

Brush Alloy 25



BRUSH Alloy 25

A dvantage For The Oil and Gas Industry

Unique property combinations of Brush Alloy 25 make it the material of choice for downhole drilling tools, production and completion tools, subsea and wellhead products.

Performance can be improved and service life extended using this alloy, leading to significant savings in drilling, completion and production costs. For highly demanding applications...MWD/LWD Tools, Drill Collars and Subs, Flex Subs and Shafts, Drill Rods, Drill Bit Bushings, Valve Components (stems, seals, balls, seats), Pump Shafts, Fasteners...specify Brush Alloy 25.

Brush Alloy 25 offers **High Strength** and **Excellent Corrosion Resistance** in combination with

- Fatigue Strength ●
- Galling Resistance ●
- Magnetic Transparency ●
- Resiliency ●
- High Hardness ●



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SPECIFICATIONS AND QUALITY SYSTEMS

Brush Alloy 25 conforms to the following industry specifications:

ASTM B196, B251, B643

API Specification 7

API Specification 6A

NACE Standard MR0175-98

Brush Wellman's manufacturing conforms to ISO 9002 Quality System Standards. BrushPRIDE, our employee-involved quality system, guides continuous improvement in our processes.



BRUSH Alloy 25 for Innovative Design

Brush Alloy 25 offers design flexibility. Because the alloy is age-hardenable, it can be produced in a wide range of strengths. Property combinations within this range can be tailored to the individual application requirements.

Figure 1: Mechanical and Electrical Properties of Brush Alloy 25 Rod, Bar and Tube

TEMPER	TENSILE STRENGTH		YIELD STRENGTH 0.2% OFFSET		ELONGATION %
	ksi	MPa	ksi	MPa	
A (TB00)	60-85	414-586	20-35	138-241	60-20
H (TD04)	85-130	586-896	75-105	517-724	30-8
AT (TF00)	110-200	759-1379	90-175	621-1207	15-4
HT (TH04)	120-225	827-1551	100-200	689-1379	13-2

Design property combinations available upon request.

Figure 2: Brush Alloy 25 Chemical Composition (weight percent)

COPPER ALLOY UNS NUMBER	BERYLLIUM	COBALT + NICKEL	COBALT + NICKEL + IRON	COPPER
C17200	1.80-2.00	0.20 min	0.60 max	Balance

Figure 3: Physical Properties of Brush Alloy 25

DENSITY		ELASTIC MODULUS		THERMAL EXPANSION COEFFICIENT		THERMAL CONDUCTIVITY		POISSON'S RATIO	MELTING TEMPERATURE	
lb/in ³	g/cm ³	10 ⁶ psi	10 ³ kg/mm ²	in/in/F 70F to 400F	m/m/C 20C to 200C	BTU/(ft•hr•F)	Watt/(m•C)		F	C
0.302	8.36	19	13.5	9.7-10 ⁻⁶	17•10 ⁻⁶	60	105	0.30	1600- 1800	871- 982



	ROCKWELL HARDNESS B or C Scale	ELECTRICAL CONDUCTIVITY	
		% IACS	m•mho•cm
	B45-B85	15-19	.09-.11
	B88-B103	15-19	.09-.11
	B95-C39	22-28	.13-.16
	B95-C45	22-28	.13-.16

TEMPER DESIGNATIONS

Copper beryllium properties are determined, in part, by composition. However, cold work and age hardening are also important. The combined effect of non-compositional factors is defined as the alloy's temper.

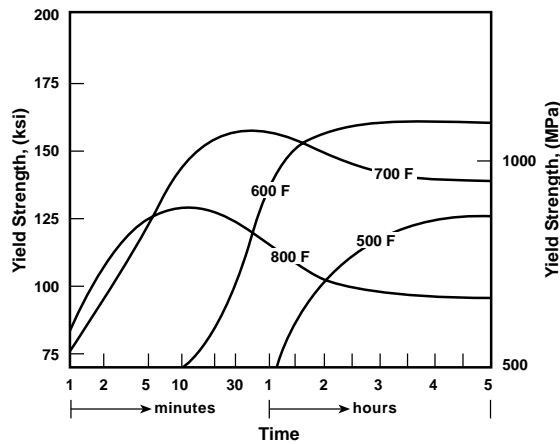
Temper designations are defined in ASTM B601. Copper beryllium in the Annealed condition is designated by a suffix letter "A", for example 25 A. Suffix letter "H" denotes an alloy has been Hardened by cold working. The suffix "T" following an "A" or "H" designates an alloy which has been given a standard heat treatment, for example 25 AT or 25 HT.

AGE HARDENING

Age hardening response depends on time, temperature and amount of cold work because strengthening is governed by precipitate size and distribution. For ease of heat treatment, a time-temperature combination is designated to produce maximum strength. For Brush Alloy 25, this combination is in the range of 3 hours at 600-675F.

Aging at times shorter than required to achieve peak strength is known as under-aging. Toughness, fatigue strength and, in some cases, corrosion resistance, benefit from an underaged microstructure. Overaging involves heating for a time longer than needed to achieve peak strength. Electrical and thermal conductivities and dimensional stability are maximized by overaging. Altering the aging temperature can also achieve similar results.

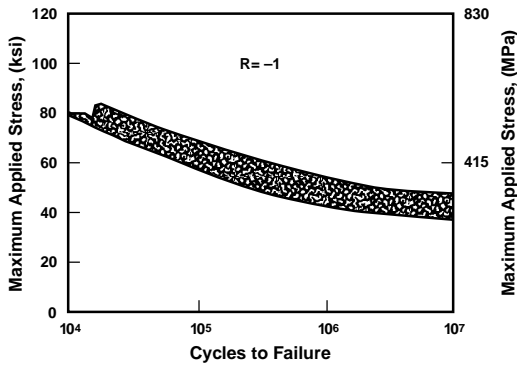
Figure 4: Brush Alloy 25 Age Hardenability



FATIGUE PERFORMANCE

Brush Alloy 25 has a long history of success in downhole components subject to cyclic loading. It resists fatigue failure with high static strength, toughness and an ability to diffuse strain by work hardening.

Figure 5: Rotating Beam Fatigue Strength for High Strength Alloy 25 >140 ksi (965 MPa) 0.2% Offset Yield Strength



CORROSION RESISTANCE

Brush Alloy 25 has excellent corrosion resistance. In marine environments, its performance is unsurpassed. Components have seen more than thirty years of service without evidence of fouling or detrimental corrosion. This low sea water corrosion rate makes Brush Alloy 25 an ideal material choice for subsea components.

Additionally, Brush Alloy 25 is not susceptible to sulfide or chloride stress corrosion cracking, resists carbon dioxide and is effectively immune to hydrogen embrittlement. In sour environments, it is used where exposure is intermittent.

Brush Alloy 25 meets the requirements of NACE Standard MR0175-98.

Figure 6: Resistance to Chloride Stress Corrosion Cracking

Temperature, F (C)	300 (150)	311 (155)	300 (150)
Applied Stress (percent of 0.2% yield strength) ksi (MPa)	100 (689)	100 (689)	100 (689)
Oxygen Content (parts per million in saturating gas)	1	1	5000
pH	8	3	7
Chloride Concentration (weight percent)			
sodium	3	0	0
potassium	10	0	6
magnesium	0	42	25
Test Duration, hours	720	1000	1000
Test Result	no cracking	no cracking	no cracking

ELEVATED TEMPERATURE STRENGTH

Brush Alloy 25 demonstrates excellent stability of tensile properties from cryogenic temperatures through 500F, despite long exposure. When tested at conventional strain rates, tensile properties retain room temperature values through 500F.





GALLING RESISTANCE

Brush Alloy 25 has superior galling resistance. This is one of the primary reasons that Brush Alloy 25 is selected for equipment where the service conditions include high loading and relative motion between metal components. Brush Alloy 25 resists galling to many other alloys and resists galling to other Alloy 25 components.

Figure 7: Galling Resistance Comparisons of Specific Alloys

ALLOY 1 vs. ALLOY 2		THRESHOLD GALLING STRESS	
		ksi	MPa
Alloy 25 (145, 1000)	Alloy 25 (145, 1000)	100 +	689+
Alloy 25 (145, 1000)	17-4PH (146, 1007)	90 +	621+
Alloy 25 (145, 1000)	MP35N (145, 1000)	75 +	517+
Alloy 25 (145, 1000)	Nitronic 50 (79, 545)	60 +	414+
Alloy 25 (145, 1000)	Monel K500 (115,793)	50 +	345+
Alloy 25 (145, 1000)	Gall Tough (65, 448)	50 +	345+
Alloy 25 (145, 1000)	Ti-6Al-4V (142, 979)	7.5 ¹	52 ¹
Nitronic 50 (79, 545)	Nitronic 50 (79, 545)	2	14
Monel K500 (115, 793)	Monel K500 (115, 793)	<10	<69
Ti-6Al-4V (142, 979)	Ti-6Al-4V (142, 979)	<2.5	<17

- ¹Alloy 1 galled to Alloy 2.
- Test method per ASTM G98.
- Values shown are unlubricated threshold galling stress (ksi, MPa) for button and block galling test.
- Values given as 50+ indicate the samples did not gall.
- Number in parentheses following alloy designations are 0.2% offset Yield Strength (ksi, MPa).
- Other alloy comparisons available.



CRYOGENIC BEHAVIOR

Brush Alloy 25 is used in liquefied gases and at sub-zero temperatures since strength, ductility and toughness are maintained in cryogenic conditions. Brush Alloy 25 has no ductile to brittle transition temperature, as do many high strength steels.



**WHEN YOU CAN'T RISK
THE CHANCE OF MAGNETIC
HOT SPOTS**

Brush Alloy 25 is an ideal material for instrument housings. Its unique combination of high strength, ductility, magnetic transparency and corrosion resistance provides the instrument designer with a material that will provide years of performance under severe drilling conditions.

A key aspect of instrument housing design is the ability to withstand down-hole pressures. Equations in API Bulletin #5C3 relate the yield strength of the material (Y_p), the outside diameter of the tube (D) and the wall thickness (t) to the amount of pressure (R_{yp}) a tube can withstand before collapsing.

$$R_{yp} = 2Y_p \left(\frac{(D/t) - 1}{(D/t)^2} \right)$$

The ability to age harden Brush Alloy 25 to various strength and ductility combinations offers a wide variety of design possibilities which are ideally suited to withstand downhole collapse pressure. The available strength and elongation combinations for Brush Alloy 25 Instrument Grade Tube are shown below.

Figure 8: Minimum Strength and Elongation for Brush Alloy 25 Instrument Grade Tube

YIELD STRENGTH 0.2% OFFSET		ELONGATION %
ksi	MPa	
150	1034	5
140	965	6
130	896	8
120	827	10
110	759	12

Brush Alloy 25 Instrument Grade Tube is manufactured to precision tolerances and is available from stock.



MAGNETIC PROPERTIES

Brush Alloy 25 is non-magnetic. Magnetic permeability is near unity meaning that the alloy is nearly perfectly transparent to slowly varying magnetic fields. Localized deformation or surface abrasion will not cause magnetic "hot spots" and the material will not become magnetized by machining.



BRUSH Alloy 25 for Drill Collars And Subs

ELIMINATE GALLING AND SEIZING

A special grade of copper beryllium has been developed for drill collars and subs. Brush Alloy 25 Drill String Temper (DST) meets the requirements of American Petroleum Institute Spec 7 for drill collars and rotary substitutes. In addition, it is noted for its ability to minimize galling in threaded tool joints.

Figure 9: Mechanical Properties for Brush Alloy 25 DST

DRILL COLLAR OUTSIDE DIAMETER	MINIMUM TENSILE STRENGTH ASTM E8		MINIMUM YIELD STRENGTH 0.2% OFFSET		MINIMUM ELONGATION	MINIMUM IMPACT ENERGY		
	inches	ksi	MPa	ksi		MPa	%	ft-lbF
3½ - 6%		140	965	110	759	12	13	17.6
7 - 11		135	931	100	698	13	13	17.6
over 11		120	927	90	621	13	13	17.6

GALLING RESISTANCE

Thread seizure during make-up and under the stress and heat of the downhole environment is one of the headaches of the driller leading to destruction of subs and collars during disassembly. This problem can be completely eliminated by using copper beryllium thread saver subs and collars. Pin/Box couples of copper beryllium to itself, or copper beryllium to stainless steel do not gall or seize even at torques more than 100% greater than the API minimum, with or without lubricant.

Disassembly and reassembly are facilitated and thread re-cuts or sub replacement is eliminated, saving time and money.

Figure 10: Resistance to Galling in Threaded Joints

COUPLE (pin/box)	ONSET OF GALLING FAILURE (% OF API MINIMUM TORQUE)	
	Lubricated	Non-lubricated
Stainless/Stainless ¹	130%	<100%
Alloy 25/Stainless ²	N.F. (180%)*	–
Alloy 25/Stainless ¹	N.F. (200%)*	200%
Alloy 25/AISI 4140 ²	N.F. (205%)*	–
Alloy 25/Alloy 25 ¹	N.F. (200%)*	N.F. (200%)*

¹API 3 1/2 IF ²API 6 5/8 REG * No Failure (Test Limit)

FRACTURE TOUGHNESS AND FATIGUE CRACK PROPAGATION

Brush Alloy 25 DST offers the highest fracture toughness and resistance to crack propagation of any precipitation strengthened copper alloy. These property attributes provide the designer considerable flexibility to engineer damage tolerant and inspectable applications using Brush Alloy 25 DST.

Figure 11: Plane Strain Fracture Toughness of Brush Alloy 25 AT

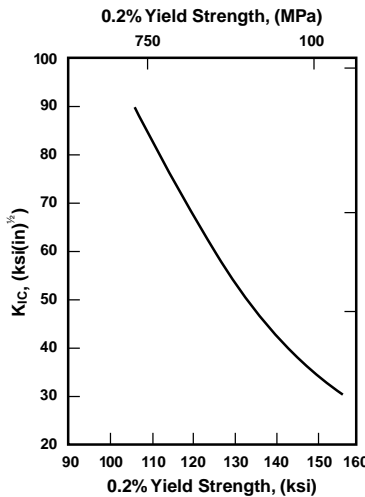
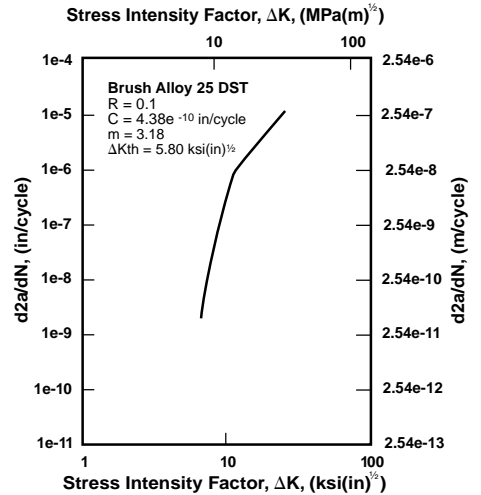


Figure 12: Fatigue Crack Propagation Resistance of Brush Alloy 25 DST 110 ksi (965 MPa) 0.2% Offset Yield Strength



MACHINABILITY

Brush Alloy 25 can be machined using conventional methods. Because of easy chip removal, machinability of Brush Alloy 25 is better than that of other high performance alloys. Since machinability rates are much higher, production is more efficient and manufacturing costs are reduced.

The material can also be electrical discharge machined, photo-chemically etched, welded and brazed.

Figure 13: Turning – Single Point Carbide Tool

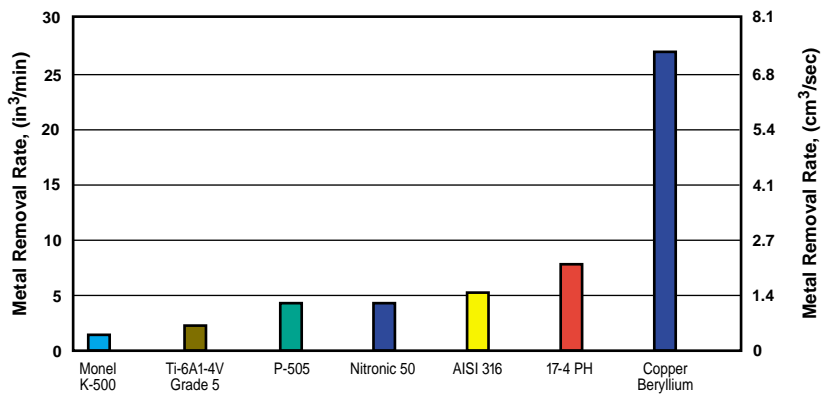
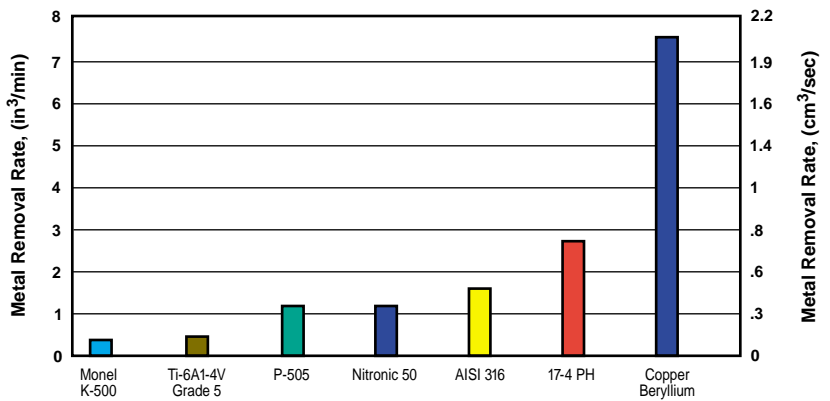


Figure 14: Drilling – High Speed Tool Steel Bit



WORLDWIDE AVAILABILITY

Brush Alloy 25 is available from inventory in a wide range of standard tube, rod, bar, plate, strip and casting ingot. Brush Wellman maintains a strategic worldwide network of service centers, independent distributors and authorized agents.

For further information on product availability or to place an order, contact:

In North America – Brush Wellman's Warren, Michigan Service Center at 800-521-8800 or 810-772-2700.

Outside North America – Brush Wellman's Export Sales Department in Cleveland, Ohio at 216-486-4200.

Ask to speak with the Brush Wellman Sales Engineer or Authorized Distributor/Agent in your area.

TECHNICAL ASSISTANCE

Detailed information regarding material properties, safe handling, specific applications and fabrication assistance is available from Brush Wellman's Customer Technical Service Department in Cleveland, Ohio at 800-375-4205 or 216-486-4200.



HEALTH AND SAFETY

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Brush Wellman Inc. in Cleveland, Ohio at 216-486-4200.

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