heating under controlled conditions so that submicroscopic particles of Ni_3 (Ti, Al) are precipitated thoughout the matrix. The thermal processing used to effect precipitation is commonly called age hardening or aging. The composition of the alloy is given in Table 46.

Typical applications for alloy K–500 are pump shafts and impellers; doctor blades and scrapers; oil-well drill collars and instruments; electronic components; springs; and valve trim.

PHYSICAL CONSTANTS AND THERMAL PROPERTIES

The nominal physical constants of MONEL alloy K–500 are shown in Table 47. Thermal and electrical properties appear in Table 48, and magnetic characteristics in Table 49[35]. Effect of temperature on modulus of elasticity is shown in Figure 26.

Table 46—Limiting Chemical Composition, %, of MONEL Alloy K-500

Nickel (plus Cobalt)	63.0-70.0	Silicon	0.50 max.
Carbon	0.25 max.	Copper	Bal.
Manganese	1.50 max.	Aluminum	2.30-3.15
Iron	2.00 max.	Titanium	0.35-0.85
Sulfur	0.01 max.		

Table 47—Physical Constants of MONEL Alloy K-500

Density, gram/cc	8.46
lb/cu in.	0.306
Melting Range, °F	2400-2460
Modulus of Elasticity, 10^6 psi, Tension	26.0
Torsion	9.5
Poisson's Ratio	0.32

Table 48—Thermal Properties of MONEL Alloy K-500

Temperature, °F	Mean Linear Expansion, [a] in./in./°F × 10^{-6}	Thermal Conductivity, [b] Btu/in./hr/sq ft/°F	Specific Heat, [b] Btu/lb/°F	Electrical Resistivity, [c] ohm/circ mil/ft
−320	6.2	–	–	330.8[d]
−250	6.5	86	0.071	–
−200	6.8	92	0.077	–
−100	7.2	103	0.087	–
70	–	121	0.100	370
200	7.6	136	0.107	372
400	8.1	156	0.114	378
600	8.3	178	0.117	385
800	8.5	198	0.120	390
1000	8.7	220	0.125	393
1200	9.1	240	0.132	396
1400	9.3	262	0.141	400
1600	9.6	282	0.157	408
1800	–	302[e]	0.186[e]	418

[a] Between 70°F and temperature shown. Age-hardened material. Data at −100°, −200°, and −250°F are from Arp et al.[33] Lucks and Deem[34] show data on annealed material that correspond quite well with heat-treated material. These values are, in in./in./°F × 10^{-6}: 6.48 at −250°F, 6.57 at −200°F, 6.85 at −100°F, 7.35 at 200°F, 7.86 at 400°F, 8.08 at 600°F, 8.32 at 800°F, 8.64 at 1000°F, 8.97 at 1200°F, 9.28 at 1400°F, 9.62 at 1600°F and 9.90 (extrapolated) at 1800°F.

[b] Data are from Lucks and Deem.[34] Material was in the annealed condition prior to test.

[c] Electrical resistivity is markedly influenced by thermal history because of the age-hardening characteristics of the alloy. The data shown (except for at −320°F) were obtained at The International Nickel Company Research Laboratory, Bayonne, New Jersey. They represent values measured on decreasing temperature on material in an equivalent to annealed condition with a small amount of age hardening.

[d] Resistivity of sample from this test tested at room temperature: 355.5 ohm/circ mil/ft.

[e] Extrapolated.

Table 49—Magnetic Characteristics of MONEL Alloy K-500

Condition	Tensile Strength, psi	Permeability[a]	Curie Temperature, °F, for Permeability of			
			1.01	1.02	1.05	1.1
Annealed, Quenched	92,500	1.0011	−210	−210	—	—
Annealed, Age-Hardened	151,000	1.0018	−153	−178	−202	−210
Cold-Drawn 20%	137,000	1.0011	−210	—	—	—
Cold-Drawn 20% and Age-Hardened	186,500	1.0019	−130	−150	−182	−210
Cold-Drawn 50%	151,250	1.0010	−210	—	—	—
Cold-Drawn 50% and Age-Hardened	198,000	1.0019	−130	−150	−182	−210

[a] Room temperature, 200 oersted.

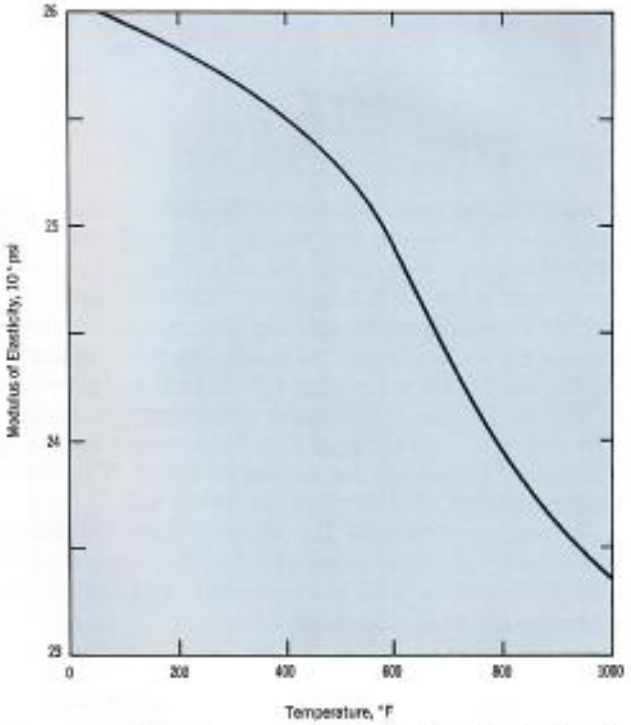


Figure 26—Effect of temperature on modulus of elasticity in tension of MONEL alloy K-500 (determined by dynamic method).

A useful characteristic of the alloy is that it is virtually nonmagnetic, even at quite low temperatures (see Table 49). It is possible, however, to develop a magnetic layer on the surface of the material during processing. Aluminum and copper may be selectively oxidized during heating, leaving a magnetic nickel-rich film on the outside of the piece. The effect is particularly noticeable on thin wire or strip where there is a high ratio of surface to weight. The magnetic film can be removed by pickling or bright dipping in acid, and the nonmagnetic properties of the material will be restored.

The combination of low magnetic permeability, high strength, and good corrosion resistance has been used to advantage in a number of applications, notably oil-well surveying equipment and electronic components.

Emittance and solar absorptance of alloy K–500 are given in Figures 27 and 28. The data are from Wilkes[36] as found in Wood, Deem, and Lucks.[37]

MONEL alloy K–500 has been found[35] to have exceptionally good dimensional stability, both in long-time exposure tests and in cyclic tests. Results are shown in Table 50. This property of the alloy has led to its use in high-precision devices, such as gyros.

Age hardening causes an initial volume contraction. An annealed rod contracted 2.5×10^{-4} in. per in. during aging.

Table 50—Dimensional Stability of MONEL Alloy K-500

Condition	Length Change, microinch/inch					
	Aged at 70°F			Aged at 160°F		
	1 Month	3 Months	12 Months	1 Month	3 Months	Cycled[a]
Cold-Drawn	0	−5	−5	–	–	–
Cold-Drawn, Aged[b]	−5	−5	–	0	−5	0

[a] Cycled 10 times between 70°F and −95°F.
[b] 1000°F/9 hr, F.C. to 900°F, A.C.

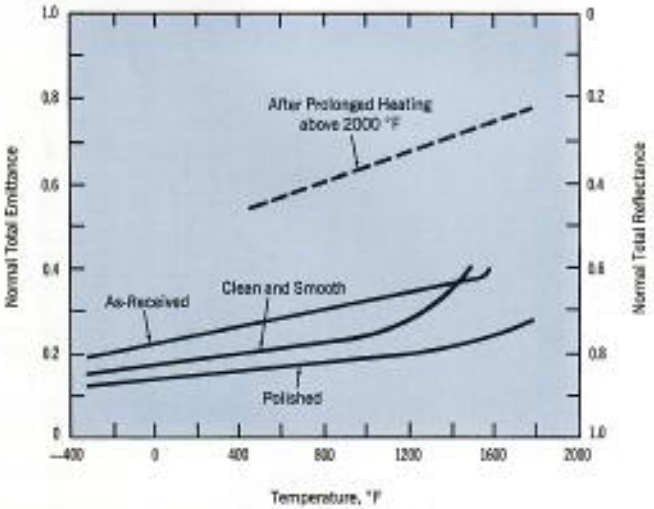


Figure 27—Normal total emittance of MONEL alloy K-500. (Total radiation detector; comparison blackbody. Measured in a 10-micron pressure of helium.)

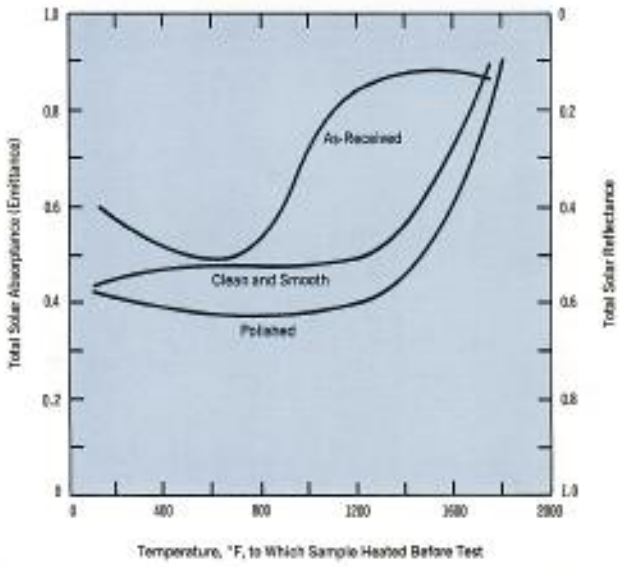


Figure 28—Total solar absorptance at 100°F of MONEL alloy K-500. (Comparison standards; comparison pyroheliometer. Measured in air.)

MECHANICAL PROPERTIES

Tensile Properties and Hardness

The nominal ranges of room-temperature tensile properties and hardness are shown in Table 51. Approximate relationships between tensile properties and hardness for rods and forgings appear in Figures 29 and 30, and similar relationships for sheet and strip are shown in Figure 31. Notch properties are compared with those of smooth specimens in Table 52.

Short-time, high-temperature tensile properties of alloy K–500 rod in various conditions are shown in Figures 32–34. Testing speeds for hot-rolled bar were 0.016 inch per minute through the yield strength and 0.026 inch per minute from there to fracture. The cold-drawn specimens were tested at 0.00075 inch per minute through the yield strength, then 0.075 inch per minute.

Effect of temperature on hardness of hot-finished and hot-finished, aged material[39] is shown in Table 53.

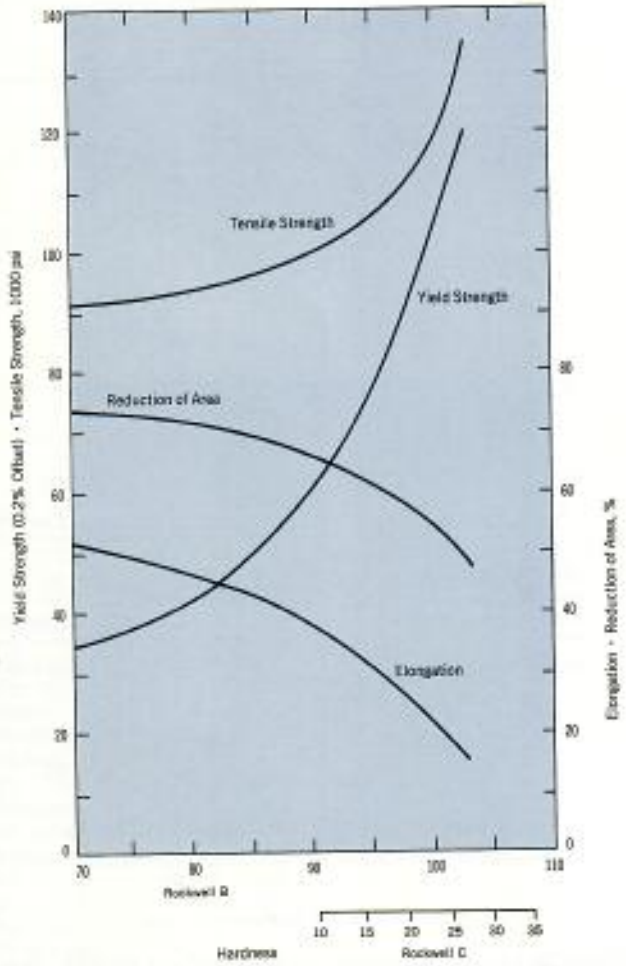


Figure 29—Approximate relationships between tensile properties and hardness of MONEL alloy K-500 hot-finished rods and forgings and cold-drawn rods.

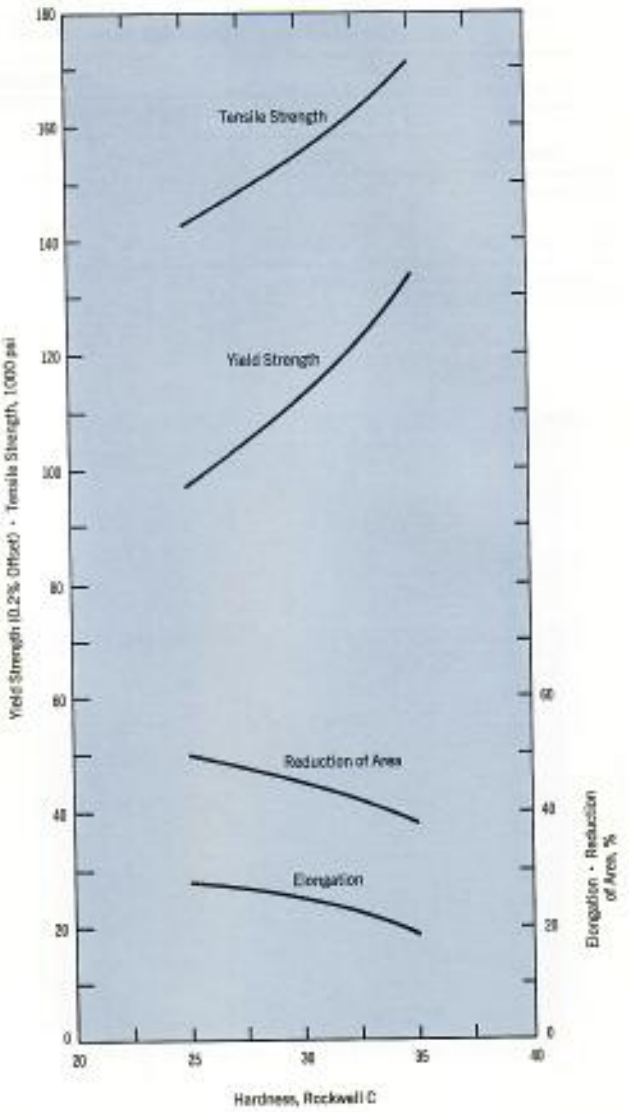


Figure 30—Approximate relationships between tensile strength and hardness of MONEL alloy K-500 age-hardened rods and forgings.

Table 51—Nominal Mechanical Property Ranges[a] of MONEL Alloy K-500

Form and Condition	Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Elongation, %	Hardness	
				Brinell (3000-kg)	Rockwell
Rod and Bar					
Hot-Finished	90–155	40–110	45–20	140–315	75B–35C
Hot-Finished, Aged[b]	140–190	100–150	30–20	265–346	27–38C
Hot-Finished, Annealed	90–110	40–60	45–25	140–185	75–90B
Hot-Finished, Annealed and Aged[b]	130–165	85–120	35–20	250–315	24–35C
Cold-Drawn, As-Drawn	100–140	70–125	35–13	175–260	88B–26C
Cold-Drawn, Aged[b]	135–185	95–160	30–15	255–370	25–41C
Cold-Drawn, Annealed	90–110	40–60	50–25	140–185	75–90B
Cold-Drawn, Annealed and Aged[b]	130–190	85–120	30–20	250–315	24–35C
Sheet, Cold-Rolled, Annealed	90–105	40–65	45–25	—	85B max.
Strip, Cold-Rolled					
Annealed	90–105	40–65	45–25	—	85B max.
Annealed and Aged[b]	130–170	90–120	25–15	—	24C min.
Spring Temper	145–165	130–160	8–3	—	25C min.
Spring Temper, Aged[b]	170–220	130–195	10–5	—	34C min.
Tube and Pipe, Seamless					
Hot-Finished	—[c]	—[c]	—[c]	—[c]	—[c]
Cold-Drawn, Annealed	90–110	40–65	45–25	—	90B max.
Cold-Drawn, Annealed and Aged[b]	130–180	85–120	30–15	—	24–36C
Cold-Drawn, As-Drawn	110–160	85–140	15–2	—	95B–32C
Cold-Drawn, As-Drawn, Aged[b]	140–220	100–200	25–3	—	27–40C
Plate					
Hot-Finished	90–135	40–110	45–20	140–260	75B–26C
Hot-Finished, Aged[b]	140–180	100–135	30–20	265–337	27–37C
Wire, Cold-Drawn[d]					
Annealed	80–110	35–65	40–20	—	—
Annealed and Aged[b]	120–150	90–110	30–15	—	—
Spring Temper	145–190	130–180	5–2	—	—
Spring Temper, Aged[b]	160–200	140–190	8–3	—	—

[a] The ranges shown are composites for various product sizes and therefore are not suitable for specification purposes.
[b] Nominal properties for material age-hardened to produce maximum properties.
[c] Properties on request.
[d] Properties shown are for sizes 0.0625–0.250-in. diameter. Properties for other sizes may vary from these.

Table 52—Room-Temperature Smooth and Notch Tensile Properties of MONEL Alloy K-500

Sample	Temper	Yield Strength (0.2% Offset), psi	Notched Tensile Strength, psi	Tensile Strength, psi	NT/TS[a]	Elongation, %	Reduction of Area, %	Hardness, Rc
Rod (2½-in. Dia.)	Cold-Drawn, Annealed, and Aged	97,500	185,500	152,500	1.22	25	43.0	28
Rod (3½-in. Dia.)	Hot-Rolled and Aged	119,000	212,000	165,000	1.28	22	45.2	32
Rod (3-in. Dia.)	Cold-Drawn and Aged	122,000	215,000	161,000	1.34	22	43.2	29
Threaded Cap Screw	Cold-Drawn and Aged	125,500	205,000	169,000	1.21	18	28.5	31
Threaded Stud	Cold-Drawn and Aged	128,000	232,000	165,000	1.41	20	42.0	33
		129,500	237,500	165,500	1.43	20	41.5	32

[a] Ratio of notch tensile strength to smooth tensile strength.

The low-temperature properties of MONEL alloy K–500 are outstanding. Tensile and yield strengths increase with decrease in temperature while ductility and toughness are virtually unimpaired. No ductile-to-brittle transformation occurs even at temperatures as low as that of liquid hydrogen. Thus the alloy is suitable for many cryogenic applications.

Properties of alloy K–500 base metal and welded sheet at temperatures down to −423°F, as reported by the National Aeronautics and Space Administration,[40] are shown in Figures 35-37. Welds can be produced with the strength of age-hardened base

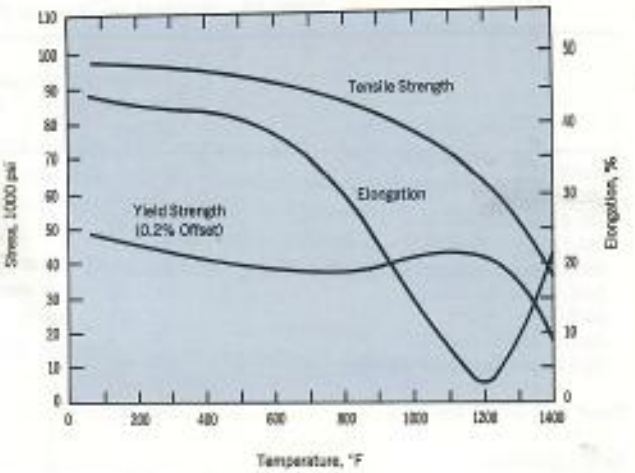


Figure 32—High-temperature tensile properties of MONEL alloy K-500 rod (hot-rolled, as-rolled).

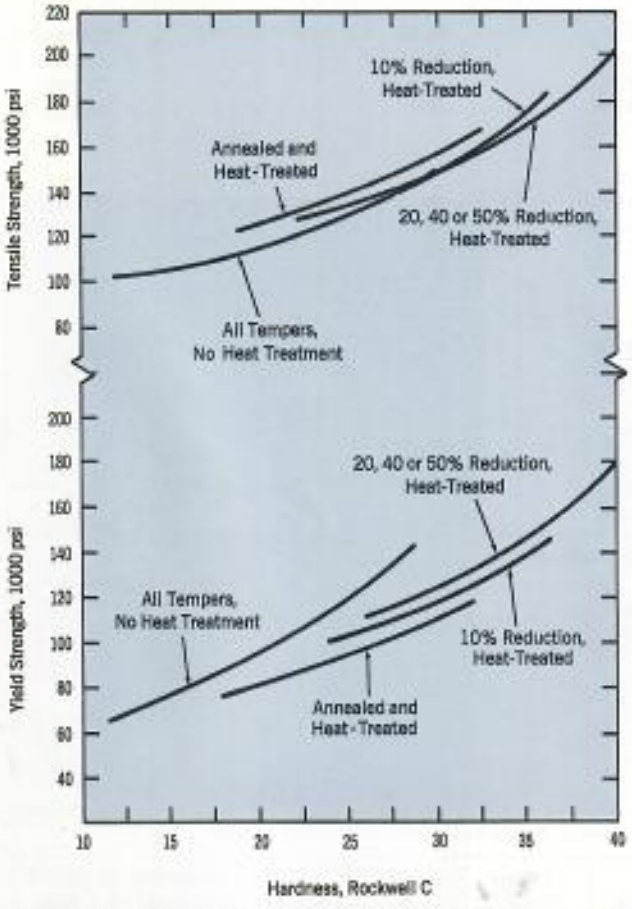


Figure 31—Approximate relationships between tensile properties and hardness of MONEL alloy K-500 strip and sheet.

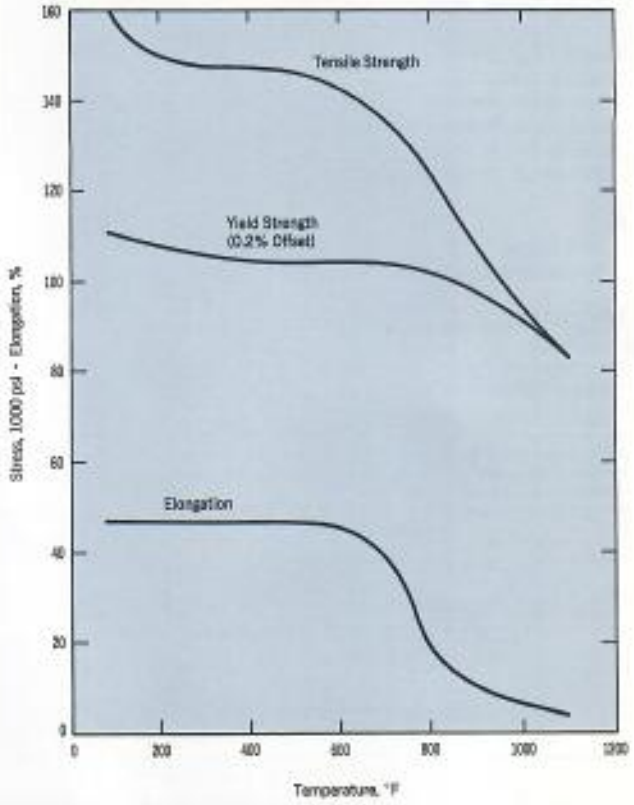


Figure 33—High-temperature tensile properties of hot-finished age-hardened MONEL alloy K-500.

Table 53—Hot Hardness of MONEL Alloy K-500 Rod

Condition	Hardness, Brinell					
	70°F	700°F	800°F	900°F	1000°F	1100°F
Hot-Finished	241	223	207	201	170	179
Hot-Finished, Aged	331	311	302	293	255	229

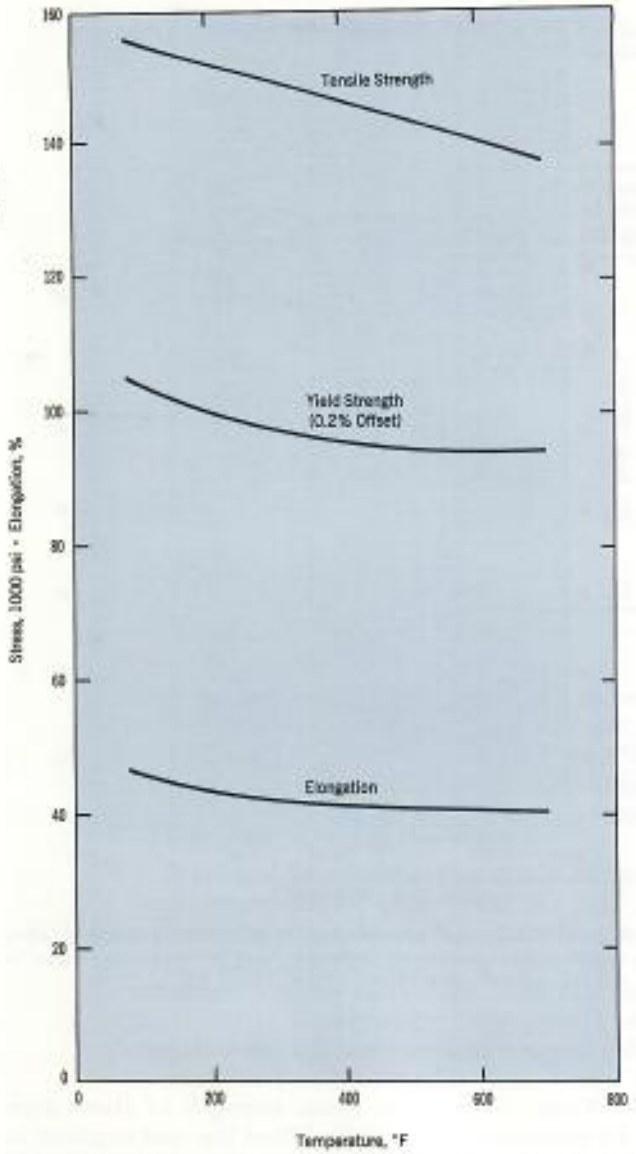


Figure 34—High-temperature tensile properties of annealed and age-hardened MONEL alloy K-500.

metal with no serious loss in ductility if aging treatments are performed after welding annealed material. Welding of age-hardened material should be avoided because of greatly reduced ductility.

Tensile tests on sheet and autogenous welds by Watson *et al* [41] are shown in Table 54.

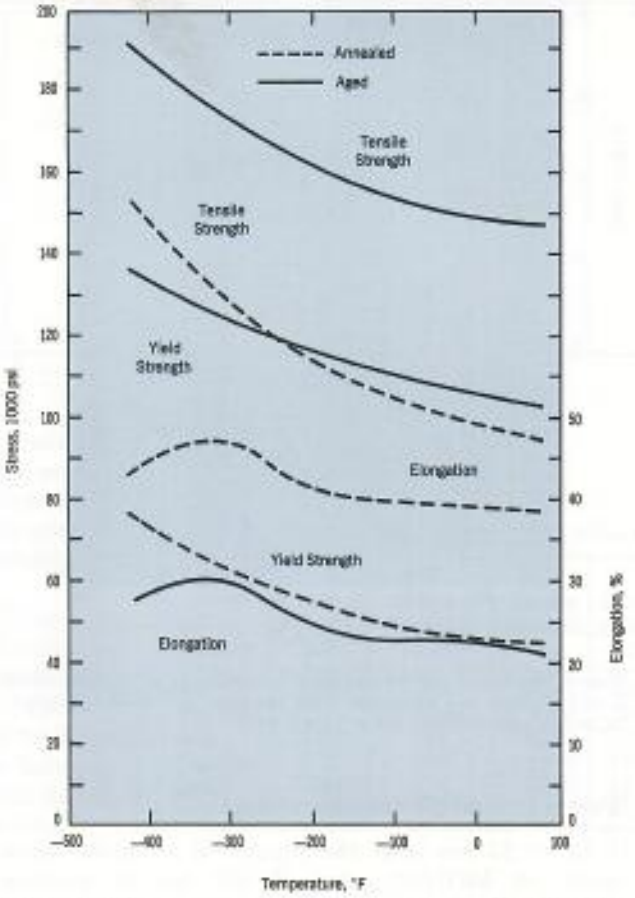


Figure 35—Low-temperature tensile properties of MONEL alloy K-500 (0.063-in. sheet).

Table 54—Tensile Properties of MONEL Alloy K-500 Sheet and Butt Welds[a]

Test Temperature, °F	Sheet				Weld		
	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation, %	NT/TS[b]	Tensile Strength, 1000 psi	Joint Efficiency, %	Elongation, %
78	154	97.3	22	0.93	141	92	11
−100	166	107	24	0.93	154	93	14
−320	183	120	30	0.95	170	93	15
−423	200	136	28	0.99	190	95	14

[a] 0.020-in. sheet age-hardened 1080°F/16 hr. Heliarc welds heat-treated after welding. Longitudinal tests.
[b] Ratio of notch tensile strength to smooth tensile strength. $K_t = 6.3$.

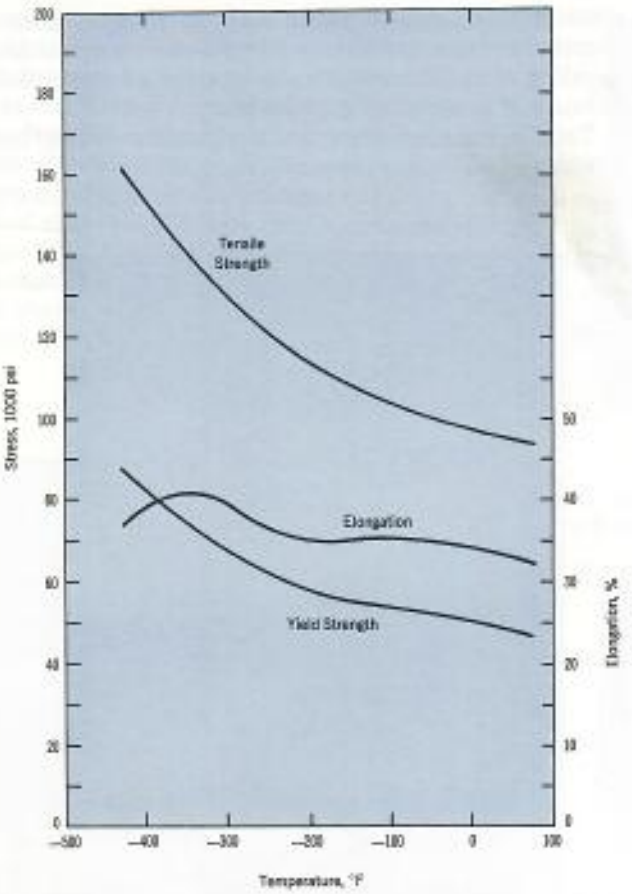


Figure 36—Low-temperature tensile properties of MONEL alloy K-500 welded and annealed (gas tungsten-arc welds in 0.063-in. sheet with MONEL Filler Metal 64).

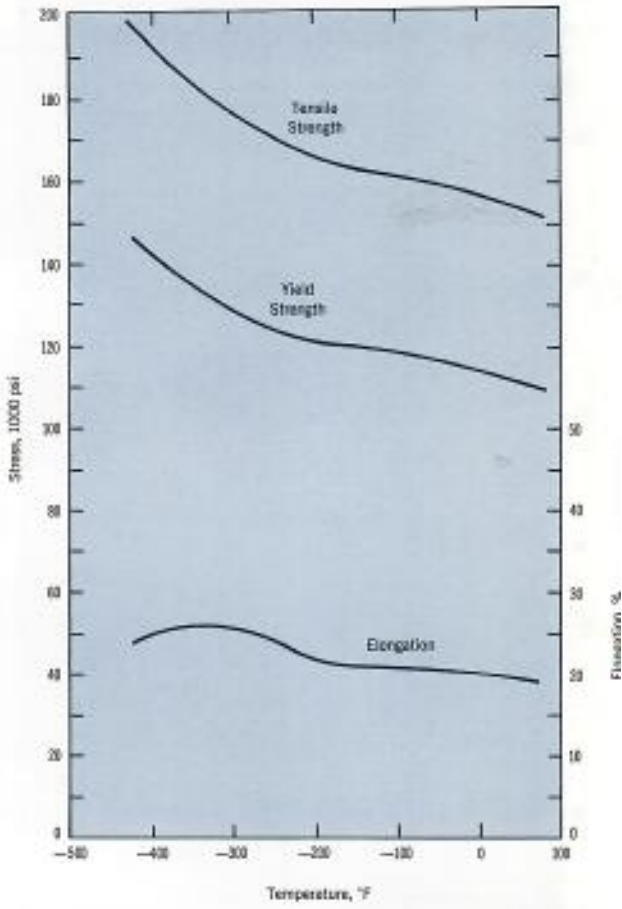


Figure 37—Low-temperature tensile properties of MONEL allo K-500 welded and age-hardened (gas tungsten-arc welds 0.063-in. sheet using MONEL Filler Metal 64).

Torsional Properties

Table 55 contains the results of torsional tests made on MONEL alloy K–500 bar in various tempers. These tests were made using reduced-diameter specimens, which were 1-in.-diameter rods turned down to 0.750-in. diameter in the gage section. For making the computations of yield strength and Johnson's apparent elastic limit, it was assumed that the shear stress varied directly from zero at the center of the test piece to a maximum at the outer surface.

More data comparing tensile and torsional properties are shown in Table 56.

Shear Properties

Shear strength of alloy K–500 is shown in Table 57. Tests were made in double shear on duplicate 0.050 × 0.250-in. specimens with the cutters set to 0.005-in. clearance. This type of test simulates the service requirements of pins used in shackles or clevises.

Table 58 lists the shear strength of rivet wir Properties were determined from the load required t produce double shearing of a 0.118 × 1.00-in. wid wire specimen in a tongue and groove jig with 0.002 in. clearance. These data show that rivets can b made to develop exceptionally high strength b partial or full heat treatment prior to driving. Th ratio of shear strength to ultimate tensile strengt decreases very slightly with increasing hardness, i

Table 55—Torsional Properties of MONEL Alloy K-500 Bar

Condition	Yield Strength (0.00% Offset)*, 1000 psi	Johnson's Apparent Elastic Limit, 1000 psi	Angle of Twist, deg /in.
Hot-Rolled	27	29	620
Hot-Rolled, Aged	57	67	104
Cold-Drawn	48	55	360
Cold-Drawn, Aged	62	71	76

* $S_S = \frac{5.08\ Mt}{d^3}$, where S_S = Torsional stress on the outer fiber, psi, Mt = Torsional moment, in.-lb, and d = Specimen diameter, in.

Table 56—Comparison of Tensile and Torsional Properties of MONEL Alloy K-500 Rod and Wire

Form	Condition	Tensile		Torsional		Ratios		
		Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Breaking Strength, 1000 psi	Proportional Limit, 1000 psi	Torsional Breaking Strength/ Tensile Strength	Torsional Proportional Limit/ Tensile Strength	Torsional Proportional Limit/ Torsional Breaking Strength
Wire (0.148-in. Dia.)	Cold-Drawn 50%	163	—	107	68	0.657	0.417	0.635
	Cold-Drawn 50%, Age-Hardened	197	—	137	75	0.696	0.380	0.547
Rod (1-in. Dia.)	Hot-Rolled	98	45	69	18	0.704	0.184	0.261
	Hot-Rolled, Age-Hardened	—	—	—	62	—	—	—
	Cold-Drawn 20%	134	103	80	45	0.597	0.336	0.562
	Cold-Drawn 20%, Age-Hardened	155	125	102	50	0.658	0.373	0.490

dicating that the longer aging periods increase tensile strength more rapidly than shear strength. Based on these tests, aging for 4 hr at 1080° to 1100°F followed by air cooling is recommended for cold-headed rivets; this treatment is adequate to develop a shear strength of about 85,000 psi in the shank.

Bearing strength data are given in Table 59. These were determined[13] with 0.062 × 1.25 × 2.5-in. material having a 3/16-in. hole drilled 3/8 in. from the edge. The pin fitted closely into the hole. The maximum load for tearing out of the hole and the load required for a permanent enlargement of the hole diameter by 2% were determined and calculated as ultimate and yield strengths, respectively, in bearing.

Table 57—Shear Strength of MONEL Alloy K-500

Condition	Maximum Strength, psi	Deflection at Maximum Strength, in./in.	Tensile Strength, psi	Elongation, %	Hardness, Rockwell C
Annealed	65,300	0.08	97,500	49.0	84B
Annealed, Aged	96,475	0.06	147,200	29.0	29
Half-Hard	71,000	0.04	122,000	12.5	25
Half-Hard, Aged	98,750	0.05	155,600	24.0	31
Full-Hard	89,500	0.04	151,500	16.5	33
Full-Hard, Aged	98,450	0.04	168,500	12.5	37

Table 58—Properties of MONEL Alloy K-500 Rivet Wire and Rivets

Property	Condition				
	As Received	Aged 2 Hours[a]	Aged 4 Hours[b]	Aged 8 Hours[c]	Aged 16 Hours[d]
	Rivet Wire				
Average Shear Stress, psi	69,300	83,200	85,300	85,000	89,200
Ultimate Tensile Stress, psi	107,300	133,000	137,600	—	147,000
Ratio	0.64	0.63	0.62	—	0.61
Hardness, Rc	13	24	26	26	32
	Rivets[e]				
Hardness, Rc					
Head	34	40	40	40	40
Shank	23	30	32	30	34

[a] 1080°F/2 hr, A.C.
[b] 1080°F/4 hr, A.C.
[c] 1080°F/8 hr, A.C.
[d] 1080°F/16 hr, furnace cool to 900°F at the rate of 15°F/hr, A.C.
[e] ½-in. diameter X ¾-in. long.

Table 59—Bearing Strength of MONEL Alloy K-500

Condition	Tensile Properties			Bearing Strength		Ratio, Bearing Strength/	
	Tensile Strength, 1000 psi	Yield Strength (0.2% Offset), 1000 psi	Elongation, %	Ultimate Strength,[a] 1000 psi	Yield Strength,[b] 1000 psi	Ultimate Strength	Yield Strength
Annealed	92.2	38.5	49.0	178.0	68.8	1.93	1.79
Annealed, Aged	145.5	98.5	31.0	295.0	162.0	2.03	1.65
Hard	145.9	139.0	5.0	294.0	190.0	1.72	1.37
Hard, Aged	196.5	177.0	10.0	358.0	262.0	1.83	1.48

[a] Tearing out.
[b] 2% enlargement of hole dia. in sheet.

Compressive Properties

The results of compressive tests on alloy K–500, made on triplicate samples from the same melt, are given in Table 60.

Impact Strength

Impact strength at room temperature is shown in Table 61 for typical specimens of various tempers. Charpy V-notch impact strength of annealed and aged hot-rolled and cold-drawn rod is in Tables 62 and 63.

The effect of low temperature on bending impact and tension impact strength, as determined by the Naval Engineering Experiment Station[42] is shown in Table 64; all samples showed ductile fracture. Charpy impact test results[43] down to −320°F may be found in Table 65.

Table 60—Compressive Strength of MONEL Alloy K-500 Rod

Property	Hot-Rolled		Cold-Drawn	
	As-Rolled	Aged	As-Drawn	Aged
Hardness				
Brinell (3000-kg)	165	300	205	330
Rockwell C	5	33	23	35
Vickers (30 kg—Diamond Pyramid)	167	316	210	336
Tension				
Tensile Strength, psi	100,000	151,000	106,000	158,000
Yield Strength (0.2% Offset), psi	47,000	111,000	85,000	120,000
Elongation, %	42.5	30.0	26.5	22.0
Compression				
Yield Strength (0.2% Offset), psi	40,000	121,000	76,000	121,000
Yield Strength (0.01% Offset), psi	34,000	96,000	55,000	102,000

Table 61—Impact Strength of MONEL Alloy K-500

Condition	Test Orientation	Charpy Keyhole Impact Strength, ft-lb
Hot-Finished	Longitudinal	74
	Transverse	51
Hot-Finished, Annealed[a]	Longitudinal	75
	Transverse	48
Hot-Finished, Aged[b]	Longitudinal	39*
	Transverse	23*
Hot-Finished, Aged[c]	Longitudinal	25*
	Transverse	20*
Hot-Finished, Annealed and Aged[d]	Longitudinal	38*
	Transverse	22*
Cold-Drawn	Longitudinal	40
Cold-Drawn, Annealed[a]	Longitudinal	90
Cold-Drawn, Aged[b]	Longitudinal	26*
Cold-Drawn, Aged[c]	Longitudinal	20*
Cold-Drawn, Annealed and Aged[d]	Longitudinal	46*

* Specimen fractured completely.
[a] 1800°F/1 hr, W.Q.
[b] 1100°F/16 hr, A.C.
[c] 1100°F/16 hr, F.C. 15°F/hr to 900°F.
[d] Anneal (a) + age (c).

Table 62—Properties of Hot-Rolled MONEL Alloy K-500 Rod (Annealed 1800°F/½ hr and Aged 1100°F/16 hr, F.C. to 1000°F/6 hr, F.C. to 900°F/6 hr, A.C.)

Diameter,[a] in.	Yield Strength (0.2% Offset), psi	Charpy V-Notch Impact Strength, ft-lb
1.250	97,300	54
1.250	92,500	72
0.875	109,300	45
1.00	111,000	38

[a] Each diameter from different heat.

Table 63—Properties of Cold-Drawn MONEL Alloy K-500 Rod (Annealed 1900°F/½ hr and Aged 1100°F/16 hr, F.C. to 1000°F/6 hr, F.C. to 900°F/6 hr, A.C.)

Diameter,[a] in.	Yield Strength (0.2% Offset), psi	Charpy V-Notch Impact Strength, ft-lb
1.250	92,500	76.25
0.812	103,000	43.75
0.687	110,600	39.5

[a] Each diameter from different heat. Data are averages of 2 tests.

Table 65—Charpy V Notch Impact Strength of MONEL Alloy K-500[a] at Low Temperatures

Temperature, °F	Impact Strength, ft-lb
Room	37.0
−110	34.0
−320	31.0

[a] ½-in. bar, aged 1100°F/21 hr, 1000°F/8 hr, A.C.

Table 64—Impact Properties of MONEL Alloy K-500

Condition	Average Energy Absorbed, ft-lb					
	Smooth Specimen			Notched Specimen[a]		
	−200°F	−120°F	+80°F	−200°F	−120°F	+80°F
			Tension Test			
Hot-Finished, Aged	158	145	141	37	37	35
Cold-Drawn, Aged	127	108	117	34	28	29
			Bending Test			
Hot-Finished, Aged	—	—	—	42	50	55
Cold-Drawn, Aged	—	—	185	30	30	32

[a] In tension test, $K_t = 3.00$; in bending test, $K_t = 4.00$.

Fatigue Strength

Fatigue strength (10^8 cycles) at room temperature of various tempers of alloy K–500 are given in Table 66. The data on rod were developed on high-speed (10,000-rpm) rotating-beam machines using polished specimens and represent average values of a number of tests. Data on strip were reported by Greenall and Gohn[44]. Specimens were subjected to alternate back-and-forth bending as a flat spring; specimens were cut with the longitudinal direction parallel to the direction of rolling.

Fatigue strength of wire is shown in Figure 38.

Table 67 shows fatigue of aged MONEL alloy K–500 at 1000°F. At low temperatures, fatigue strength increases (see Table 68). The material used in these tests was 0.051-in. sheet, cold-rolled half-hard and aged, with a tensile strength of 182,000 psi. Tests were in flexure (R = −1) at 1800 cpm except those at −423°F, which were at 3450 cpm.[45]

Table 66—Room-Temperature Fatigue Strength of MONEL Alloy K-500

Form and Condition	Fatigue Strength (10^8 cycles), 1000 psi	Tensile Strength, 1000 psi	Ratio, Fatigue Strength/ Tensile Strength
Rod, Annealed	38	88	0.43
Hot-Rolled	43	99	0.43
Hot-Rolled, Aged	51	155	0.33
Cold-Drawn	45	120	0.37
Cold-Drawn, Aged	47	170	0.28
Strip, Annealed	27	88	0.31
Spring-Temper, Aged	37	153	0.24

The effect of surface finish on fatigue strength has been studied. Table 69 shows the detrimental effect of an oxidized surface. These tests indicate that it is advisable to use polished surfaces for parts subject to cyclical stresses. The oxide surface was produced by age hardening in air.

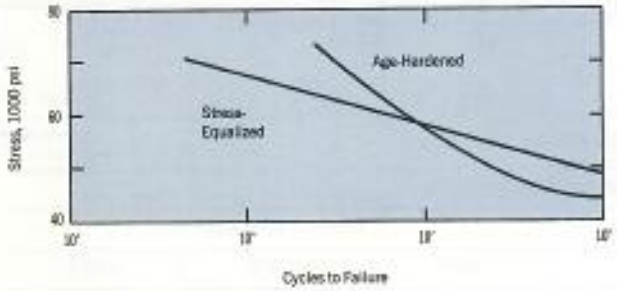


Figure 38—Fatigue strength of commercially produced MONEL alloy K-500 wire (0.0375-in.-diameter, cold-drawn 75% after final anneal). Tested in processed condition. Data determined with a rotating-wire (5000 rpm) arc-fatigue machine.

Table 67—Fatigue Strength of MONEL Alloy K-500 at Elevated Temperature

Condition	Temperature, °F	Fatigue Strength (10^8 cycles), psi
Hot-Finished, Aged	80	46,000
	1000	43,000
Cold-Drawn, Aged	80	52,000
	1000	48,000

Table 68—Fatigue Strength of MONEL Alloy K-500 at Low Temperature

Temperature, °F	Stress, 1000 psi, for a Fatigue Life of		
	10^5 Cycles	10^8 Cycles	10^7 Cycles
70	90	55	37
−110	99	67	—
−320	105	69	—
−423	143	101	—

Table 69—Effect of Surface Finish on Fatigue Strength of MONEL Alloy K-500 [a]

Condition	Surface Finish	Tensile Strength, psi	Fatigue Strength (10^8 cycles), psi	Ratio, Fatigue Strength/ Tensile Strength
Hot-Rolled, Aged	Polished	171,000	50,000	0.29
	Oxidized	172,500	39,500	0.23
Cold-Drawn, Aged	Polished	174,500	57,000	0.33
	Oxidized	167,500	39,500	0.24

[a] R. R. Moore rotating-beam specimens.

Low-Cycle Fatigue

Cyclic strain fatigue of alloy K–500 is shown in Figure 39. The curve[46] represents a best fit for data on material in different initial conditions but having received the same age-hardening treatment (1080°–1100°F/16 hr, F.C. 15°–25°F/hr to 900°F). Also, since data from both axial and completely reversed bending were used to derive the curve, it would be conservative when pure bending is being considered. In Figure 39, S_a, stress amplitude, was calculated from

$$S_a = \frac{\epsilon_{tot}}{2} \times E,$$

where ϵ_{tot} = total strain range applied to the specimen after shakedown, and E = Young's modulus of the specimen.

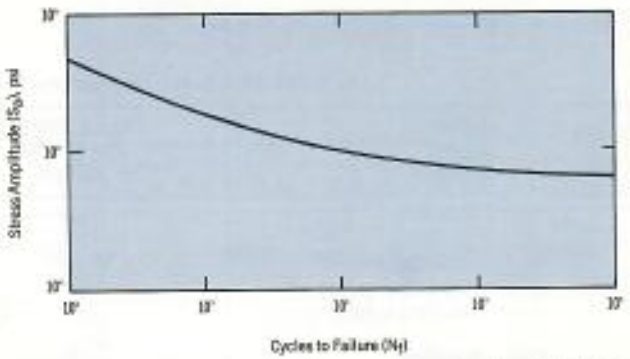


Figure 39—Cyclic-strain fatigue of age-hardened MONEL alloy K-500.

Spring Properties

MONEL alloy K–500 is useful for corrosion-resisting springs at temperatures up to 500°F. Applicable design stresses are shown in Table 70.

The recommended aging treatment after cold coiling is 1000°F/10 hr; or 980° to 1000°F/6 hr followed by cooling to 900°F at a rate of 15° to 25°F/hr. Some effects of heat treatment on properties of springs are shown in Table 71. The springs were coiled on standard automatic equipment, cold-pressed to solid height several times, and heat-treated.

Relaxation of alloy K–500 springs at 500°F is shown in Figure 40. Using a criterion of 5 to 6% relaxation in 7 days, these data indicate a maximum useful temperature of 500°F.

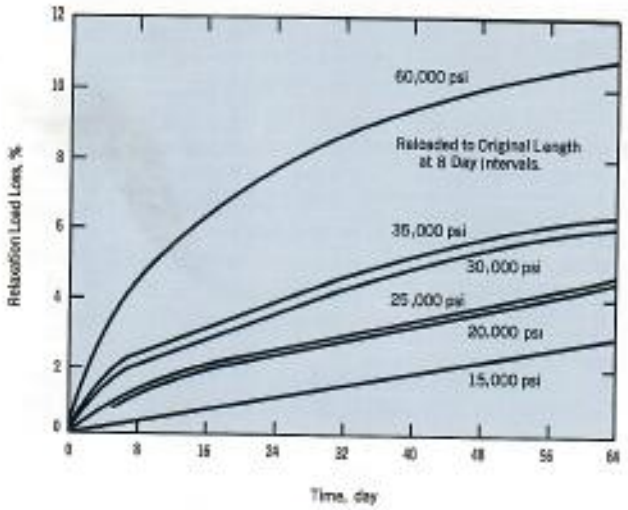


Figure 40—Relaxation at 500°F of MONEL alloy K-500 springs, age-hardened at 1000°F/6 hr. All stresses corrected for curvature; modulus corrected for temperature.

Creep and Rupture Properties

Typical creep and rupture properties of aged alloy K–500 are shown in Figures 41 and 42.

Table 70—Design Stresses for MONEL Alloy K-500 Springs [a]

Temper and Diameter, in.	Method of Coiling	Aging Treatment After Coiling	Stress, 1000 psi, for Metal Temperature		
			Up to 400°F	400° to 450°F	450° to 500°F
Spring ⅝ and Under [b]	Cold	1000°F/ 10 hr, A.C.	65	65	50
Hot-Rolled ½ and Over [b]	Hot	1100°F/ 8 hr, A.C.	65	65	55

[a] All values include the Wahl Curvature Correction Factor and are based on 5% relaxation maximum at stress and temperature after 7 days. Stresses at temperature are adjusted for modulus (G) at temperature.
[b] Selection of break in size for hot or cold winding will be governed largely by the spring index and processing.

Table 71—Properties of MONEL Alloy K-500 Helical Springs (0.148-in. dia. Spring-Temper Wire, 65 % Reduction)

Thermal Treatment After Cold Coiling	Properties of Wires			Fatigue Strength or Stress Range of Springs, 1000 psi (Curvature Correction Factor Included)		
	Tensile Strength, psi	Torsional Breaking Strength, psi	Torsional Proportional Limit, psi	10^6 Cycles	10^7 Cycles	10^8 Cycles
				Initial Stress—10,000 psi		
As-Drawn	162,500	106,300	67,500	—	—	—
Stress-Equalized 525°F/3 hr	171,800	107,200	67,500	—	—	—
Aged 980°F/6 hr, plus 900°F/6 hr	197,000	137,200	74,600	55,000	44,000	39,500
				Initial Stress—20,000 psi		
				59,500	51,000	47,000

High-Temperature Bolting Applications

Maximum allowable design stresses for alloy K–500 bolting material are listed in Table 72.

METALLOGRAPHY

MONEL alloy K–500 is produced by adding aluminum and titanium to the basic MONEL nickel-copper composition. Suitable thermal treatments

Table 72—Design Stresses for MONEL Alloy K-500 Bolting Material *

Property	Condition	
	Hot-or Cold-Finished, Annealed and Aged	Hot-Finished, Aged
Min. Spec. Tensile Strength, psi	130,000	140,000
Min. Spec. Yield Strength (0.2% Offset), psi	90,000	100,000
Min. Elongation in 2 In., %	20	20
Min. Hardness, Rockwell C	24	27
Min. Hardness, Brinell (3000-kg)	250	265
Maximum Allowable Stress, psi		
Subzero to 80°F	22,500	25,000
100°F	22,400	24,900
200°F	21,500	24,500
300°F	20,900	24,000
400°F	20,500	23,900
500°F	20,200	23,800

* Based on criteria of American Society of Mechanical Engineers Boiler and Pressure Vessel Code.

produce a submicroscopic gamma prime precipitate throughout the matrix.

Typical microstructure of hot-rolled, as-rolled alloy K–500 is shown in Figure 43.

Directions for preparing and etching macro- and microspecimens may be found in the HANDBOOK OF HUNTINGTON ALLOYS.[18]

CORROSION RESISTANCE

The corrosion resistance of MONEL alloy K–500 is substantially equivalent to that of alloy 400 except that, when in the age-hardened condition, alloy K–500 has a greater tendency toward stress-corrosion cracking in some environments. Copson and Cheng[20] discuss some conditions under which hydrofluoric acid vapors can cause cracking in alloy K–500. (See also the Section on Corrosion Resistance under MONEL alloy 400.)

MONEL alloy K–500 has been found to be resistant to a sour-gas environment. After 6 days of continuous immersion in saturated (3500 ppm) hydrogen sulfide solutions at acidic and basic pH's (ranging from 1.0 to 11.0), U-bend specimens of age-hardened sheet showed no cracking. There was some tightly adherent black scale. Hardness of the specimens ranged from 28 to 40 Rc.

The combination of very low corrosion rates in high-velocity sea water and high strength make alloy K–500 particularly suitable for shafts of centrifugal pumps in marine service. In stagnant or slow-moving sea water, fouling may occur followed by pitting, but this pitting slows down after a fairly rapid initial attack.

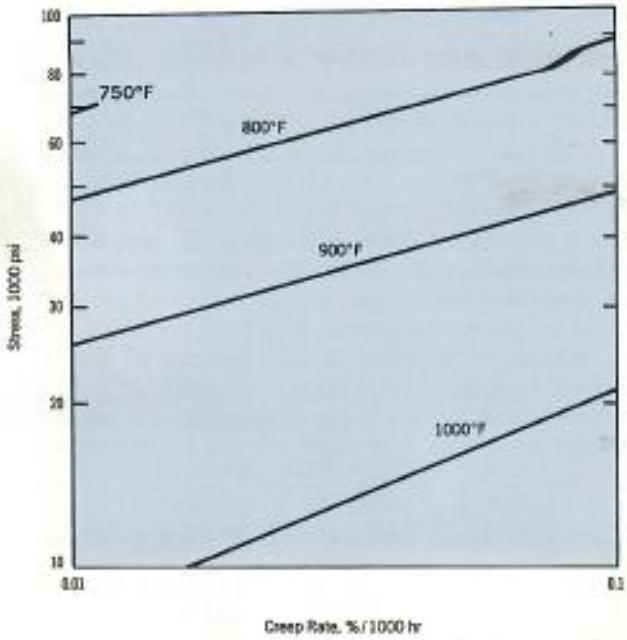


Figure 41—Creep properties of MONEL alloy K-500 (cold-drawn, aged).

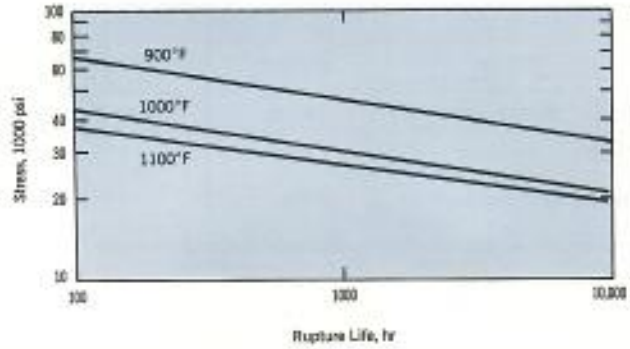


Figure 42—Rupture life of hot-finished aged MONEL alloy K-500.

Figure 43—Microstructure of hot-rolled, as-rolled MONEL alloy K-500. Etchant: Carapella's and glyceregia. 100X

WORKING INSTRUCTIONS

Heating and Pickling

THERMAL TREATMENTS. General procedures and precautions for heating alloy K-500 either in preparation for hot working or for achievement of desired mechanical properties may be found in HEATING AND PICKLING HUNTINGTON ALLOYS.[27]

Annealing is performed both for softening of the matrix after working and for solutioning of the age-hardening phase. Adequate softening may be achieved with temperatures as low as 1400°–1600°F, but heating at 1800°F for hot-finished products and 1900°F for cold-drawn products is recommended for optimum response to subsequent age hardening. Grain growth becomes fairly rapid above 1800°F, and if a fine-grained structure is desired heating time should be kept to a minimum at these higher temperatures.

For optimum aging response and maximum softness, it is important to obtain an effective water quench from the heating temperature without delay. A delay in quenching or a slow quench can result in partial precipitation of the age-hardening phase and subsequent impairment of the aging response. Addition of about 2% by volume of alcohol to the water will minimize oxidation and facilitate pickling.

The effect of water quenching from various temperatures is shown in Figure 44.

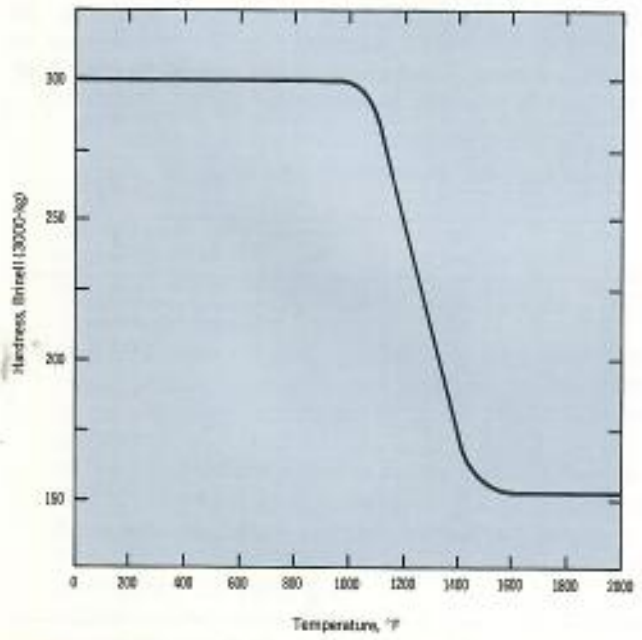


Figure 44—Effect of water quenching from various annealing temperatures on hardness of MONEL alloy K-500.

The following age-hardening procedures are recommended for achievement of maximum properties.

1. Soft material (140–180 Brinell, 75–90 Rockwell B). Hold for 16 hr at 1100° to 1125°F followed by furnace cooling at the rate of 15° to 25°F per hr to 900°F. Cooling from 900°F to room temperature may be carried out by furnace or air cooling, or by quenching, without regard for cooling rate.
   This procedure is suitable for as-forged and quenched or annealed forgings, for annealed or hot-rolled rods and large cold-drawn rods (over 1½ in. diameter) and for soft-temper wire and strip.
2. Moderately cold-worked material (175–250 Brinell, 8–25 Rockwell C).
   Hold for 8 hr or longer at 1100° to 1125°F, followed by cooling to 900°F at a rate not to exceed 15° to 25°F per hr. Higher hardnesses can be obtained by holding for as long as 16 hr at temperature, particularly if the material has been cold-worked only slightly. As a general rule, material with an initial hardness of 175–200 Brinell should be held the full 16 hr. Material close to the top figure of 250 Brinell (25 Rockwell C) should attain full hardness in 8 hr.
   These procedures are applicable to cold-drawn rods, half-hard strip, cold-upset pieces and intermediate-temper wire.
3. Fully cold-worked material (260–325 Brinell, 25–35 Rockwell C).
   Hold for 6 hr or longer at 980° to 1000°F followed by cooling to 900°F at a rate not exceeding 15° to 25°F per hr. In some instances slightly higher hardnesses may be obtained (particularly with material near the lower end of the hardness range) by holding 8 to 10 hr at temperature.
   This procedure is suitable for spring-temper strip, spring wire or heavily cold-worked pieces such as small, cold-formed balls.

NOTE: Cooling may be done in steps of 100°F, holding the furnace 4 to 6 hr at each step. For example, procedure 1 could be 16 hr at 1100°F + 4 to 6 hr at 1000°F + 4 to 6 hr at 900°F. Procedures described under 1, 2, and 3, however, will usually give higher properties. Effects of furnace cooling and step cooling on yield strength of cold-drawn rod are compared in Table 73.

In some instances it may be desired to decrease heat-treating time, either for cost saving or for obtaining intermediate properties. It is difficult to make specific recommendations which would cover the full range of possibilities. The best procedure is to make pilot tests on specimens which duplicate the cross section of the material to be hardened.

Table 74, showing the effect of short-time aging at 1100° and 1000°F, can be used as a guide. More information is given later under "Cold Forming."

Material which has been heated for any appreciable length of time in the temperature range 1100° to 1400°F will be overaged to an extent dependent on time and temperature of exposure. Overaged material will have lower mechanical properties than properly aged metal, and the properties cannot be raised by subsequent aging treatments. In order to strengthen overaged material, it must be solution-annealed (1800°–1900°F) to redissolve the age-hardening constituents, and then reaged. All benefits of cold work are lost in annealing. The highest strength obtainable is that corresponding to the annealed and aged condition.

Material that has been age-hardened to produce maximum hardness will not show an appreciable change in properties if again heated to or held at any temperature up to that at which the original heat treatment was carried out. There may be a small increase in properties if the rate of cooling in the original heat treatment was too rapid between 1050° and 800°F. If the hardened material is subsequently heated above 1100°F and then cooled, there will be a decrease in properties.

Hardened MONEL alloy K–500 has been subjected to long continued heating at 800°F. A further slow aging occurred during the first month of exposure, but continued heating caused no further significant change in properties. Average data for three typical heats are shown in Table 75.

PICKLING. Pickling is a standard method for producing a bright clean surface on alloy K–500. Procedures and precautions are described in HEATING AND PICKLING HUNTINGTON ALLOYS.[27]

Fabricating

MONEL alloy K–500 is readily fabricated by standard commerical procedures. Recommendations are given in FABRICATING HUNTINGTON ALLOYS.[23]

HOT FORMING. Proper temperature during deformation is the most important factor in achievement of hot malleability. Maximum recommended heating temperature for hot-working MONEL alloy K–500 is 2100°F. Metal should be charged into a hot furnace and withdrawn when uniformly heated. Prolonged soaking at this temperature is harmful. If a delay occurs, such that the material should be subject to prolonged soaking, the temperature should be reduced to or held at 1900°F until shortly before ready to work, then brought to 2100°F. When the piece is uniformly heated, it should be withdrawn. In the event of long delay, the work should be removed from the furnace and water-quenched.

The hot-working temperature range is 1600° to 2100°F. Heavy work is best done between 1900° and 2100°F; working below 1600°F is not recommended. To produce finer grain in forgings, the final reheat temperature should be 2000°F and at least 30% reduction of area should be taken in the last forging operation.

When hot working has been completed, or when it is necessary for MONEL alloy K–500 to cool before further hot working, it should not be allowed to cool in air but should be quenched from a temperature of 1450°F or higher. If the piece is allowed to cool slowly it will self-heat-treat (age-harden) to some extent, and stress will be set up that may lead to thermal splitting or tearing during subsequent reheating. In addition, quenched material has better response to age hardening, since more of the age-hardening constituent is retained in solution.

Table 73—Properties of MONEL Alloy K-500 Cold Drawn Rod (Annealed 1900°F/½ hr, W.Q. and Aged 1100°F/16 hr, F.C. 15°F/hr to 900°F, A.C.)

Diameter,[a] in.	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %	Reduction of Area, %	Hardness, Rc	Yield Strength (0.2% Offset),[b] psi
3¼	156,500	98,000	26	42	29	94,500
3	154,000	95,000	24	39	29	94,000
3	152,000	96,500	26	46	28	95,500
2¾	149,000	91,500	26	45	27	90,000
2⅝	156,000	99,000	25	45	29–30	98,000
1½	160,500	102,000	26	42	29	98,500
1½	152,000	100,500	26	49	29	98,500
1⅜	153,000	100,500	26	47	28	97,500
1⅛	150,000	96,500	26	51	27	96,000
1¼	153,000	100,000	26	49	28	100,000
1	155,500	99,500	26	45	29	99,000
1	156,500	101,500	25	45	29	101,500
⅞	156,000	100,500	27	46	28	97,500
⅝	155,000	99,500	27	47	26	97,000

[a] Each diameter from different melt.
[b] Aged by step procedure: 1100°F/16 hr, + 1000°F/6 hr, + 900°F/6 hr, A.C.

Table 74—Effect of Short-Time Aging on Properties of MONEL Alloy K-500 [a]

Condition	Thermal Treatment: Temperature, °F	Thermal Treatment: Time, hr	Tensile Properties: Tensile Strength, 1000 psi	Tensile Properties: Yield Strength, (0.2% Offset), 1000 psi	Tensile Properties: Elongation, %	Tensile Properties: Hardness, Rockwell C
Rod, Hot-Rolled	—	0	93	45	44	82B
	1100	2	132	82	36	17
		4	136	86	34	20
		8	142	90	33	22
Strip, Annealed	—	0	100	50	39	85B
	1100	2	142	90	31	24
		4	141	96	27	25
		8	140	98	27	26
Strip, Cold-Rolled 10%	—	0	111	90	27	19
	1100	2	155	122	23	31
		4	155	122	21	31
		8	156	123	21	31
	1000	2	141	124	24	31
		4	144	123	23	31
		8	149	129	22	32
Strip, Cold-Rolled 20%	—	0	125	115	14	23
	1100	2	163	140	18	34
		4	163	142	18	33
		8	163	141	18	33
	1000	2	169	143	17	34
		4	170	143	18	34
		8	174	148	18	35
Strip, Cold-Rolled 40%	—	0	143	136	5	27
	1100	2	175	159	14	37
		4	176	159	14	36
		8	174	156	14	36
	1000	2	182	165	11	37
		4	183	164	14	37
		8	184	167	13	38
Strip, Cold-Rolled 50%	—	0	148	141	4	29
	1100	2	179	166	12	38
		4	181	165	12	38
		8	177	161	13	38
	1000	2	187	173	10	39
		4	189	174	13	39
		8	189	174	11	39

[a] These data are offered as a guide to short-time aging treatments and are not suitable for specification purposes.

The surface of the material will be oxidized to a lesser degree and will be easier to pickle if it is quenched in water containing about 2% by volume of alcohol.

COLD FORMING. In the annealed condition, alloy K–500 can be cold-worked by standard procedures. Although the alloy requires considerable power to form, it has excellent ductility. Its increase in hardness with increasing cold work, in comparison with other materials, is shown in Figure 23. Figure 45 shows the effect of cold work and cold work plus age hardening on tensile strength and hardness.

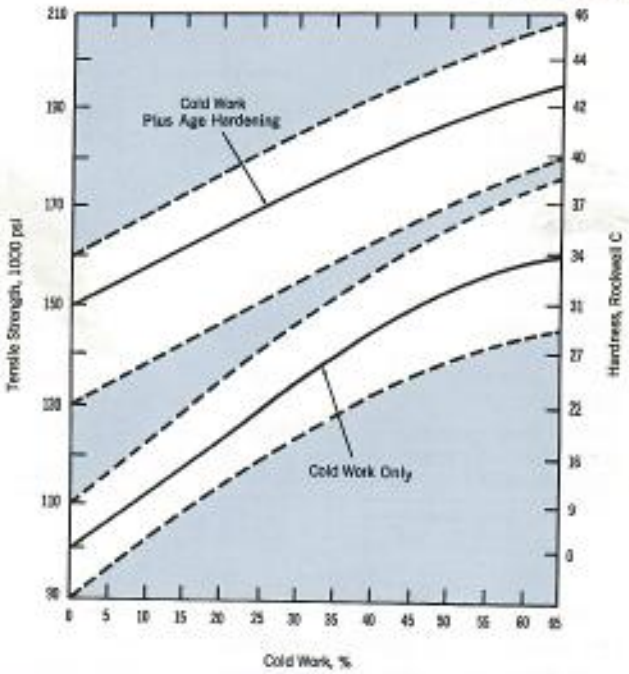


Figure 45—Effect of cold work and age hardening on properties of MONEL alloy K-500.

Machining

Heavy machining of alloy K–500 is best accomplished when the material is in the annealed condition or hot-worked and quenched condition. Age-hardened material, however, can be finish-machined to close tolerances and fine finishes. The recommended practice, therefore, is to machine slightly oversize, age-harden, then finish to size. During aging, a slight permanent contraction (about 0.0002 in./in.) takes place, but little warpage occurs because of the low temperatures and slow cooling rates involved.

Information on procedures and tooling for machining alloy K–500 is given in MACHINING HUNTINGTON ALLOYS.[30]

Joining

The alloy can be joined by welding, brazing and soft soldering processes common to industry. Procedures are described in JOINING HUNTINGTON ALLOYS.[31] Applicable processes and welding materials are:

Gas Tungsten-Arc and Gas Metal-Arc Welding	MONEL Filler Metal 64
Oxyacetylene Welding*	MONEL Filler Metal 64
Shielded Metal-Arc Welding	MONEL Welding Electrode 134

*Flux is required; consult Technical Service.

Table 75—Long-Time Aging of Hot-Rolled MONEL Alloy K-500 Rod

Thermal Treatment	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %	Izod Impact, ft-lb	Hardness, Brinell, (3000-kg)
Hot-Rolled	97,500	40,500	44.0	83	169
1080°F/16 hr	147,000	92,000	28.0	48	270
1080°F/16 hr + 800°F/1 month	161,500	109,000	26.0	26	310
1080°F/16 hr + 800°F/2 months	165,000	112,000	25.0	23	307
1080°F/16 hr + 800°F/4 months	162,300	109,200	25.5	24	310
1080°F/16 hr + 800°F/8 months	164,300	113,200	23.1	27	308
1080°F/16 hr + 800°F/16 months	163,500	112,000	24.5	25	305

Welding should be done on annealed material and the assembly should be stress-relieved before aging. It is important that the assembly be taken through the age-hardening range as quickly as possible. This can be done by charging the weldment into a furnace held at 1450°F–1500°F, bringing it up to temperature, holding for a few minutes, then withdrawing it from the furnace and cooling as rapidly as possible. Exact procedures will necessarily depend on the nature of the weldment and the available equipment. Consult Technical Service for specific recommendations.

Properties of metal-arc welds made with MONEL Welding Electrode 134 are shown in Tables 76 and 77 and Figure 46.

AVAILABLE PRODUCTS AND SPECIFICATIONS

MONEL alloy K–500 is furnished in a wide range of standard mill forms, including sheet, strip, rod, bar, plate, tube, shapes, and forgings. Popular forms and sizes are available from stock, and many specialty items may be obtained from converters. Inquire for complete information from any of the offices listed on the back cover of this bulletin.

Applicable specifications are:

Product	Federal	Military	SAE
Bar, Rod, Forgings	QQ–N–286	MIL–N–17506	AMS–4676
Plate, Sheet, Strip	QQ–N–286	MIL–N–17506	—
Pipe and Tube	QQ–N–286	MIL–N–17506	—
Wire	QQ–N–286	MIL–N–17506	—

Table 76—Properties of Butt-Joint Weld in MONEL Alloy K-500 ⅛-in. Sheet [a]

Condition	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %
As-Welded	94,000	43,500	33
Age-Hardened (1100°F/16 hr)	142,000	102,000	16

[a] Metal-arc process using MONEL Welding Electrode 134.

Table 77—Properties of Butt Welds in MONEL Alloy K-500 Plate [a]

Plate Thickness, in.	Tensile Strength, psi		Elongation in Free Bend, %	
	As-Welded	Aged[b]	As-Welded	Aged[b]
⅛	89,100	129,900	46	19
¼	90,900	128,700	51	18
⅜	95,500	121,400	40	14

[a] Welded by shielded metal-arc process with MONEL Welding Electrode 134.
[b] 1100°F/16 hr.

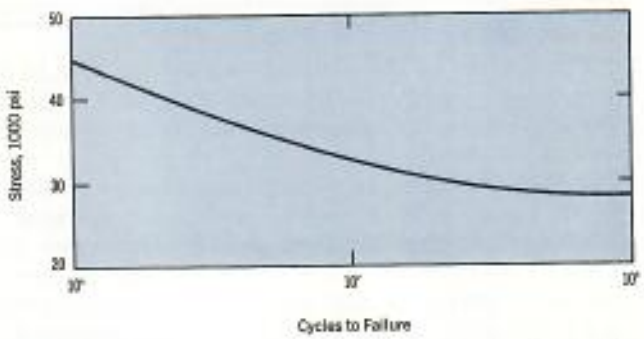


Figure 46—Room-temperature fatigue strength of welded MONEL alloy K-500 (metal-arc process using MONEL Welding Electrode 134). Specimens age-hardened after welding.

MONEL alloy 502

MONEL nickel-copper alloy 502, a modification of alloy K–500, is designed to provide improved machinability. The carbon and titanium contents have been adjusted to reduce the formation of titanium carbides which are abrasive to carbide cutting tools. Since improved machinability is not produced by inclusions, a good surface finish can be obtained with the alloy. Composition of alloy 502* is shown in Table 78.

In addition to its good machinability characteristics, alloy 502 can be successfully welded into joints with excellent properties. The alloy maintains high strength up to about 800°F. Corrosion resistance is essentially the same as that of alloy K–500.

Values for physical constants and thermal properties of MONEL alloy K–500 may be used for alloy 502.

MECHANICAL PROPERTIES

Typical room-temperature tensile properties of rod in various conditions are given in Table 79. Figure 47 shows high-temperature properties of cold-drawn, annealed and aged material.

*MONEL alloy 502 replaces MONEL alloy 501, which is no longer produced.

Table 78—Limiting Chemical Composition, %, of MONEL Alloy 502

Nickel (plus Cobalt)	63.0-70.0	Silicon	0.5 max.
Carbon	0.10 max.	Copper	Bal.
Manganese	1.50 max.	Aluminum	2.50-3.50
Iron	2.00 max.	Titanium	0.50 max.
Sulfur	0.010 max.		

Table 79—Room-Temperature Tensile Properties of MONEL Alloy 502 Rod

Diameter, in.	Condition[a]	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %	Reduction of Area, %	Hardness
4	Hot-Rolled	85,000	37,000	47	75	74 Rb
	Hot-Rolled and Aged	141,000	92,000	28	53	23 Rc
	Hot-Rolled and Annealed	83,000	34,500	48	75	73 Rb
	Hot-Rolled, Annealed, and Aged	143,000	95,000	27	52	24 Rc
3⅜	Cold-Drawn	87,000	55,000	42	71	83 Rb
	Cold-Drawn and Aged	140,000	94,000	25	44	25 Rc
	Cold-Drawn and Annealed	80,500	38,000	49	79	74 Rb
	Cold-Drawn, Annealed, and Aged	138,000	93,500	26	46	24 Rc
¾	Cold-Drawn	93,000	71,000	37	77	89 Rb
	Cold-Drawn and Annealed	86,000	50,000	43	79	84 Rb
	Cold-Drawn, Annealed, and Aged	141,000	98,000	28	47	—

[a] Annealing conditions—1400°F/½ hr. Aging conditions—1150°F/2 hr, F.C. to 1050°F/4 hr, F.C. to 950°F/4 hr, A.C.

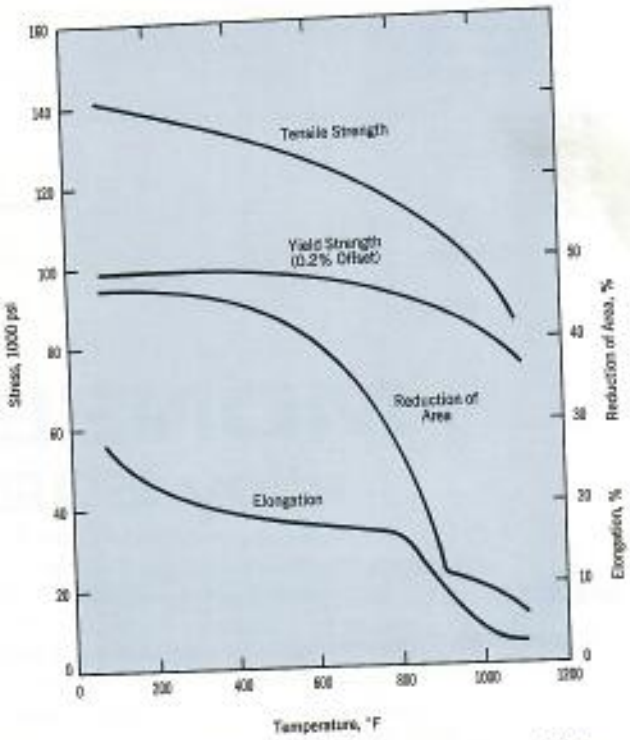


Figure 47—High-temperature tensile properties of cold-drawn MONEL alloy 502 rod (annealed 1400°F/½ hr, W.Q. and aged 1150°F/2 hr, F.C. to 1050°F/4 hr, F.C. to 950°F/4 hr, A.C.).

WORKING INSTRUCTIONS

HEATING AND PICKLING. The low carbon and titanium content of alloy 502 allows the gamma prime hardening constituent to go into solution at 1300°F. The recommended annealing condition therefore is 1350° to 1400°F/½ hr, followed by water quenching or rapid air cooling. The alloy should not be heated above 1400°F as higher temperatures will result in decreased strength. This low annealing temperature lessens the tendency toward oxidation, distortion, and grain growth sometimes associated with exposure to high temperatures.

This alloy is age-hardened by precipitating gamma prime at 1150°F/2 hr, followed by F.C. to 1050°F/4 hr, F.C. to 950°F/4 hr, A.C. This 10-hr aging cycle is only about one third as long as that required for alloy K–500. Aging alloy 502 for total times longer than 10 hr produces only insignificant improvement in mechanical properties.

MONEL alloy 502 is pickled by the same procedures as for alloy K–500. Pickling solutions and recommendations are given in HEATING AND PICKLING HUNTINGTON ALLOYS.[37]

HOT FORMING. Maximum recommended heating temperature for hot working alloy 502 is 2100°F. Metal should be charged into a hot furnace and withdrawn when uniformly heated throughout. Prolonged soaking at this temperature is harmful. If a delay occurs, such that the material would be subjected to prolonged soaking, proceed as follows: Reduce temperature to or hold at 1900°F until shortly before ready to work, then bring to a uniform 2100°F and withdraw. In the event of extreme delays, remove work from the furnace and water-quench.

The recommended metal temperature for heavy reductions is 1700° to 2100°F. Light reductions may be taken at temperatures down to 1200°F. Working at the lower temperatures produces higher physical properties and finer grain size in the finished work.

Heavy forging should not be carried out so rapidly that the metal becomes overheated from working. Use of an optical pyrometer is recommended.

Preheating of tools and dies to about 500°F is helpful.

A controlled forging procedure is required to meet specification requirements in materials over 1 in. in thickness. It is necessary to control both the amount of reduction and the finishing temperature to obtain the desired properties. A recommended procedure consists of taking at least 30 to 35% reduction following the final reheat. This is accomplished as follows:

1. Reheat.
2. Forge to a section having about 25% larger area than the final shape (at least 5% reduction).
3. Cool to 1300°F.
4. Finish to size (25% reduction).
5. Water-quench.

Grain refinement is promoted by using a temperature of 2000°F for the final reheat and by increasing the amount of reduction after the last reheat.

When hot working has been completed, or when it is necessary to allow the material to cool before further hot working, it should not be allowed to cool in air but should be quenched. If the piece is allowed to cool slowly, it will self-anneal and age-harden simultaneously. Quenched material has better response to age hardening since strain hardening imparted by hot working operations will be retained.

The surface of the piece will be less oxidized and easier to pickle if it is quenched in water containing about 2% by volume alcohol.

MACHINING. MONEL alloy 502 does not rely on nonmetallic inclusions for its good machinability. Because it does not contain these inclusions, machined surfaces are bright and smooth with no stringers. Chips produced can be long and stringy and cutting tools should have chip breakers.

With carbide tooling, the machinability of alloy 502 is superior to that of alloy K–500. With high-speed-steel tooling, the two are nearly the same. A comparison of the tool lives of carbide and high-speed-steel tools when cutting alloys K–500 and 502 is shown in Figure 48. Conditions of these tests are given in Table 80.

For best results, alloy 502 should be rough-machined slightly oversize while unaged, aged, and finish-machined.

Some guidelines for automatic machining of alloy 502 are given in MACHINING HUNTINGTON ALLOYS.

JOINING. MONEL alloy 502 has been repair-welded in the aged condition with 100% joint efficiency. Test results indicate that a structure of age-hardened material can be repair-welded in the field and reaged. The test consisted of 2 pieces of forged material, machined to rectangular specimens with beveled edges. The beveled edges were butted together and welded to a steel backing plate (Figure 49). The assembly was annealed 1400°F/½ hr, A.C. and aged 1150°F/2 hr, F.C. to 1050°F/4 hr, F.C. to 950°F/4 hr, A.C. The joint was welded with MONEL Welding Electrode 134, and the structure was reaged. No strain-age or underbead cracking was determined, and side-bend test results were satisfactory. Tensile properties of the weld are given in Table 81.

In other tests under severe conditions, no thermal cracking occurred. The test specimens were welded annealed and age-hardened hot-rolled discs, which were reaged, and rewelded.

AVAILABLE PRODUCTS AND SPECIFICATIONS

MONEL alloy 502 is furnished as bar, rod, plate, and forgings. Popular forms and sizes are available from stock; specialty items may be obtained from converters. Inquire for information from the offices on the back cover.

Federal specification QQ–N–286 is applicable to alloy 502.

Table 80—Machinability Testing Conditions (Turret Lathe; 15-HP DC motor; Speeds, 20-1500, Infinitely Variable)

Parameter	Tools	
	Carbide	High-Speed Steel
Feed, in./rev	0.0825	0.01175
Depth of Cut, in.	0.050	0.100
Effective Cutting Angles,°		
Back-Rake	0	8
Side-Rake	5	22
End-Clearance	5	6
Side-Clearance	5	6
End-Cutting-Edge	15	6
Side-Cutting Edge	15	15
Nose Radius, in.	1/32	3/64

Table 81—Properties of Reaged, Welded Age-Hardened MONEL Alloy 502 (Welded with MONEL Welding Electrode 134)

Specimen	Tensile Strength, psi	Yield Strength (0.2% Offset), psi	Elongation, %
Transverse Across Weld	138,500	95,500	22
	137,500	93,500	22
All-Weld Metal	150,000	112,000	7
	148,000	109,500	17

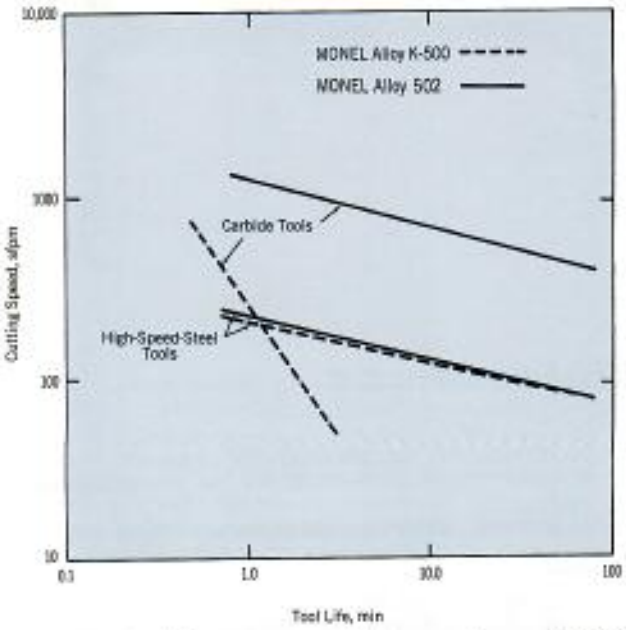


Figure 48—Tool-life tests on cold drawn-as drawn MONEL alloys K-500 and 502. (See Table 80 for test conditions.)

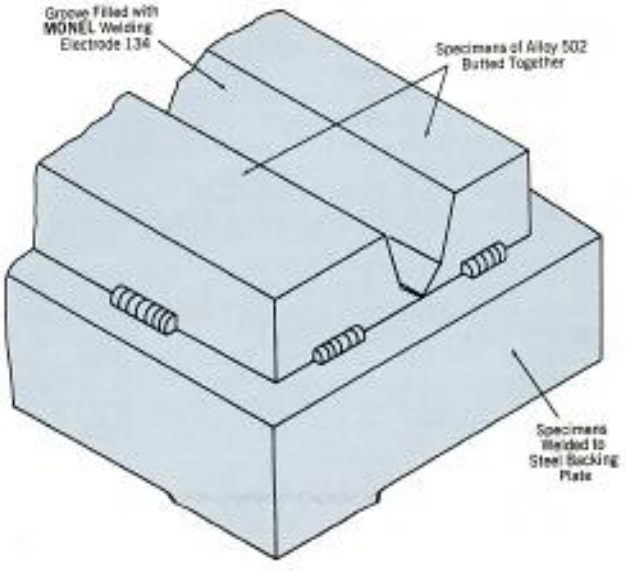


Figure 49—Weldability test setup.

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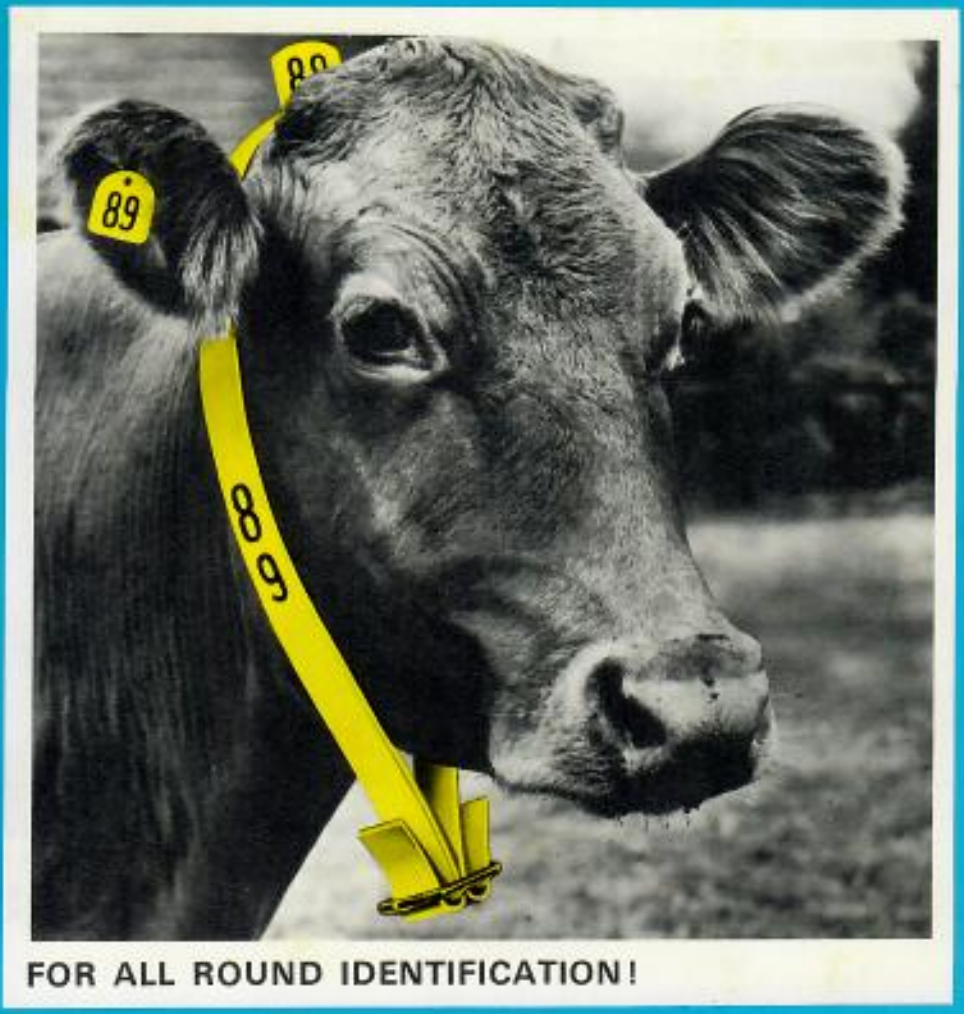
Dalton



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DALTON

Baravo

Économie de temps—Durable—Nettoyage facile—Pas de meilleure solution pour élever les veaux.
Le Baravo permet de nourrir chaque veau d'une manière naturelle.
La méthode Baravo pour la nourriture des veaux peut être adapté pour une ou plusieurs bêtes.
Le Baravo peut être placé n'importe où.

Die künstliche Kuhmutter für Kälber

Zeitsparend—Stabil—Einfaches Reinigen—Kein Eingewöhnen nötig.
Das Kalb saugt langsam wie bei der Kuh.
Kein lästiges Umfallen und zeitraubendes Reinigen der Futtereimer.
Die Calfeteria kann an jedem Gatter oder Zaun eingehängt werden.

Mamadeira para Alimentação de Vitelos

Poupa tempo, dura anos e é fácil de limpar. Não há melhor maneira de criar vitelos.
A Mamadeira permite que cada vitelo se alimente de maneira natural.
Pode adaptar-se a qualquer método de alimentação de vitelos, quer se trate de animais isolados ou em grupo.
A Mamadeira pode colocar-se em qualquer parte.

Calfeteria opfodrings-system

Sparer tid,—holder i årevis—nem at rengøre, ingen bedre måde at opfodre kalve pa.
"Calfeteriet" tillader hver enkelt kalv at opfodres på naturlig måde.
"Calfeteriet" kan tilpasses til en eller flere kalve, og det kan anbringes overalt.

Sistema de alimentación Calfeteria

Ahorra tiempo—Dura años—De fácil limpieza—No hay mejor modo de criar terneros.
La Calfeteria permite a cada ternero alimentarse de forma natural.
La Calfeteria puede adaptarse a cualquier método individual o de grupo utilizado en la alimentación de los terneros.
La Calfeteria puede colocarse en cualquier lugar.

Kalvetaria voedingssystemen

Tijd sparend—gaat jaren mee-gemakkelijk te reinigen—geen betere methode om kalveren op te fokken.
Het kalvetaria systeem kan bij iedere methode van voeren aangepast worden, zowel bij ieder apart als bij groepen tegelijk.
Het kalveraria systeem biedt de mogelijkheid ieder kalf op de natuurlijke wijze te voeren.
Het kalveraria systeem kan overal aangebracht worden.

Calfeteria—Sistema di Alimentazione

Risparmio di tempo—Dura per anni—Facile da pulire.
Non ci sono migliori soluzioni per allevare i vitelli.
La Calfeteria permette ad ogni vitello un nutrimento in modo naturale.
Il metodo Calfeteria per il nutrimento dei vitelli puo' essere adattato per una o piu' bestie.
La Calfeteria puo' essere piazzata in ogni luogo.

DALTON

Calf De-Horner.
Electric or Battery Model.
Permanently de-horns the calf in 20 seconds by searing the tiny bloodvessels which supply the horn bud. ANAESTHETICS MUST BE USED.

Ecorneur
Electrique ou à batterie.
Ecorne définitivement les veaux en 20 secondes en cautérisant les minuscules vaisseaux sanguins qui alimentent la corne naissante.

Kalb—Enthorner
Batterie—Modell 6 Volt und 12 Volt.
Anzuschliessen an jede Auto-batterie.
Dauerhafte Kalb—Enthornung in 20 Sekunden.
Versiegelt die winzigen Adern die das Horn versorgen.

Scorna Vitelli
Batterie a 6 volt o a 12 volt
Scorna definitivamente i vitelli in 20 secondi cauterizzando i minuscoli vasi sanguigni che alimentano il corno nascente.

EX 2

Descornador de vitelos. Modelo eléctrico ou alimentado por bateria.
Descorna permanentemente os vitelos em 20 segundos, cauterizando os delgados vasos sanguíneos que irrigam o rebento do corno.

Kalveafhorner Elektrisk eller drevet ved hjaelp af batteri. Kan afhorne kalven pa 20 sekunder ved at brænde de små blodårer over, som forsyner hornknopperne.

Descuernador de Terneros. Modelo eléctrico o de Batería.
Descuerna permanentemente el ternero en 20 segundos insensibilizando los finos vasos sanguineos que riegan los brotes del cuerno.

Kalf onthorenapparaat. Netspanning of batterij model.
Een blijvende onthoorning in 20 seconden door het afsnoeren van de bloedvaatjes die de horen-knobbeltjes voeden.

EX3

Weighband for cattle and pigs—Durable—Indicates live and dead weight separately.

Le Ruban Métrique pour les bovins et les porcins.
Durable—Indique séparément le poids vif ou le poids après abattage.

Gewichtsmessband
Für Rinder und Schweine.
Strapazierfähig.
Getrennte Skalen für Lebend—und Totgewichte.

Fita para Determinação do Peso de Bovinos e Suínos
É durável, indicando o peso vivo e o peso morto separadamente.

Vejebaand til kvæg og grise—holdbare—viser levende og slagtet vægt hver for sig.

Cinta pesadors para Ganado Vacuno y Cerdos
Permanente—Indica peso vivo y muerto separadamente.

De weegband voor runderen en varkens—duurzaam—geeft levend en geslacht gewicht afzonderlijk aan.

Nastro Metrico per il peso Dei Bovini e Dei Suini
Durevole—Indica separatamente il peso vivo e morto.

DALTON

Kleermark Cold Branding Kit
Brand with the easy-to-use Kleermark Cold Branding Kit. This new non-toxic cold branding method allows cattle to be branded quickly and painlessly. Complete in metal case.

Marquage à froid Kleermark
Marquez avec le très simple appareil Kleermark!
Ce nouveau système de marquage à froid non toxique permet de marquer les bovins rapidement et sans risque.
Présentation en coffret métal.

Kleermark Kaltbrandmarkierung
Dieser neue nicht ätzende Kaltbrand erlaubt schmerzlose und ungefährliche Markierung.
Komplett in stabilem Metalletui.

Estojo de Marcação a Frio Kleermark
Permite a marcação do gado com facilidade.
Este novo método de marcação a frio, não tóxico, permite marcar o gado ràpidamente e sem lhe causar dor.
Apresentado numa caixa metálica.

Maa ikke forhandles i Danmark

WE REGRET THAT KLEERMARK KITS AND FLUID CAN ONLY BE SENT SEA & AIR FREIGHT AND NOT BY POST.

DALTON

Juego de Marcaje en frio Kleermark
Marque con el juego de marcaje en frio Kleermark de fácil uso.
Este nuevo método de marcaje en frio no-tóxico permite marcar el ganado rapidamente y sin dolor.
Completo en caja de metal.

Kleermark koud brand methode
Merk met de gemakkelijk te gebruiken Kleermark koud brand set.
Deze nieuwe niet toxische koud brand methode biedt de mogelijkheid
uw vee snel en pijnloos te merken.

Marchio a freddo Kleermark
Il semplicissimo sistema Kleermark, non tossico, permette di marchiare a freddo, rapidamente e senza rischi i bovini.
Presentato con cassetta metallica.

Milk Sucking Preventor
in metal

Disque Anti-Têt
en métal

Saugschutzgerät
in Metall

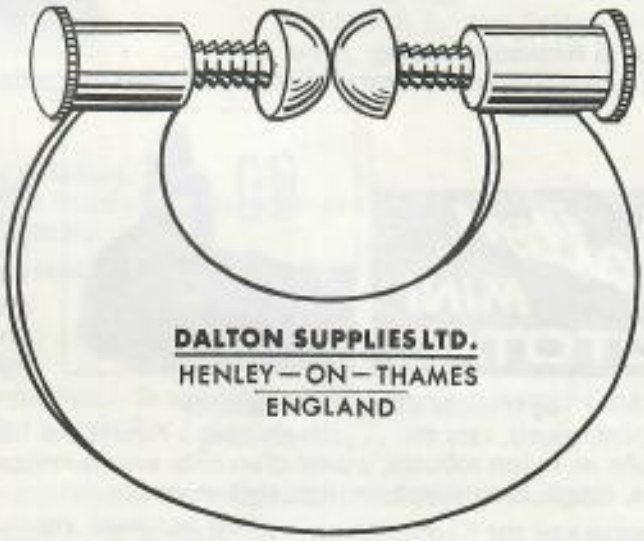
Preventivo de Sucção de Leite
metálico

Forhindre korene i at patte
af metal

Preventor de mamadas
de metal

Anti-melkzuigenklem
van metalen

Disco Anti-Succhio
in metallo



EX5

Milk Sucking Preventor
in plastic

Disque Anti-Têt
en plastique

Saugschutzgerät
in plastik

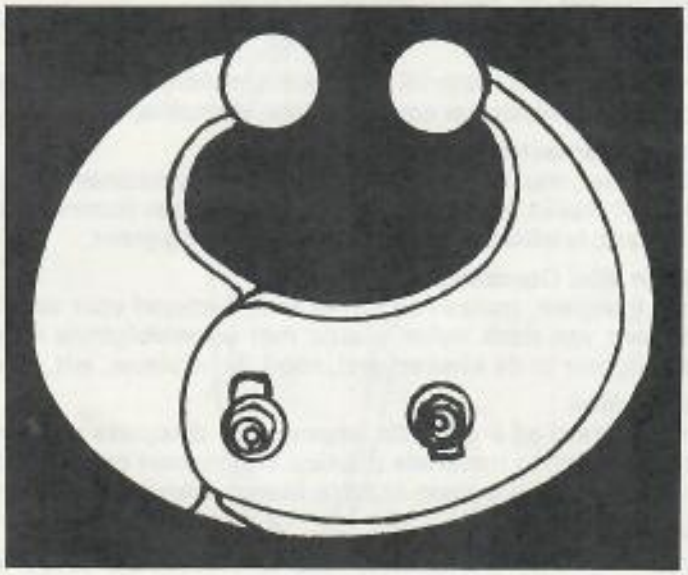
Preventivo de Sucção de Leite
em plástico

Forhindre kørene i at patte
af plastic

Preventor de mamadas
de plástico

Anti-melkzuigenklem
van plastic

Disco Anti-Succhio
in plastica



EX6

DALTON

EX7

Ankle Straps
Double-sided for immediate identification.

Attache de Patte
Double numérotage permettant une identification immédiate de n'importe quel côté.

Fessel-bänder
Doppelt numeriert zur sofortigen identifizierung.

Cintas de marcação, de aplicação na canela
Numeradas de dois lados para imediata identificação.

Ankelmærket
Nummer på begge sider til hurtig identificering.

Cintas de tobillo
De dos lados para detección inmediata.

Enkelbanden
Tweezijdig genummerd voor direkte herkenning.

Gambale di Riconoscimento
La doppia numerazione permette l'identificazione immediata da qualsiasi parte.

EX8

Dalton Mini Tags
For rabbits, mice and rats etc., designed for veterinary research in laboratories. Made of strong nylon plastic with consecutive numbers up to 9999 embossed on one side. Available in yellow, red, light blue, white, orange, pink and green.

Dalton Mini Tag (Plaque d'oreille miniature)
Pour lapins, souris, rats etc. . . , développée à l'usage des laboratoires de recherche veterinaire. Fabriquée en nylon robuste, graveé d'un côté avec numéros consécutifs jusqu'à 9999. Disponible en jaune, rouge, bleu, blanc, orange, rose et vert.

Mini Ohrmarken zur Kennzeichnung von Kaninchen, Mäusen, Ratten usw. für Laborzwecke. Hergestellt aus strapazierfähigem Kunststoffmaterial — kann mit fortlaufenden Nummern bis 9999 auf der Oberseite geprägt werden. Erhältlich in den Farben gelb, rot, hellblau, weiss, orange, rosa und grün.

Mini-Brincos de Identificação—"Dalton"
Destinados a coelhos, ratinhos, ratos, etc., para utilização em laboratórios de investigação veterinária.
Feitos de sólido material de plástico nylon, com numeração consecutiva até 9999 gravada num lado. Disponíveis nas cores amarela, vermelha, azul claro, branca, laranja, rosa e verde.

Dalto Minimærker
Til kaniner, mus og rotter etc. beregnet til veterinær forskning i laboratorier.
Lavet af stærkt nylon plastik med fortløbende numre op til 9999 trykt pa den ene side. Kan fås i gult, rødt, lyseblåt, hvidt, orange lyserødt, og grønt.

Dalton Mini Oormerken
Voor konijnen, muizen en ratten enz., bestemd voor veterinair onderzoek in labaratoria.
Gemaakt van sterk nylon plastic met opeenvolgende nummers bedrukt aan een zijde t/m 9999.
Verkrijgbaar in de kleuren geel, rood, licht blauw, wit, oranje, rose en groen.

Dalton Mini
Per topi, ratti ed animali da laboratorio; disegnata per le ricerche veterinarie in laboratorio.
Fatta di robusto materiale plastico con numeri consecutivi fino a 9999, incisa su un lato.
Ottenibile in giallo rosso azzurro bianco arancio rosa e verde.

Mini Marcas Dalton
Para conejos, ratones y ratas, etc., destinados a investigación veterinaria en laboratorios.
Hechas de Nylon Plástico fuerte con numeración correlativa hasta el 9999; estampadas en relieve en un lado. Disponibles en amarillo, rojo, azul claro, blanco, naranja, rosa y verde.

DALTON

EX 9

Marker Straps for cattle and sows.
Durable – Ensures immediate identification – Available with or without top piece.
Available in red, white, green, blue and yellow.

Collier d'identification pour bétail et truies
Durable—Permet une identification immédiate—Disponible avec ou sans numéro au sommet.
Disponible en rouge, blanc, vert, bleu et jaune

Markierungshalsbänder für Rinder und Säue.
Dauerhaft und stabil—Von weitem erkennbar.
Lieferbar auch mit zusätzlichem Nummernsteg.
Erhältlich in den Farben rot, blau, weiss, gelb und grün.

Coleiras para Identificação de Bovinos e Suinos.
Duráveis, assegurando uma identificação imediata. Fornecem-se com ou sem peça cimeira, nas cores vermelha, branca, verde, azul e amarela.

Halsmærker til kvæg og grise garanterer hurtig identificering. Kan fås med eller uden topstykke.
Numre fra 1 til 999.
Fås i rødt, hvidt, grønt, blåt eller gult.

Collares de Marcar para Ganado y Cerdos.
Permanentes—Asegura identificacion inmediata—Se suministra con o sin pieza superior.
Se suministran rojo, blanco, verde, azul y amarillo.

Merk Banden voor runderen en varkens.
Duurzaam—Garandeert onmiddelijke identificatie—Verkrijgbaar met of zonder topstuk.
Verkrijgbaar in de kleuren: rood, wit, groen, blauw en geel.

Collare per L'Identificazione per bovini e suini.
Durevole—Permette una immediata identificazione.
Disponibile con o senza numero superiore.
Ottenibile in rosso, bianco, verde, blu e giallo.

Mini Marker Straps

Mini Collier d'Identification

Mini Markierungshalsbänder

Mini Coleiras Para Identificação

Mini Halsmærker

Mini Cintas de Marcar

Mini Merk Banden

Mini Collare per l'Identificazione

EX 10

DALTON

Rototags
Easy to read—Easy to apply—In unbreakable Nylon Plastic.
No torn ears—No infection. For sheep and other small animals.
This tag is supplied in two parts. Available in 10 vivid colours.
Can be embossed up to 6 numbers or characters.

Tiptag (plaque d'oreille Rototag)
Facile à lire—Facile à poser—Fabriqué en nylon incassable.
Pas d'oreille déchirée.
Pas d'infection.
Pour bovins et autres petits animaux.
Cette attache est livrée en 2 parties.
Disponible en 10 couleurs vives.
Peut être gravée jusqu'à 6 chiffres ou caractères.

Rototag Ohrmarken
Gut leserlich—Leicht einziehbar mittels einer Spezialzange—Unzerbrechlich.
Aus Nylon Kunststoff.
Kein Ausreissen—Keine Infektionsgefahr—Für Schafe, Ziegen und Ferkel.
Diese Marke wird in zwei Teilen geliefert.
In allen Grundfarben erhältlich.
Bis zu 6 Buchstaben oder Zahlen können angebracht werden.

Brincos Rototag para Marcação de Gado.
Fáceis de ler e de aplicar. Fabricados em plástico de nylon inquebrável.
Não rasgam as orelhas nem causam infecção. Destinam-se a ovinos e a outros animais de pequena corpolência.
Fornecem-se com macho e fêmea separados. Fabricam-se em 10 cores vivas.
Podem comportar até 6 algarismos ou letras gravadas.

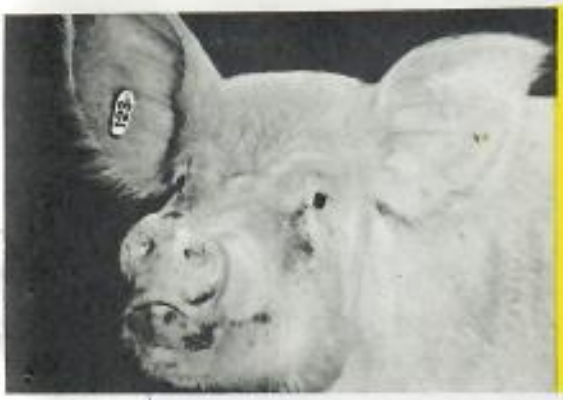
Rotoøremærker kan nemt læses—nemme at sætte i—og lavet af meget stærkt Nylon plastik.
Ingen revne ører—ingen betændelse. Til får og smådyr.
Fås i 10 farver og derfor utallige farvekombinationer.
Kan trykkes med op til 6 numre eller bogstaver.
Påsættes med Rototangen.

Rototags
Fácil de leer. Fácil de poner—En plástico de nylon irrompible.
No desgarra orejas—No Infección—Para ovejas y otros pequeños animales.
Esta marca se suministra en dos partes. A disposición en 10 colores vivos.
Pueden grabarse hasta 6 números o letras.

Roto oormerken
Gemakkelijk af te lezen—eenvoudig aan te brengen—onbreekbaar-geen uitscheuren—geen infectie.
Voor schapen en andere kleine dieren.
Verkrijgbaar in 10 kleuren. Er kunnen maximaal 6 cijfers of letters op aangebracht worden.

Marca Rototag
Facile da leggere—Facile da mettere
In nylon infrangibile.
Non piu' orecchie lacerate—Nessuna infezione.
Per ovini ed altri piccoli animali.
Questa targhetta e' divisa in due parti—Ottenibile in 10 vividi colori.
Puo' essere stampata fino a 6 numeri o lettere.

DALTON



Ex 12

Jumbo Ear Tags
For cattle and pigs—Available in 10 vivid colours—Can be embossed up to 999—Higher numbers from 1000 onwards can be supplied on request.
Jumbo Tags for calves insert at 5 weeks old.

Toptag (Plaque d'oreille Jumbo)
Pour bovins et porcins.
Disponible en 10 couleurs vives.
Peut être gravée jusqu'au numero 999—Les chiffres dépassant le millier peuvent être gravés sur demande.
Les TOPTAGS doivent être posés sur les veaux à l'âge de 5 semaines.
Toutes les attaches d'oreilles DALTON se posent en un seul mouvement.

Jumbo Ohrmarken
Für Rinder und Schweine.
Diese Grösse ist erhältlich in allen Grundfarben.
Kann bis 999 bedruckt werden.
Höhere Nummern können auch auf Wunsch geliefert werden.
Jumbo Ohrmarken sind auch für Kälber ab 5. Lebenswoche benutzbar.

Brincos Jumbo para Marcação de Gado
Destinam-se à marcação de bovinos e suínos. Fabricam-se em 10 cores vivas.
Podem ser numerados, por gravação, até 999. A pedido, podem fornecer-se estes brincos por forma a comportarem a gravação de numeros superiores a 1.000.
Os vitelos podem ser marcados com estes brincos, a partir das 5 semanas de idade.
Todos os brincos Dalton são aplicados mediante uma simples e única operação.

Jumbo øremærker til kvæg og søer kan fås i 10 livlige farver. Kan trykkes op til 999.
Højere numre fra looo og opefter kan rekvireres. Jumboøremærkerne kan påsættes kalve fra de er 5 uger gamle.
Påsættes med Jumbotangen.
Alle Dalton øremærker sættes på med eet greb.

Jumbo Tags para orejas
Para Granado vacuno y Cerdos —Surtido en 10 colores vivos—Puede grabarse hasta el numero 999 —Se pueden suministrar a solicitud numeros más altos a partir de 1000.
Jumbo tags para terneros a colocar a la edad de 5 semanas.
Todas las marcas de orejas Dalton se aplican en una sola acción.

Jumbo oormerk
Voor runderen en varkens—Verkrijgbaar in 10 kleuren—leverbaar met nummers tot 999.
Hogere nummers kunnen op speciaal verzoek gemaakt worden.
Het jumbo oormerk kan bij kalveren aangebracht worden op de leeftijd van 5 weken.
Alle Dalton oormerken worden aangebracht in één handeling.

Marca Jumbo ad orecchio
Per bovini e suini.
Ottenibile in 10 vivi colori.
Puo' essere stampata fino a 999.
Le cifre che superano il mille possono essere ottenute a richiesta.
La Jumbo Tags deve essere applicato ai vitelli a 5 settimane di eta'.

DALTON

EX13

Goliath Tag
The largest ear tag for animal identification—For cattle and pigs.
One inch high numerals or letters—Can be read easily.
Available in green, white, yellow, pink, red and blue.

Plaque d'oreille Goliath
La plus large attache d'oreille pour l'identification des bovins et des porcins.
Les numéros ou les lettres ont une hauteur de 2 cm 1/2.
Facilement lisible.
Disponible en vert, blanc, jaune, rose, rouge et bleu.

Goliath—Ohrmarken
Die grösste Ohrmarke für Tiermarkierung.
Für Rinder und Schweine.
Die Nummern oder Buchstaben sind 2½ cm gross und sehr gut erkennbar.
Erhältlich in den Farben grün, weiss, gelb, rot, blau und rosa.
Leicht anzubringen mittels einer Spezialzange.

Brincos Goliath para Marcação de Gado
É o maior brinco que se fabrica para a identificação de animais.
Destina-se a marcação de gado bovino e suíno.
Comporta letras ou números medindo 2,5 cm.—Podem ler-se fácilmente.
Fornecem-se nas cores vermelha, branca, amarela, rósea e azul.

Store oremærker til mækning af dyr—til kvæg og soer
2½ cm høje numre eller bogstaver. Kan læses på stor afstand.
Fas i grønt, hvidt, gult, lyserødt, rødt og blåt.
Påsættes med Goliathtangen.

Marca Goliath
La marca de oreja más grande para identificación del animal—Para Ganado vacuno y Cerdos.
Numeros o Letras de una pulgada de altura. Puede leerse fácilmente.
Se suministran verde, blanco, amarillo, rosa, rojo y azul.

Goliath oormerk
Het grootste oormerk—Voor runderen en varkens.
2½ cm grote cijfers of letters—kan gemakkelijk afgelezen worden.
Verkrijgbaar in groen, wit, geel, róse, rood en blauw.

Marca Goliath ad orecchio
La piu'grande marca ad orecchio per l'identificazione di Bovini e suini.
I numeri o le lettere hanno l'altezza di 2 cm ½.
Facilmente leggibili—Disponibili in verde, bianco, giallo, rosso e blu.

DALTON

EX 14

Neck Tags for Cattle
Simple and colourful—Easily read.
Nylon Neck Tags available in white, red, yellow, green and blue.
These can be supplied with or without nylon rope or chain.

Medaillon pour bovins
Simple et coloré—Facile à lire.
Le médaillon en nylon est disponible en blanc, rouge, jaune, bleu et vert.
Le médaillon peut être délivré avec ou sans corde en nylon ou chaîne.

Markierungsschilder
Nummernschilder aus Nylon—Bis zu drei grossen sichtbaren Nummern.
Nylon Nummernschilder in den Farben weiss, gelb, rot, blau und grün.
Erhältlich mit oder ohne Nylonschnur oder Kette.

Marcas de identificação de Bovinos, para pendurar ao Pescoço
Fabricadas em cores que não desvanecem. Fácilmente legíveis.
As marcas para pescoço, em nylon, fornecem-se nas cores vermelha, amarela, azul, verde e branca.
Umas e outras podem ser fornecidas com ou sem corda em nylon ou cadeia.

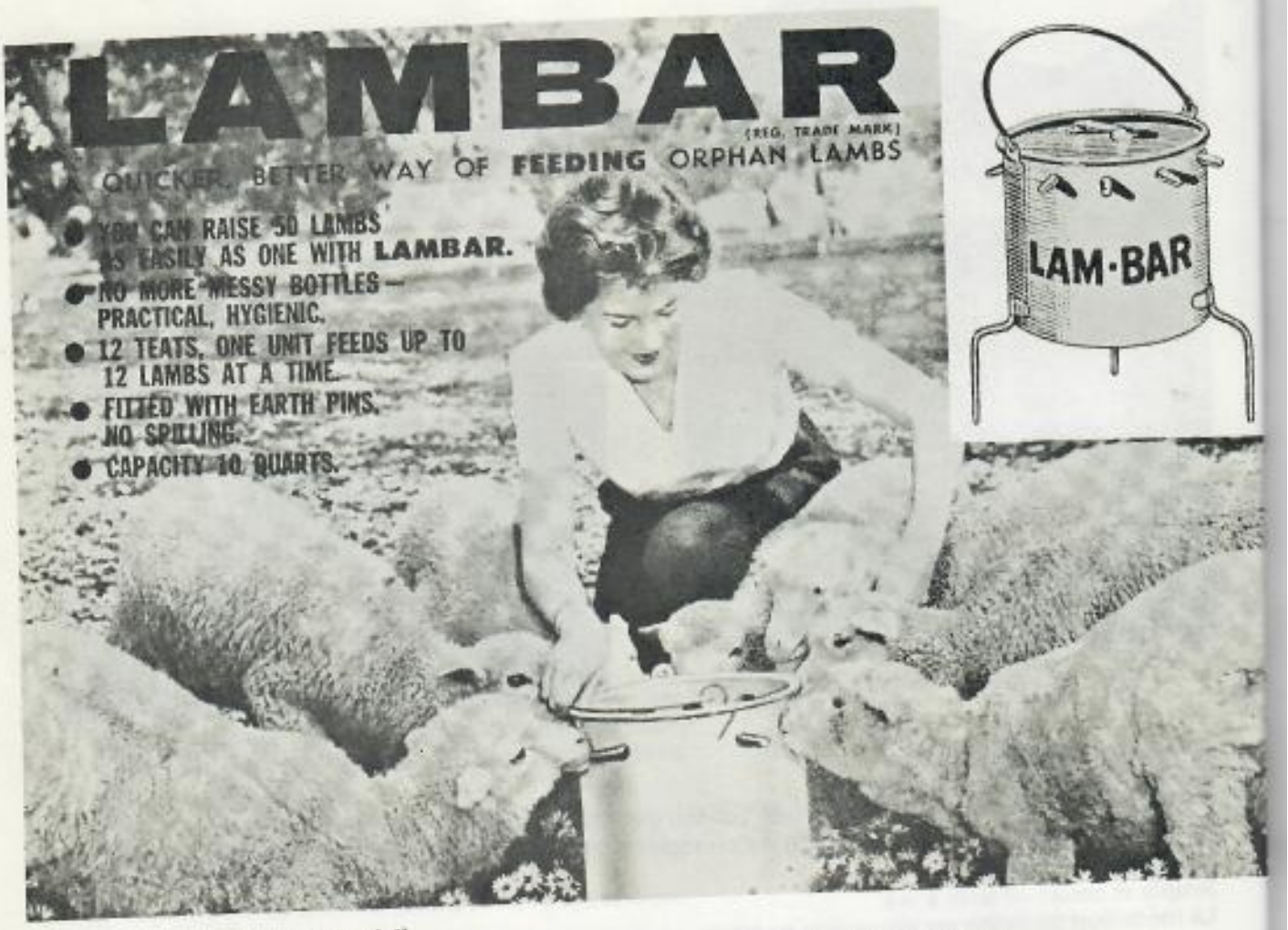
Halsmærker til kvæg
Op til 3 numre eller bogstaver.
Nem identificering af Deres besætning.
Tallene er meget tydelige, og mærkerne fås i stærke farver.
Kan fås i flere forskellige farver, og med eller uden nylon bånd eller kæde.

Medallones de cuello para Ganado
Sencillos y de vivos colores—Se leen facilmente.
Medallones de cuello de nylon surtidos en rojo, amarillo, azul, verde y blanco.
Ambos pueden suministrarse con o sin cuerda de nylon o cadena.

Nekplaatjes voor rundvee
Eenvouding en kleurrijk—Gemakkelijk afleesbaar.
Nylon Nekplaatjes verkrijgbaar in rood, geel, blauw, groen en wit.
Zowel bij de nylonplaatjes kan een nylon koord of ketting worden geleverd.

Medaglione per bovini
Semplice e colorato—Facile da leggere.
Il medaglione in nylon e' disponibile in bianco, rosso giallo, blu e verde.
Il medaglione si puo' ottenere con a senza corda in nylon o con o senza catena.

DALTON



Lam-Bar (12 teat model)
A quick and simple way of feeding lambs—Feeds up to 48 lambs in 20 minutes.

Baragno (à 12 tétines)
Le plus simple des nourrisseurs pour agneaux.
Permet d'alimenter 48 agneaux en 20 minutes.
Lam-Bar (12 Sauger Modell)
Die einfachste Art der Lämmerfütterung (12 Sauger Modell)
In 20 Minuten können 48 Lämmer gefüttert werden.

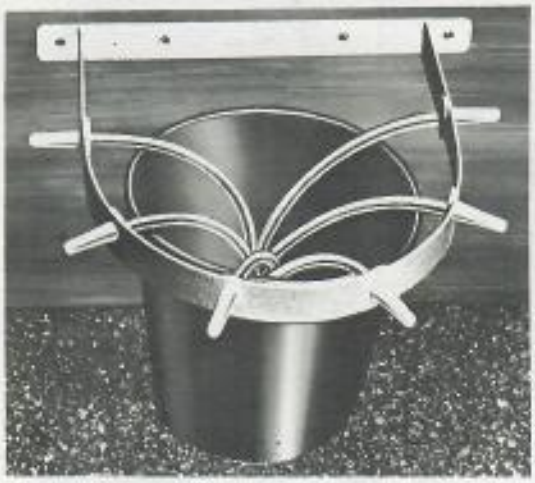
Mamadeira para cordeiros (modelo com12 tetas)
Proporciona uma maneira rápida e simples de alimentar os cordeiros.
Alimenta até 48 cordeiros em 20 minutos.

Lammebar (12 sutter)
En nem og hurtig måde at opfodre lam—opfodrerop til 48 lam på 20 minutter.

Lam-Bar (modello a 12 tette)
Il piu' semplice dei metodi per nutrire gli agnelli Permette l'alimentazione di 48 agnelli in 20 minuti.

Lam-Bar (modelo de 12 tetas)
Un metodo sencillo y rápido de alimentar corderos—Alimenta hasta 48 corderos en 20 minutos.

Lam-Bar (12 speens model)
Een snelle en eenvoudige methode om lammeren te voeren. U kunt tot 48 lammeren voeren in 20 minuten.



EX16

Lam-Bar (6 teat model)
Robust metal bracket supplied complete with four screws for attachment and 6 teats and tubes.

Lam-Bar (Baragno à 6 tétines)
Se compose d'un support robuste, en métal, fourni avec 4 vis pour le montage, ainsi que 6 tétines et tubes.

Lam-Bar (6 Sauger Modell)
Strapazierfähiger Metallbogen komplett mit 4 Schrauben zur Befestigung und 6 Sauger und Schläuche.

Lam-Bar (modelo con 6 pezones)
Con Soporte de metal fuerte; se suministra completo con 4 tuercas para sujeción y 6 pezones y tubos.

Dalton Lammebar model (6 sutter)
Robust metalholder forsynet med fire skruer til fastgørelse og. Seks sutter og slanger.

Lam-Bar (Modelo de 6 tetos)
Fornece-se completo, com um suporte metálico, robusto, com quatro parafusos para fixação e 6 tetos e respectivos tubos.

Lam-bar (6 speens model)
Zwaar metalen beugel kompleet geleverd met vier schroeven voor het aanbrengen en 6 spenen en slangen.

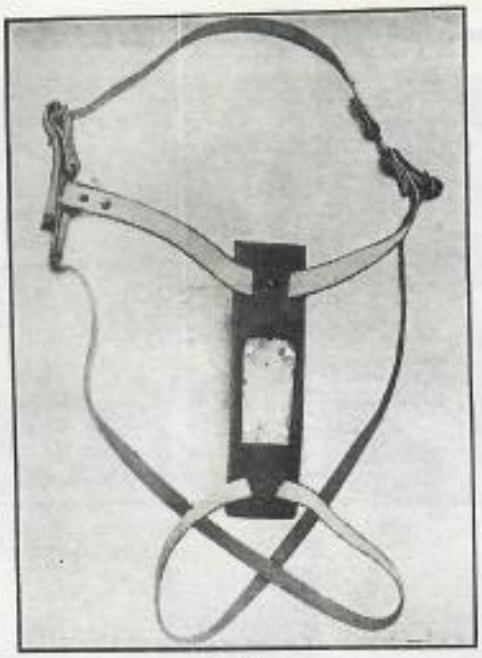
Lam-Bar (modello a sei tette)
Robusto semicerchio metallico fornito completo di quattro viti per fissarlo, di 6 tette e relativi tubi.

EX15

MARKING COLLAR FOR LAMBS
MARKIERUNGSBÄNDER FÜR LÄMMER
COLEIRAS PARA IDENTIFICAÇAÕ DE CORDEIROS
HALSMÆRKER TIL LAM TIL HURTIG IDENTIFICERING
CINTAS DE MARCAR PARA CORDEROS
MERKBANDEN VOOR LAMMEREN
COLLARE PER L'IDENTIFICAZIONE PER AGNELLI

EX17

DALTON



EX 18

Marker for Rams
Harness and crayons for rams and mating identification of ewes.
The harness is adjustable and fits all rams whether shorn or unshorn.
It is easy and simple to fit the crayons to the harness.
Crayons are available in blue, red, yellow and green.

Harnais Marqueur pour Béliers
Harnais et Crayons pour béliers servant à repérer les brebis saillies.
Le Harnais est ajustable et s'adapte à tous les béliers tondus ou non.
Il est facile et simple d'adapter les Crayons au Harnais.
Les crayons sont disponibles en bleu, rouge, jaune et vert.

Markierungsgeschirr für Schafböcke
Geschirr mit Kreide zur Kennzeichnung von Mutterschafen.
Das Geschirr ist regulierbar für geschorene und ungeschorene Schafböcke.
Die Kreiden sind in den Farben blau, rot, grün und gelb lieferbar.
Sie sind schnell und einfach anzubringen.

Arreios para carneiros
Arreios e lápis para carneiros de cobrição e para identificação das ovelhas cobertas.
O arreio é ajustável e adapta-se a todos os carneiros de cobrição, tosquiados ou não.
Os lápis adaptam-se de maneira fácil e simples ao arreio.
Fornecem-se os lápis nas cores azul, vermelha , amarela e verde.

Vædder seletøj
Seletøj og kridt til vædder viser løbningsidentification af hundyrene.
Seletøjet kan tilpasses og passe alle væddere enten de er klippede eller uklippede.
Det er nemt at påsætte kridtet i seletøjet. Kridt kan fås i blåt, rødt, gult og grønt.

Aparejos para carneros
Aparejos y lapices para carneros e identificación de apareamientos de ovejas.
El aparejo es ajustable y sirve para todos los carneros, esquilados o no.
Es fácil y sencillo ajustar los lapices al aparejo.
Los lapices se surten en azul, rojo, amarillo y verde.

Dekstempel voor rammen
Harnas en kleurblokken om gedekte ooien te merken.
Het harnas past iedere ram geschoren of ongeschoren.
De kleurblokken kunnen gemakkelijk verwisseld worden.
Kleurblokken verkrijgbaar in rood, geel, blauw en groen.

Bardatura per montoni
Bardatura e colori per montoni, serve per identificazione delle pecore.
La bardatura e' aggiustabile e si adatta a tutti i montoni.
I colori sono ottenibili in blu, rosso, giallo e verde.

DALTON

Ex 19

Dalton Flexo Tags
For cattle identification. Consists of the Dalton Jumbo Tag complete with flexible tab. Embossed with large numbers on both sides or available plain with self marking ink. Simple–humane application with our Jumbo pliers.

Dalton Flexo Tag (Plaque d'oreille flexible)
Pour l'identification des bovins. La plaque se compose de la Dalton Jumbo Tag incorporant une attache flexible. Gravée en gros chiffres de chaque côté, ou bien disponible non gravée mais avec l'approvisionnement d'encre à marquer selon besoin.
Elle se pose facilement, et humainement, avec pinces Jumbo.

Flexo Ohrmarke zur Kennzeichnung von Rindern
Besteht aus der Jumbo Ohrmarke komplett mit biegsamer Lasche, welche beiderseits mit grossen Nummern bis 999 geprägt ist.
Kann auch unnumeriert mit Markierungsfarbe und Stift zur Selbstmarkierung geliefert werden.
Einfache–humane Einziehung mit der Jumbo Zange.

Marcas Flexibles Dalton
Para la identificación de ganado. Consisten en un Jumbo Tag completo con una lenguesta flexible. Impresas en números grandes en ambos lados ó dispuestas para ser marcadas con tinta. Simple aplicación con nuestras tenazas Jumbo.

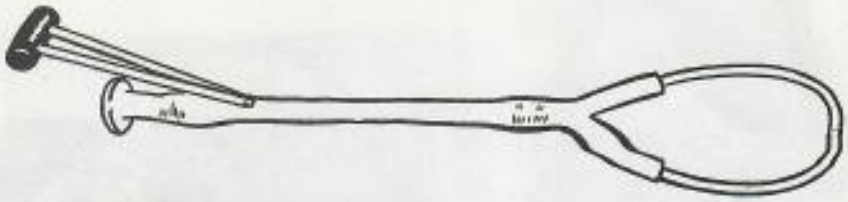
Dalton Flexo Mærke
Til kvæg identifikation. Består af hele Dalton Jumbomærket tillige med et stort bøjeligt mærke med nummer.
Trykt med store numre på begge sider eller kan også fås unummereret med mærkeblæk. Let human isættelse med vor Jumbotang.

Marcas de Identificação Flexo "Dalton"
Para identificação de bovinos. Consiste de brincos "JUMBO DALTON" com presilhas flexiveis. Gravadas com números grandes de ambos os lados, ou disponíveis simples, com tinta própria para marcar. Simplicidade de aplicação com os nossos alicates "JUMBO", com o menor sofrimento para os animais.

Dalton Flexo Oormerken
Voor herkenning van vee. Bestaat uit het Dalton Jumbo oormerk kompleet met een buigzaam lable
Bedrukt met grote nummers op beide zijden of onbedrukt verkrijgbaar met inkt om zelf nummers of letters aan te brengen.
Gemakkelijk zonder problemen aan te brengen met onze Jumbo tang.

Dalton Flexo
Per identificare il bestiame. Si compone di una marca ad orecchio Jumbo completa con la marca grande flessibile Flexo.
Incisa a grandi numeri su ambedue i lati, è ottenibile ora liscia con l'apposito inchiostro per inciderla.
Semplice ed umana applicazione con le nostre pinze Jumbo.

DALTON



EX 20

DAL Lambing Instrument
The simplest, safest and surest aid to lambing problems ever devised.
Can be sterilised in boiling water or any reliable antiseptic.

DAL Lasso d'Agnelage
Le plus simple—le plus propre—le plus sûr pour faciliter le problème de l'agnelage.
Peut être stérilisé dans de l'eau bouillante ou dans un antiseptique recommandé.

DAL—Geburtshelfer für Lämmer
Die erfolgreichste und sicherste Methode zur Beseitigung von Problemen bei Lammgeburten.
Kann in kochendem Wasser oder mit einer zuverlässigen keimtötenden Lösung sterilisiert werden.

DAL—Instrumento para facilitar o parto nas ovelhas
Constitui o instrumento mais simples, inofensivo e seguro, jamais imaginado, para auxiliar a resolver os problemas que surgem no parto das ovelhas.
Pode esterilizar-se em água a ferver ou em qualquer outro anti-séptico de confiança.

DAL Læmme Instrument
Den nemmeste, sikreste og bedste hjælp, der nogensinde er opfundet til læmmeproblemer.
Kan steriliseres i kogende vand og i enhver anvendelig antiseptisk vædske.

Instrumento DAL para alumbramiento
La ayuda más simple y más segura para problemas de alumbramiento que se haya inventado.
Puede esterilizarse en agua hirviendo o en cualquier antiséptico en buenas condiciones.

DAL Lammeren Verlos Instrument
De eenvoudigste, veiligste en zekerste hulp bij het lammeren.
Kan gesteriliseerd worden met kokend water en ieder ontsmettingsmiddel.

DAL—Strumento per facilitare il parto della pecora
Il piu' semplice, il piu' sicuro aiuto per il problema dell'agnellaggio.
Puo' essere sterilizzato in acqua bollente o in un antisettico consigliato.

Savewe
This product will save your ewes at fractional cost.

Sauve Brebis
Cet appareil sauvera la vie de vos brebis au prix d'une dépense minime.

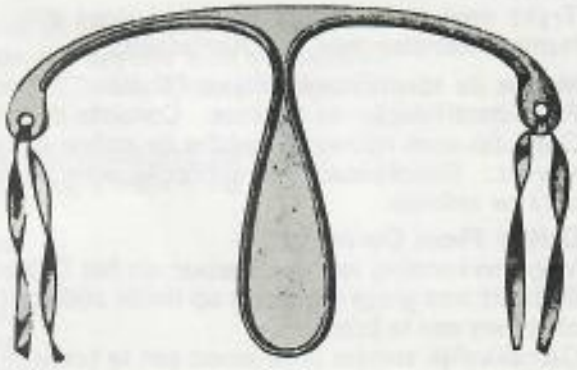
Savewe —Der Schafretter
Dieses Produkt rettet die Mutterschafe wenn diese an Gebärmuttervorfall leiden.

Savewe
Este instrumento salvaria a vida das ovelhas por um custo minimo.

Savewe
Vil redde Deres hundyr for en meget lille udgift.

Savewe
Este instrumento salvará sus ovejas a coste reducido .

Savewe
Dit produkt spaart Uw ooien voor een onbeduidend deel van de kosten.

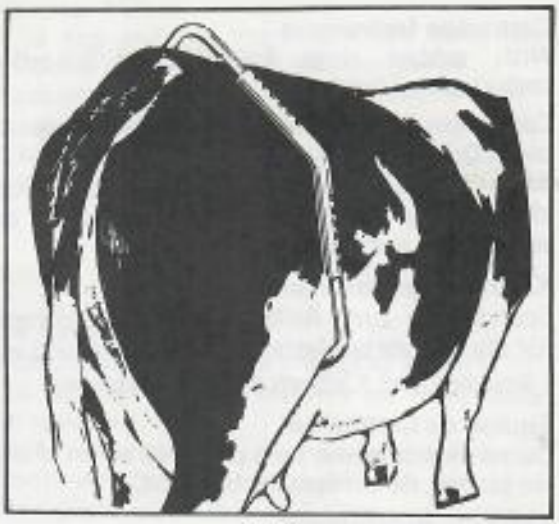


EX 21

D.E.18

Savewe—Salva Pecore
Questo apparecchio salvera' la vita delle vostre pecore a prezzo minimo.

DALTON



EX 22

Cow Immobiliser
Anti-kick device guarantees trouble-free milking and treatment of udders without the risk of being kicked. Adjustable–simple to slip on.

Cow immobiliser (Entraves-flancs pour vaches)
Instrument anti-ruades, pour faciliter la traite et le traitement des pis sans crainte des ruades.
Adaptable selon grosseur de la bête–facile à poser.

Schlagfessel für Kühe
Verhindert Unfälle und garantiert "Melken ohne Ärger".
Erleichtert Behandlung von entzündeten Eutern.
Verstellbar–Einfach anzubringen.

Immovilizador Para Vacas
Mecanismo para evitar el coceamiento; proporciona un ordeño sin problemas y el tratamiento de ubres sin riesgo de ser coceado.
Ajustable mediante un simple deslizamiento.

Ko sparkbeskytter
Effektiv sparkbeskytter, der garanterer ingen besværligheder under den daglige malkning og behandling af yveret. Ingen risiko for spark. Beskytteren er let at justere.

Imobilizador de Vacas
Um dispositivo anti-couce que garante uma mungidura sem incómodos e o tratamento dos úberes sem o risco de ser escouceado. Ajustavel e simples de fazer deslizar.

Koe Spanbeugel
Tegen-slaan garandeert melken zonder moeilijkheden en behandeling van uier zonder het risiko geslagen te worden.
Verstelbaar-makkelijk aan te brengen.

Immobilizzatore per mucche
Apparecchio anti calcio garantisce una mungitura libera da fastidi ed il trattamento delle tette senza il rischio di essere calciati.
Regolabile, semplice da infilare.

DALTON

Ex 23

Castration Instrument
With rubber rings for efficient bloodless castration of lambs and calves.

Castration Instrument (Instrument de castration)
Avec des anneaux en caoutchouc. Pour effectuer la castration des agneaux et des veaux, sans aucun saignement.

Kastrierungsinstrument
Spannzange zum Anlegen von Gummiringen für die bewahrte Methode der Kastrierung von Lämmern und Kälbern ohne Blutverlusst.

Equipo de Castracion
Con arillos de goma para una castración eficaz, sin sangre, de corderos y terneros.

Kastrationsinstrument
Med af gummiringe til effektiv ublodig kastration af lam og kalve.

Instrumento Para Castração
Com aneis de borracha para uma eficiente castração de cordeiros e vitelos, sem derramamento de sangue.

Kastreer Instrument
Met rubber ringen voor het doeltreffend kastreren van lammeren en kalveren zonder bloeden.

Strumento per la castrazione
Con anelli di gomma per una efficiente castrazione senza sangue di agnelli e bovini.

Automatic Scale Scoop
Designed for accurate weighing of feeding stuffs.
Scale marked up to 3 kilos in 200 grms.
Constructed throughout from non-corrosive metals, with zero adjuster.

Ex 24

Pelle-Peseuse Automatique
Conçue pour évaluer le poids exact des produits alimentaires.
Graduation de 200 grammes à 3 Kilogrammes.

Automatische Schaufel—Waage
Erleichtert schnelle und genaue Messung des Futters.
Wiegt bis zu drei Kilogramm.

Pala-Balanza automatica, de mano
Proyectada para pesar correctamente piensos.
Con escala de 200 gr. hasta un total de 3 kilos.

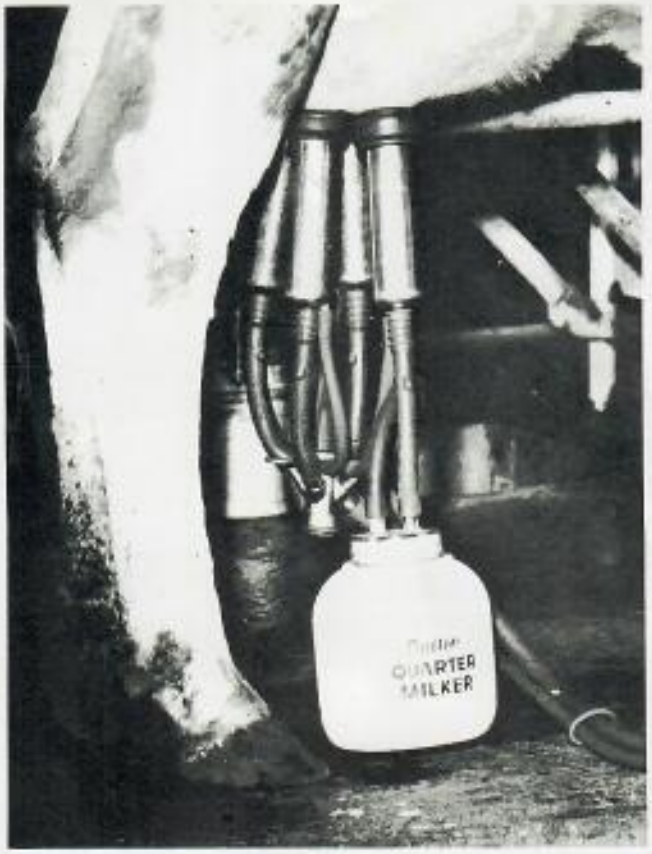
Sessola automatica
Appositamente studiata per pesare accuratamente il mangime.
Pesa da 200 grammi a 3 Kilogrammi.
In metallo inattaccabile, con azzeratore.

Hurtig udvejningsskovl
Udformet til hurtig og akkurat vejning af foder. Verjer fra ½ pund op til 7 pund. Lavet he
igennem af stærkt uforgængelig materiale—brækker ikke.
Fineste kvalitet fjeder balance med nul justering.

Destina-se a pesar, com exactidão, substâncias alimentares.
É provido de uma escala graduada em fraccoes de 200 gramas, permitindo pesagens até 3 kg.
Inteiramente fabricado com metais não corrosivos, com ajustador à posição zero.

Automatische Weegschaalschep vereenvoudigt snel en secuur afwegen van voedingsstoffen.
De schaal is tot 3 kg verdeeld in 200 grams delen.

DALTON



Ex 25

Quarter Milker
Fits any milking machine—Milk from the affected part is filtered into container.
Special non-return valve prevents milk contamination.
Unbreakable container made of high impact plastic.

Le Pot à Mammite
Adaptable à toutes les machines à traire.
Le lait des trayons infestés est filtré dans le récipient.
Une valve spéciale de non-retour évite la contamination du lait sain.
Récipient incassable fait dans une matière plastique solide.

Viertel Melker
Zum Melken von entzündeten Eutern.
Trennt hygienisch einwandfreie von infizierter Milch.
Das Ventil des Viertelmelkers verhindert irgendwelche Infizierung.
Passt an jede Melkmaschine.
Der Behälter ist aus unzerbrechlichem Kunststoff hergestellt.

Ordenhador de Quarto
Adapta-se a qualquer máquina de ordenhar. O leite proveniente de qualquer quarto afectado é filtrado para dentro do recipiente.
Uma válvula especial que impede o retorno do fluxo, evita a contaminação do leite.
O recipiente, feito de matéria muito resistente aos choques, é inquebrável.

Mælke-Isolator
Anvendes til maskin-malkning af køer, hvor mælken på grund af infektion i en enkelt kirtel eller efter behandling med antibiotika ikke ma komme sammen med den sunde mælk.
Beholderen er lavet af virkelig høj kvalitet plastik, og en ventil forhindrer den dårlige mælk i at blive sammenblandet med den gode mælk.

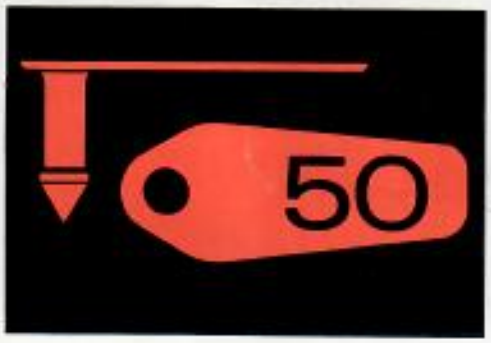
Ordeñador Mecánico
Sirve para cualquier máquina ordenadora La leche de la parte afectada es filtrada al pasar al recipiente.
Una válvula especial sin retorno impide la contaminación de la leche.
Recipiente hecha de plástico irrompible.

Kwartier melker
Kan op iedere melkmachine toegepast worden. De melk uit het aangetaste gedeelte komt in een apart vat. De terugslag klep voorkomt bevuiling van de andere melk.
Het vat is gemaakt uit onbreekbare kunststof.

Quarter Milker—Mungitore Meccanico
Adattabile con tutte le macchine da mungitura.
Il latte infetto viene filtrato nel recipiente.
Una speciale valvola evita il contagio del latte sano.
Recipiente infrangibile in solida materia plastica.

Dalton

ACTUAL SIZE OF TAG



DALTON SUPPLIES LTD.

Manufacturers of Agricultural Equipment

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Makers of:
Rototags
Jumbo Tags
Goliath Tags
Flexi Tags
Mini Tags
Super Universal Tags
Marker Straps
Neck Tags
Ankle Straps
Weighband
Quarter Milkers
Calf Dehorners
Calfeteria
Lam Bar
Lambing Instruments
Cow Immobilizers
Milk Sucking Preventors
Scale Scoops

CEC/LMG

15th October, 1975

G. H. Balazs, Esq.,
Marine Biologist,
University of Hawaii at Manoa,
P.O. Box 1346,
Coconut Island,
Kaneohe,
Hawaii 96744.

Dear Sir,

Thank you for your letter of the 2nd instant, and enclosed please find our pro-forma invoice No. 518 giving details of CIF charges by air parcel post and surface parcel post for the items listed.

Due to the amount of lettering specified for the Rototags and Jumbo Tags this will necessitate the manufacture of a special block for the embossing of these tags, price of which we have included in the above. Delivery will be approximately 3-4 weeks again due to the manufacture of the special embossing blocks, but thereafter delivery should be more prompt. These special blocks will, of course, be your property held by us for future use for your embossing.

Please let us know if you require any further information.

We look forward to hearing from you.

Yours faithfully,
DALTON SUPPLIES LTD.,

C. E. CROMPTON.

Enc.

DALTON SUPPLIES LTD.

NETTLEBED
HENLEY-ON-THAMES
OXON, RG9 5AB
ENGLAND

V.A.T. REG. No. 194 8082 31

Telephone/Telephone/Telefon Nettlebed 457/8/9

Cables/Câblogrammes/Telegrammadresse - Rototag

Telex No. 847547

Date/Datum 13th Oct., 1975

Your ref./Votre ref./Betrifft Your letter dated 2.10.75 refers.

Proforma ~~Invoice~~ No. 518

Description of goods / Description des marchandises / Bezeichnung der Waren: Agricultural Goods

TO— / A—

G. H. Balazs, Esq.,
Marine Biologist,
University of Hawaii at Manoa,
P.O.Box 1346,
Coconut Island, Kaneohe,
Hawaii 96744.

Country of Destination / Pays de destination / Bestimmungsland: Hawaii

Terms of Sale / Conditions de vente / Verkaufsbedingungen: C.I.F.

Payment Terms / Conditions de paiement / Zahlungsbedingungen: Cash against documents

Item / Article / Artikel	Quantity / Quantité / Menge	Description / Güter	Price / Prix / Preis	£	p
1	100	Mini Tags, embossed one side:-			
		1901-2000 - on male portion			
		OAHU - on female portion			
		(Colour to be advised)			
		@ £3.80 per 100		3.80	
		Less 20% discount		0.76	
					3.04
		Plus embossing fee for second side			0.60
2	1	pr. Mini Tag Applicators,			
		@ £2.75 each		2.75	
		Less 20% discount		0.55	
					2.20
3	100	Rototags, embossed one side:			
		2001-2100 - on male portion			
		NOTIFY U.HAWAII - on female portion			
		(Colour to be advised)			
		@ £3.50 per 100		3.50	
		Less 20% discount		0.70	
					2.80
		Plus embossing fee for second side			0.60

Est. Del'y Ex Works / Départ des usines estimé au / Voraussichtliche Lieferung ab Work

2/cont. .....

Approx. Packing Details / Détails d'emballage estimé / Ungefähre Angaben der Verpackung

Net Ex-works / Net départ usines / Netto ab Work	Total £ / Total £ / Summe £	54.04
Bank fee		3.00
Freight/Postage / Fret/Port / Fracht/Porto	Air parcel post 2 pkg.	6.00
	Surface direct	2.85
Insurance / Assurance / Versicherung	Insurance	0.25
Nett FOB/CIF/C & F / Nett FOB/CIF/C & F / Nett FOB/CIF/C & F	Total £ / Total £ / Summe £	63.29

We thank you for the order/enquiry detailed above and ask that you point out any errors/omissions immediately. Delivery is estimated in good faith and we will do all possible to maintain it. Final invoices, however, will advise you of despatch.
Nous vous remercions de la commande/demande de renseignements dont les détails figurent ci-dessus et vous prions de bien vouloir nous signaler immédiatement toutes erreurs ou omissions. La date de livraison a été estimée au plus juste et nous ferons tout notre possible pour la maintenir. Les factures définitives, cependant, vous informeront de l'expédition.

For DALTON SUPPLIES LTD.
Pour
Für

DALTON SUPPLIES LTD.

NETTLEBED
HENLEY-ON-THAMES
OXON, RG9 5AB
ENGLAND

V.A.T. REG. No. 194 8082 31

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Telex No. 847547

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		NOTIFY U.HAWAII - on female portion			
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		@ £3.50 per 100	3.50		
		Less 20% discount	0.70		
				2.80	
		Plus embossing fee for second side		0.60	

2/cont. .....

Est. Del'y Ex Works / Départ des usines estimé au / Voraussichtliche Lieferung ab Werk

Approx. Packing Details / Détails d'emballage estimé / Ungefähre Angaben der Verpackung

Net Ex-works / Net départ usines / Netto ab Werk	Total £ / Total £ / Summe £	
Freight/Postage / Frac/Port / Fracht/Porto		
Insurance / Assurance / Versicherung		
Nett FOB/CIF/C & F / Nett FOB/CIF/C & F / Nett FOB/CIF/C & F	Total £ / Total £ / Summe £	

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For DALTON SUPPLIES LTD.
Pour
Für

DALTON SUPPLIES LTD.

NETTLEBED
HENLEY-ON-THAMES
OXON, RG9 5AB
ENGLAND

V.A.T. REG. No. 194 8082 31

Telephone/Téléphone/Telefon Nettlebed 457/8/9

Cables/Câblogrammes/Telegrammadresse - Rototag

Telex No. 847547

Date/Datum 13th Oct., 1975

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Proforma/Pro forma
No. 518

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TO:— / A:— G. N. Balazs, Esq.,
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Coconut Island, Kaneohe,
Hawaii 96744.

Country of Destination / Pays de destination / Bestimmungsland: Hawaii

Terms of Sale / Conditions de vente / Verkaufsbedingungen: C.I.F.

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Est. Del'y Ex Works / Départ des usines estimé au / Voraussichtliche Lieferung ab Werk

2/cont. .....

Net Ex-works / Net départ usines / Netto ab Werk — Total £ / Total £ / Summe £

Approx. Packing Details / Détails d'emballage estimé / Ungefähre Angaben der Verpackung

Freight/Postage / Fret/Port / Fracht/Porto

Insurance / Assurance / Versicherung

Nett FOB/CIF/C & F / Nett FOB/CIF/C & F / Nett FOB/CIF/C & F — Total £ / Total £ / Summe £

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Pour
Für

DALTON SUPPLIES LTD.

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OXON, RG9 5AB
ENGLAND

V.A.T. REG. No. 194 8082 31

Your ref./Votre ref./Betrifft

Telephone/Téléphone/Telefon Nettlebed 457/8/9

Cables/Câblogrammes/Telegrammadresse - Rototag

Telex No. 847547

Date/Datum 13th Oct., 1975

Proforma/~~Order~~ No. 518 /cont. ...

Description of goods
Description des marchandises
Bezeichnung der Waren

TO:—

A:—

Country of Destination
Pays de destination
Bestimmungsland

Terms of Sale
Conditions de vente
Verkaufsbedingungen

Payment Terms
Conditions de paiement
Zahlungsbedingungen

Item Article Artikel	Quantity Quantité Menge	Description Güter	Price Prix Preis	£ p
		- 2 -		
4	1	Special Block for embossing female portion of Rototags.		15.00
5	1	pr Rototag Applicators,		
		@ £2.00 each	2.00	
		Less 20% discount	0.40	1.60
6	100	Jumbo Tags, embossed both sides;		
		2101-2200 - on male portion		
		NOTIFY UNIV MARINE LAB HAWAII 96744 - on female portion		
		@ £7.50 per 100	7.50	
		Less 20% discount	1.50	6.00
7	1	Special Block ~~for~~ embossing female portion of Jumbo Tags.		20.00
8	~~1~~	pr Jumbo Tag Applicators,		
		@ £2.75 each	2.75	
		Less 20% discount	0.55	2.20
		COUNTRY OF ORIGIN U.K. R.H.Harwood		

Est. Daily Ex Works
Départ des usines estimé au
Voraussichtliche Lieferung ab Werk: 3-4weeks, due to delivery of the special blocks

Approx. Packing Details
Détails d'emballage estimé
Ungefähre Angaben der Verpackung

nett weight approx.between 1.021-1.929 kgs.
gross " " " 1.929-2.837 kgs.

Net Ex-works / Net départ usines / Netto ab Werk	Total £ / Total £ / Summe £	54.04
Bank fee		3.00
Freight/Postage / Fret/Port / Fracht/Porto	Air parcel post 2 pkg.	6.00
	Surface ditto	2.65
Insurance / Assurance / Versicherung	Insurance	0.25
Net FOB/CIF/C & F / Net FOB/CIF/C & F / Net FOB/CIF/C & F	Total £ / Total £ / Total £	63.29
	Air p. 2 p.	

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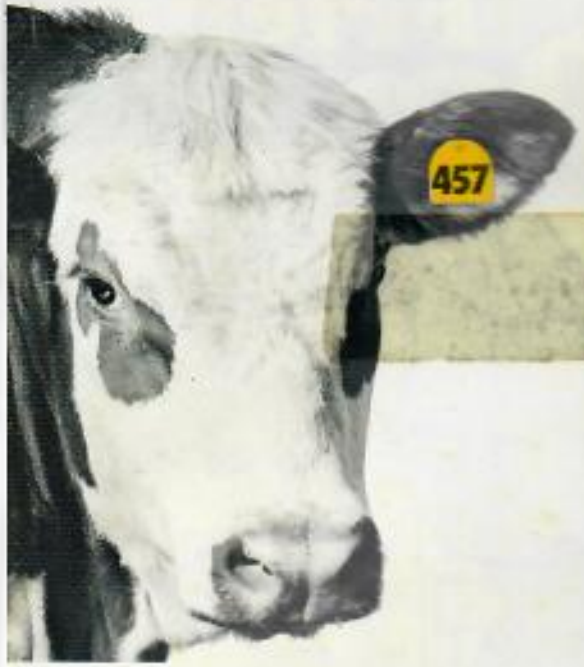
For DALTON SUPPLIES LTD.
Pour
Für

Dalton SUPPLIES LTD

International Manufacturers of World Renowned ANIMAL IDENTIFICATION SYSTEMS

NEW Dalton RIESE TAG



Pat. Pending

New Dalton Riese Tag

for cattle and sow identification.

Soft as silk all through – even the pin is flexible.

Click – and it is fitted with our special pliers. No blood – no fuss.

Identification from front and rear, large clear numbers up to 999 embossed both sides.

Die neue RIESE Ohrmarke

zur Kennzeichnung von Rindern, Kälbern und Schweine.

Ganz biegsam – sogar der Dorn ist biegsam

Klick – und es ist eingezogen, kein Blutverlust, schnell und einfach.

Schnellerkennung von Vorder – und Rückseite des Tieres – gross klare Nummern bis 999 beiderseits geprägt.

La nouvelle attache Dalton "RIESE"

Pour l'identification des bovins et des porcs.

Douce comme la soie par tout – même l'aiguille est flexible.

En un coup de main – elle est fixée avec nos pinces spéciales.

Pas de sang – Pas de douleur.

Marquage lu des deux faces – Chiffres grands et lisibles jusqu'à 999 imprimés en relief des deux côtés.

Nueva Marca Dalton Riese

para identificación de ganado vacuno y de cerda.

Tan suave como la seda – incluso la clavija es flexible.

Un golpe seco "click" – y queda acoplada con nuestras tenazas especiales.

Sin sangre – Sin molestia.

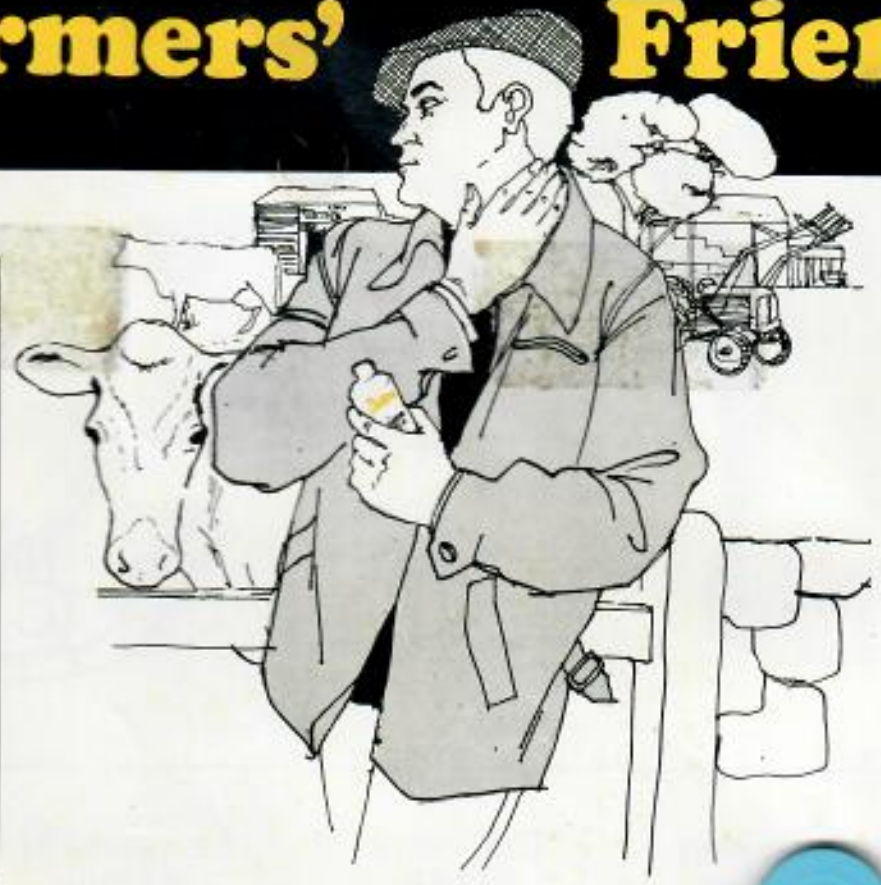
Identificación frontal y trasera, números grandes y claros, hasta el 999, grabados en ambos lados.

Dalton

NETTLEBED
HENLEY-ON-THAMES
OXON

Dalton SWEET RELIEF With Menthol

The Farmers' Friend



Dalton 'Sweet Relief'

with Menthol gives relief from Rheumatic Pain, Lumbago, Sciatica and Fibrositis, simply smooth it on the affected part.

A sprinkle of "Sweet Relief" on a damp cloth is excellent as an application in cases of sprain, bruising and swellings.

Added to a footbath it acts as a soothing balm for sore feet. In cases of nervous strain – overtiredness – a dab on the forehead and neck is revitalising and invigorating.

Dalton 'Sweet Relief'

mit Menthol gibt Erleichterung von rheumatischen Schmerzen, Ischias, Hexenschuss und Gliederschmerzen – einfach auf die betreffende Stelle reiben.

Ein Umschlag mit "Sweet Relief" ist vorzüglich in Fällen von Verstauchungen und Anschwellungen.

Ein paar Tropfen zum Fussbad wirkt als milderner Balsam.

Im Falle von nervöser Überanstrengung, Übermüdung – ein paar Tropfen auf Stirn und Nacken reiben: wirkt belebend und erfrischend.

Dalton 'Sweet Relief'

au Menthol soulage les douleurs rhumatismales, lumbago, sciatique et fibromatose. Le passez simplement sur les parties douloureuses.

Un peu de "Sweet Relief" sur un linge humide est excellent comme traitement dans les cas de foulures, froissements et enflures.

Utilisé dans un bain de pieds, il agit comme un baume apaisant pour des pieds douloureux.

Dans le cas d'une fatigue nerveuse, surmenage – une compresse sur le front et le cou est revitalisante et défatiguante.

F

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remedio en casos de torceduras, contusiones e hinchazones.

Aplicado a un baño de pies actúa como un bálsamo sedante para pies doloridos.

En casos de tensión nerviosa – fatiga excesiva – un frote ligero sobre la frente y el cuello es revitalizante y vigorizante.

Dalton

UNIVERSAL EAR TAG

NEW

Universal 3-piece identification ear tag for pigs, cattle, calves and sheep. Easy humane application with Dalton Jumbo pliers — no blood — no ear slitting — no prior hole cutting.
Made in durable flexible nylon material.
Choice of 3 colours: yellow, red and blue.
Available embossed with large numbers or plain for self-marking with durable marking ink and pen.

Attache d'oreille universelle, pour l'identification des porcins, bovins, veaux et moutons. Elle se pose facilement, sans danger avec les pinces Jumbo. Pas de sang, pas de déchirures de l'oreille. L'attache est posée d'un geste rapide. Elle se compose de la "Dalton Jumbo Tag" à laquelle est incorporé une attache flexible, disponible en Jaune, Rouge et Bleu, gravée en gros chiffres, ou bien disponible non gravée, avec la fourniture d'encre à marquer, ou d'un stylo selon les besoins.

Universal Tierkennzeichnungsohrmarken für Schweine, Rinder, Kälber und Schafe. Einfache, humane Einziehung mit der Dalton Jumbozange — kein Blutverlust — kein Ohrenschlitzen — kein Vorlochen. Besteht aus der Jumbo Ohrmarke mit einer biegsamen Lasche aus Kunststoff.
Erhältlich in den Farben gelb, rot und blau.
Erhältlich numeriert mit grossen Nummern oder unnumeriert zur Selbstmarkierung mit Markierungsfarbe und Stift.

Marca Auricular Universal de Identificación de 3-piezas para Cerdos, Vacas, Terneros y Ovejas. Puede aplicarse facilmente y sin dolor con las tenazas Dalton Jumbo — no produce sangre — no desgarra la oreja — no hay que hacer previamente agujero.
Fabricada en material de nylon flexible y duradero.
Hay 3 colores a elegir: amarillo, rojo y azul.
Puede facilitarse con números grandes grabados, ó en liso para que uno mismo pueda marcarla con pluma y tinta permanente.

Mini Flexi mærket til grise kalve og får er let at isætte med Dalton Jumbotangen. Ingen blod, ingen revne ører og ingen forund gående hulklipning af øret. Lavet i et holdbart fleksibelt nylon-materiale.
Valg af 3 farver, gul, rød og blå. Kan fås trykt med store numre eller unummerede til selvmærkning med holdbart blæk og en pen.

Os Brincos de Identificação "Universal" constituídos por 3 peças, destinam-se à marcação de suínos, bovinos, vitelos e ovinos. A aplicação, com os Alicates Jumbo Dalton, faz-se fàcilmente, com o mínimo de sofrimento para os animais, não causando hemorragia, golpes, e sem a necessidade de abertura prévia de orifícios. Estes brincos são fabricados em nylon flexível e são bastante duráveis.
Fornecem-se em 3 côres: amarelo, vermelho e azul, e encontram-se disponíveis para exportação já gravados com números de largas dimensões ou lisos para marcação pelo cliente, com tinta de marcar durável e pena.

Het universele 3-delige oormerk ter herkenning van varkens, vee, kalveren en schapen. Gemakkelijke en pijnloze bevestiging met de Dalton Jumbotang — geen bloedverlies — geen gescheurde oren — het merk wordt in één snelle handeling aangebracht. Gemaakt van duurzame, sterk buigzame kunststof.
Kleuren: geel, rood en blauw. Bedrukt met grote nummers of onbedrukt verkrijgbaar met pen en inkt om zelf nummers of letters aan te brengen.

Marca universale ad orecchio in tre pezzi per suini, bestiame di grossa taglia e pecore.
Applicazione facile ed umana con le pinze Jumbo, senza spargere sangue, senza lacerare orecchie, senza fare alcun buco prima di applicare.
Di flessibili e durevole materiale plastico.
Ottenibile in 3 colori: giallo, rosso e blu.
Ottenibile incisa in grandi numeri o liscia per incidere da se con inchiostro speciale e speciale durevole penna.

Dalton
NETTLEBED
HENLEY-ON-THAMES
OXON

Dalton NEW SUPER EAR TAG

The new Dalton Super Eartag for cattle/sow identification can rightly be called the universal tag. Fitted with a universal joint (unique in ear tags) the tag quickly swings free, out-of-trouble, in a complete circle if necessary.

Application is made humanely with Universal pliers. Numbers or letters are premanently embossed.

Super tags are made in strong, robust flexible material for hard wear.

Colours: flame red, yellow and light blue.

Price:

La nouvelle attache d'oreille 'Super' peut être nommée à juste titre la plaque d'oreille universelle. Avec un joint universel (unique pour plaques d'oreille) qui permet l'attache de tourner de tous côtés, sans difficulté, même s'il le faut dans un cercle.

Elle se pose facilement et humainement avec pinces Dalton 'Super'.

Numéros ou lettres sont gravés durablement sur l'attache.

L'attache 'Super' est faite dans une matière flexible et solide.

Disponible en rouge, jaune et bleu clair.

Prix:

Die neue Dalton Super Ohrmarke kann mit Recht Universalmarke genannt werden. Hergestellt mit einem Universalgelenk (eine Neuheit für Ohrmarken) welches ermöglicht schnelles Abdrehen der Marke, wenn nötig in einem vollen Kreis. Einziehung ist human mit der Super Ohrmarkenzange, Nummern und Buchstaben sind dauerhaft in das Material eingeprägt.

Super Ohrmarken sind aus strapazierfähigen, biegsamen Material hergestellt worden.

Erhältlich in den Farben rot, gelb and hellblau.

Preis:

Dalton's nieuwe Superoormerk kan met recht het Universele oormerk genoemd worden. Het is voorzien van een draaibaar verbindingsstuk (geheel nieuw bij oormerken). Dit maakt het mogelijk dat het merk zonder moeilijkheden alle kanten uit kan draaien, zo nodig in een cirkel.

De bevestiging geschiedt pijnloos met de Dalton Supertang.

Nummers of letters worden blijvend in het oormerk gedrukt.

Super oormerken zijn gemaakt van een sterk buigzaam materiaal voor blijvende duurzaamheid.

Kleuren: vlamrood, geel en lichtblauw.

Prijs:

La nuova marca ad orecchio Super della Dalton può senza dubbio essere chiamata la marca universale. Applicata con un giunto cardanico (rosa unica nelle marche ad orecchio) la marca ruota rapidamente, libera da ogni ipiglio, senza pericolo di incastrarsi, se necessario anche compiendo un cerchio completo.

Si applica in maniera semplice ed indolore con le speciali pinze Dalton.

I numeri e le lettere sono incisi permanentemente.

Le marche ad orecchio Super sono fatte con uno speciale metriale plastico flessibile e robusto, resistente ad ogni tipo di sollecitazione.

Colori: Rosso fiamma, giallo e azzurro.

Prezzo:

Daltons nye super-øremærke kan med rette kaldes universal-mærket. Sammensat med et led (enestående for øremærker), frigøres mærket hurtigt, uden problemer, og kan drejes en hel omgang, hvis nødvendigt.

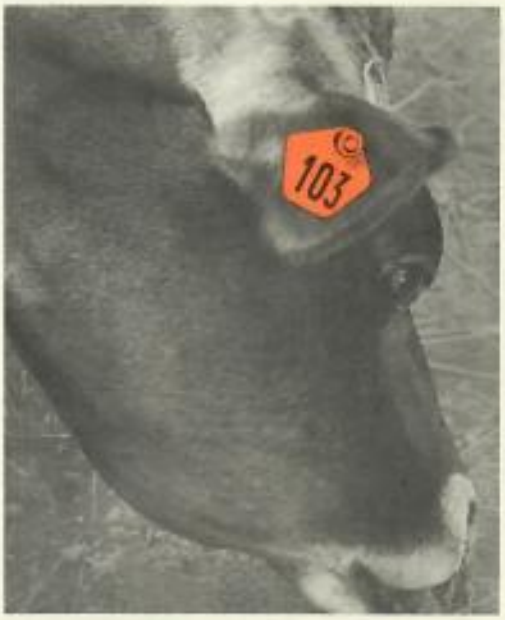
Mærkningen foregår humant med Daltons super-tang.

Numre og/eller bogstaver er uforgængelige.

Super-mærket leveres i et stærkt, robust, flexibelt materiale, og kan stå for hårdt slid.

Farver: flammerød, gul og lys blå.

Pris:



Dalton
NETTLEBED
HENLEY-ON-THAMES
OXON

DALTON
SUPPLIES LTD.

Dalton Supplies Ltd.,
Nettlebed, Henley-on-Thames,
Oxfordshire, England.
(Cables: ROTOTAG HENLEY-ON-THAMES (U.K.).)
(Phone: NETTLEBED 457/8/9. Telex 847547)

Miss P. Harwood
SENIOR SECRETARY

Dalton Supplies Ltd.
Leeson Close, Dublin 2, Eire.
Tel: 61242

Dalton Continental B.V.
6420 Lichtenvoorde,
Nijverheidsstraat 16, Holland.
(Belgium, Luxemburg)
Tel: 05433 – 2497 Telex: 44555

[redacted]

Dalton Continental B.V.
4291 Suderwick/Westf.
Die Liene/Ecke, Hohlweg,
Federal Republic of Germany
Tel: 02874 – 2268

Dalton Supplies Ltd.,
Lyngbakkevej, Nr. Vinge,
9500 Hobro, Denmark.
Tel: (06) 65 23 83

Dalton Supplies Ltd.
Observatoriegatan 21, 113 29 Stockholm,
Sweden
Tel: 31 76 76

Dalton Österreich
A-4880 St. Georgen im Attergau
Wildenhagerstr. 4, Austria
Tel: 07667/252

Dalton Italia
06024 GUBBIO, Via Reposati 32, Italy.
Tel: 922431

Dalton Agricultural Supplies Pty. Ltd.,
Box 216 Applecross,
Western Australia 6153
Tel: 64 4164

Mrs. C.E. Crompton
OVERSEAS DEPT.

Mr. D. Shepherd
ACCOUNTANT

DALTON

EX1

Calfeteria Feeding System

Saves time—Lasts for years—Easy cleaning—No finer way of rearing calves.
The Calfeteria allows each calf to feed the natural way.
The Calfeteria can be adapted to any single or group method used in feeding calves.
The Calfeteria can be placed anywhere.

University of Hawaii at Manoa

Hawaii Institute of Marine Biology
P.O.Box 1346 • Coconut Island • Kaneohe, Hawaii 96744
Cable Address: UNIHAW

October 2, 1975

Mrs. C.E. Crompton
Dalton Supplies Ltd.
Nettlebed RG9 5AB
Henley-on-Thames
England

Dear Mrs. Crompton:

Thank you for the prompt reply to my inquiry about plastic ear tags for sea turtles. Our success with metal tags has been limited, therefore I believe that an evaluation of your product is certainly warranted. Initially, only small quantities will be required, however, should they prove suitable under Hawaiian conditions we would want to place a large order.

I am concerned as to whether our stamping needs can be met on each of the different sizes. The smallest lettering on the sample tags in your catalog was on the mini tag. I take these letters to measure approximately 4mm. Using this size of a letter, we may beable to get the needed information on each tag. I shall set forth our requirements for an initial trial order, and would appreciate your response as to the feasibility and cost.

1. Mini Tags- numbered 1901-2000 (quantity-100); stamped as follows- OAHU
   one pair application pliers
2. Rototags- numbered 2001-2100 (quantity-100); stamped as follows-
   one pair application pliers

   NOTIFY
   U.HAWAII
3. Jumbo tags- numbered 2101-2200 (quantity-100); stamped as follows-
   one pair application pliers

   NOTIFY UNIV
   MARINE LAB
   HAWAII96744

In each case the consecutive numbering should be with the largest size possible. Also, I am wondering if it is possible to utilize the <u>inside</u> surface of the female portion of the tags. This would be in addition to the outside portions of both the male and female components. If possible, it would be nice to use this space for further lettering regarding tag return. How do you normally like to have payment made?

Thank you in advance for your assistance in this matter.

Sincerely,

George H. Balazs
Marine Biologist

DALTON SUPPLIES LTD.

Manufacturers of Agricultural Equipment

REG. OFFICE
NETTLEBED RG9 5AB
HENLEY-ON-THAMES, ENGLAND.
REG. No. 432210 ENGLAND

TELEPHONE NETTLEBED 457/8/9 — 377 487 498 TELEX No. 847647
ENGLISH FACTORIES AT HENLEY-ON-THAMES · STOKE ROW · CHELTENHAM
TELEGRAPHIC ADDRESS ROTOTAG HENLEY-ON-THAMES (U.K.)

Makers of:
Rototags
Jumbo Tags
Goliath Tags
Flexi Tags
Mini Tags
Super Universal Tags
Marker Straps
Neck Tags
Ankle Straps
Weighband
Quarter Milkers
Calf Dehorners
Calfeteria
Lam Bar
Lambing Instruments
Cow Immobilizers
Milk Sucking Preventors
Scale Scoops

CEC/LMG 26th September, 1975

G. H. Balazs, Esq., Marine Biologist,
University of Hawaii at Manoa,
P.O. Box 1246,
Coconut Island,
Kaneohe,
Hawaii 96744.

Dear Sir,

Thank you for your letter received on the 23rd instant, requesting information regarding tags suitable for sea turtles.

Please find enclosed a copy of our export catalogue, complete with samples of the female portions of our range of world famous animal identification ear tags, and price list. We would be pleased to allow you a discount of 20% on the stated prices.

For the tagging of sea turtles we would particularly recommend our Jumbo Tag, which has been used by Ministries of Agriculture, Department of Fisheries, in various countries for the tagging of turtles with great success.

Upon request we would be pleased to quote CIF charges for specified quantities of our products, and any further information you may require.

We look forward to hearing from you and assure you of our best attention at all times.

Yours faithfully,
DALTON SUPPLIES LTD.,

C. E. CROMPTON.

Enc.

E. & O. E.

PLEASE NOTE THAT THE PRICES QUOTED ARE SUBJECT TO ALTERATION WITHOUT PRIOR NOTICE

July 1975

DALTON SUPPLIES LIMITED. NETTLEBED, HENLEY ON THAMES. OXON. RG9 5AB
TELEPHONE : NETTLEBED 457/8/9 TELEX: 847547

CAT NO.	CATALOGUE PRODUCT	RETAIL PRICE	POSTAGE
EX 1	CALFETERIA		
	Single Unit	£ 1.35	15p
	Straight Three	£ 8.70	60p
	Straight Four	£10.50	75p
	Straight Six	£13.00	80p
	Spare Teats	£ 0.50	15p
	Spare Brackets	£ 0.43	15p
	Spare Tubes	£ 0.43	15p
EX 2	CALF DEHORNERS (All types)	£ 7.00	29p
EX 3	WEIGHBAND	£ 1.60	15p
EX 4	KLEEPMARK KIT	£15.00	Extra
	Replacement Bottles of fluid	£ 1.50	"
EX 5	METAL MILK SUCKING PREVENTOR	£ 2.15	15p
EX 6	PLASTIC MILK SUCKING PREVENTOR	£ 2.00	15p
EX 7	ANKLE STRAPS	£ 0.30	Extra
EX 8	MINI TAGS - 100 Plain tags	£ 2.70	"
	Application Pliers	£ 2.75	"
	MINI TAGS - 100 numbered one side	£ 3.80	"
EX 9	MARKEP STRAPS		
	Side numbers only complete with buckles	£ 0.80	Extra
	Side numbers only minus buckles	£ 0.60	"
	With additional top number	£ 0.95	"
	With additional top number minus buckles	£ 0.75	"
	Calf Size complete with buckle	£ 0.75	"
	Calf Size complete with top piece and buckle	£ 0.90	"
	Individual names embossed	£ 0.10	"
	Numbered Sleeves	£ 0.05	"
EX 11	ROTOTAGS		
	25 tags embossed one side	£ 1.50	15p
	50 tags embossed one side	£ 2.25	15p
	100 tags embossed one side	£ 3.50	20p
	100 Blank tags	£ 2.25	20p
	Extra embossing charge for names or herd numbers on female portion for first 100 or under, plus £0.60		
	for each additional 100, plus	£ 0.30	
	Application Pliers	£ 2.00	20p

CAT NO.	CATALOGUE PRODUCT	RETAIL PRICE	POSTAGE
EX 12	JUMBO TAGS		
	25 Tags numbered both sides	£ 2.15	15p
	50 Tags numbered both sides	£ 4.00	15p
	100 Tags numbered both sides	£ 7.50	25p
	Plain Tags		
	100 Plain tags	£ 6.00	25p
	Application Pliers	£ 2.75	29p
EX 13	GOLIATH TAGS		
	100 Tags embossed both sides	£15.00	51p
	100 Tags Plain	£12.00	51p
	Application Pliers	£ 3.00	25p
EX 14	NECK TAG ONLY	£ 0.20	Extra
	Poly Neck Tag and Chain	£ 1.00	"
	Neck Tag complete with 48" Steel chain	£ 0.95	"
	Complete with nylon cord and weight fixture	£ 0.35	"
EX 15	LAMBAR 12 Teat Model	£15.00	75p
	Spare Teats	£ 0.20	Extra
	Spare Tubes	£ 0.10	"
	Non return valves (optional)	£ 0.50	"
EX 16	LAMBAR (6 Teat Model)	£ 8.00	60p
EX 17	Discontinued		
EX 18	RAM HARNESS Leather	£ 7.55	30p
	" " Plastic or nylon webbing	£ 7.00	30p
	Crayons	£ 1.20	15p
	BULL HARNESS	£ 9.20	30p
EX 19	LONG FLEXIBLE EAR TAGS Large numbers, with herd number on anchor tag per 100	£13.50	42p
	Plain Flexible Tags for self marking, complete with plain anchor tags, per 100	£10.00	42p
	Bottle of permanent Marking Ink, complete with free felt pen.	£ 0.95	Extra
	Application pliers	£ 2.75	29p
EX 20	LAMBING INSTRUMENT	£ 1.65	15p

PLUS 8% V.A.T. POST/PACKING PAID ON ORDERS OVER £50 NETT. U.K. ONLY

CAT NO.	CATALOGUE PRODUCT	RETAIL PRICE	POSTAGE
EX 21	SAVEWE	£ 0.75	15p
	Carton of 4	£ 2.70	15p
EX 22	COW IMMOBILIZER	£ 2.70	51p
EX 23	PARAGON INSTRUMENT	£ 3.50	Extra
	100 Paragon Rings	£ 0.45	"
	500 Paragon Rings	£ 1.95	"
EX 24	SCALE SCOOP	£10.00	51p
EX 25	QUARTER MILKER	£ 4.90	29p
	Replacement Tops	£ 1.10	Extra

GOODS OBTAINABLE - NOT ILLUSTRATED IN OUR CATALOGUE

DALTON HALTERS (adjustable) Nylon Webbing	£ 4,00	20p
TEAT PROTECTORS	£11.00	51p
FOOT ROT SHEARS (When available)	£ 4.50	Extra
SINGLE BOW SHEEP SHEARS	£ 2.30	"
DOUBLE BOW SHEEP SHEARS	£ 2.35	"
SWEET RELIEF including postage and VAT	£ 0.66	
9 TEAT CHURN TOP complete with 9 TEATS AND TUBES	£13.00	80p
9 TEAT CHURN TOP complete with only 6 Teats and Tubes	£11.00	75p
Spare Teats	£ 0.50	15p
Spare Tubes	£ 0.43	Extra
DALTON ROPE HALTERS		
Sisal	£ 1.05	Extra
Cotton	£ 1.25	"
FARMERS MASK	£ 0.65	"
FARMERS RESPIRATOR	£ 4.95	"
Respirator Refill	£ 1.60	"

PLUS 8% V.A.T. POST AND PACKING PAID ON ORDERS OVER £50. NETT. U.K. ONLY

GOODS OBTAINABLE - NOT ILLUSTRATED IN OUR CATALOGUE

	RETAIL PRICE	POSTAGE
SUPER TAGS		
100 Tags Embossed	£15.00	42p
Application Pliers	£ 2.75	22p
UNIVERSAL EAR TAG		
100 Tags Embossed	£11.00	42p
100 Tags Plain	£ 8.00	42p
Application Pliers	£ 2.75	29p
NEW DALTON MARKING STICKS	£ 0.40	15p
NEW RIESE TAG		
100 Tags Embossed	£12.00	29p
100 Tags Plain	£10.00	29p
Application Pliers	£ 3.00	29p
Bottle of permanent Marking Ink, complete with free felt pen	£ 0.95	Extra
GENERAL PURPOSE METAL EAR TAG		
100 Tags Embossed	£ 3.75	29p
Special Application Pliers	£3.00	29p
LAMBAR UNIT	£ 0.73	15p
WEENUM DUMMIES	£ 0.99	Extra
SPARE TEATS	£ 0.42	"
KAWE CATTLE COAXER with batteries	£ 9.96	"
FARMERS SEALING KIT	£11.45	"
BULL HOLDERS, COILED SPRING, SMALL ONLY	£ 1.20	"
FENCING PLIERS	£ 3.70	"
AUTO LOCK SAFETY BOLTS	£ 0.95	"
BULL RINGS, STAINLESS STEEL		
SIZES : 2¾"	£ 1.22	"
" 3"	£ 1.30	"

PLUS 8% V.A.T. POST AND PACKING PAID ON ORDERS OVER £50 NETT. U.K. ONLY

IF YOU DO NOT FIND WHAT YOU REQUIRE IN OUR CATALOGUE, PLEASE ENQUIRE