

MONEL[®] nickel-copper alloy R-405 (UNS N04405) 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. The composition is shown in Table 1.

Thermal expansion of alloy R-405 is shown in Table 2. The values for physical constants and other thermal properties of MONEL alloy 400 may be used for MONEL alloy R-405 and are shown in Tables 3 and 4.

Table 3 - Physical Constants of MONEL Alloy 400^a

Density, g/cm ³	8.80
lb/in. ³	0.318
Melting Range, °F	2370-2460
°C	1300-1350
Modulus of Elasticity, 10 ³ ksi	
Tension	26.0
Compression	26.0
Torsion	9.5
Poisson's Ratio	0.32
Curie Temperature, °F	70-120
°C	21-49

^a These values also apply to MONEL alloy R-405, the free-machining version of MONEL alloy 400.

Table 1 - Limiting Chemical Composition, %, of MONEL Alloy R-405

Nickel (plus Cobalt)	63.0 min.
Carbon	0.3 max.
Manganese	2.0 max.
Iron	2.5 max.
Sulfur	0.025-0.060
Silicon	0.5 max.
Copper	28.0 - 34.0

Table 2 - Thermal Expansion of MONEL Alloy R-405

Temperature, °F	Mean Linear Expansion, ^a 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

^a Between 70°F and temperature shown.

Table 4 - Thermal Properties of MONEL Alloy 400

Temperature		Mean Linear Expansion ^b		Thermal Conductivity ^a		Specific Heat ^a		Electrical Resistivity ^{a,c}	
°F	°C	in/in/°F x 10 ⁻⁶	µm/m•°C	Btu-in/ft ² •°F	W/m•°C	Btu/lb•°F	J/kg•°C	ohm-circ mil/ft	µΩ•m
-320	-200	-	-	-	-	-	-	205	0.360
-300	-180	6.1	11.1	113	16.5	0.050	223	-	-
-200	-130	6.4	11.4	130	18.2	0.078	320	-	-
-100	-70	6.7	12.1	139	19.8	0.088	378	-	-
70	21	-	-	151	22.0	0.102	427	307	0.511
200	100	7.7	14.2	167	24.0	0.105	445	322	0.537
400	200	8.6	15.2	193	26.9	0.110	459	337	0.559
600	300	8.8	15.7	215	30.1	0.114	470	346	0.574
800	400	8.9	16.1	238	33.4	-	-	355	0.587
1000	500	9.1	16.3	264	36.5	-	-	367	0.603
1200	600	9.3	16.6	287	39.4	-	-	379	0.620
1400	700	9.6	17.0	311	42.4	-	-	391	0.639
1600	800	9.8	17.4	335 ^d	45.5 ^d	-	-	403	0.658
1800	900	10.0 ^d	17.7	360 ^d	48.8 ^d	-	-	415	0.675
2000	1000	10.3 ^d	18.1 ^d	-	-	-	-	427	0.692

^a These values also apply to MONEL alloy R-405, the free-machining version of MONEL alloy 400.

^b Annealed material. Between 70°F (21°C) and temperature shown.

^c Annealed material.

^d Extrapolated.



MONEL® alloy R-405

Mechanical Properties

The ranges of nominal mechanical properties of MONEL alloy R-405 rod and bar are shown in Table 5.

Fatigue strength of alloy R-405 in various conditions is shown in Table 6. Toughness of the material is shown by the impact data in Tables 7, 8 and 9. The tension and torsion data are from Catlin and Mudge. Table 10 gives compressive properties found for the alloy.

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 and in Section III, Nuclear Vessels, of the Code.

Table 7 - 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 5 - Nominal Mechanical Property Ranges of MONEL Alloy R-405 Rod and Bar ^a

Condition	Tensile Strength, ksi	Yield Strength (0.2% Offset), ksi	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 6 - Fatigue Strength of MONEL Alloy R-405 Rod ^a

Condition	Fatigue Strength (10 ⁸ Cycles), ksi	Tensile Strength, ksi	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.

Table 8 - 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, ksi	Yield Strength (0.2% Offset), ksi	Elongation in 2 in., %	Reduction of Area, %	Hardness, Brinell (3000 kg)
Cold-Drawn 24%, Stress-Relieved	90	17.0	64.7	83.15	74.35	28.0	66.6	180
Annealed 1450°F/3 hr	148	35.0	69.1	73.35	28.00	44.5	70.1	116

^a Specimens completely broken.

Table 9 - 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	606	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 3/16 in.

Table 10 - Compressive Properties of MONEL Alloy R-405 Rod

Temper	Compression		Tension			
	Yield Strength (0.01% Offset), ksi	Yield Strength (0.2% Offset), ksi	Tensile Strength, ksi	Yield Strength (0.01% Offset), ksi	Yield Strength (0.2% Offset), ksi	Elongation, %
Hot-Rolled	26.0	34.0	76.0	33.0	36.0	39.5
Cold-Drawn ^a	51.0	66.0	83.0	62.0	74.0	28.0
Annealed ^b	23.0	26.0	73.0	25.0	28.0	44.5

^a Stress-equalized at 525°F after cold drawing.

^b Cold-drawn + 1450°F/3 hr, F.C.

Working Instructions

MONEL alloy 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 the publication “Machining” on the Special Metals Corporation website, www.specialmetals.com.

Joining

MONEL alloy R-405 may be joined by standard welding, brazing and soldering techniques. In general, processes and procedures are the same as for MONEL alloy 400. More information on joining can be found in the SMC publication “Joining” on the website www.specialmetals.com.

Available Products and Specifications

MONEL alloy R-405 is designated UNS N04405 and 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.

Applicable specifications are:

Bar and Rod: ASME SB-164, ASTM B-164, Federal QQ-N-281, SAE AMS 4674 & 7234, Military MIL-N-894, NACE MR-01-75.

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www.specialmetals.com



U.S.A. Special Metals Corporation

Billet, rod & bar, flat & tubular products
3200 Riverside Drive
Huntington, WV 25705-1771
Phone +1 (304) 526-5100
+1 (800) 334-4626
Fax +1 (304) 526-5643

Billet & bar products
4317 Middle Settlement Road
New Hartford, NY 13413-5392
Phone +1 (315) 798-2900
+1 (800) 334-8351
Fax +1 (315) 798-2016

Atomized powder products
100 Industry Lane
Princeton, KY 42445
Phone +1 (270) 365-9551
Fax +1 (270) 365-5910

Shape Memory Alloys
4317 Middle Settlement Road
New Hartford, NY 13413-5392
Phone +1 (315) 798-2939
Fax +1 (315) 798-6860

United Kingdom

Special Metals Wiggin Ltd.
Holmer Road
Hereford HR4 9SL
Phone +44 (0) 1432 382200
Fax +44 (0) 1432 264030

Special Metals Wire Products
Holmer Road
Hereford HR4 9SL
Phone +44 (0) 1432 382556
Fax +44 (0) 1432 352984

China

Special Metals Pacific Pte. Ltd.
Room 1802, Plaza 66
1266 West Nanjing Road
Shanghai 200040
Phone +86 21 3229 0011
Fax +86 21 6288 1811

Special Metals Pacific Pte. Ltd.
Room 910, Ke Lun Mansion
12A Guanghua Road
Chaoyang District
Beijing 100020
Phone +86 10 6581 8396
Fax +86 10 6581 8381

France

Special Metals Services SA
17 Rue des Frères Lumière
69680 Chassieu (Lyon)
Phone +33 (0) 4 72 47 46 46
Fax +33 (0) 4 72 47 46 59

Germany

Special Metals Deutschland Ltd.
Postfach 20 04 09
40102 Düsseldorf
Phone +49 (0) 211 38 63 40
Fax +49 (0) 211 37 98 64

Hong Kong

Special Metals Pacific Pte. Ltd.
Unit A, 17th Floor, On Hing Bldg
1 On Hing Terrace
Central, Hong Kong
Phone +852 2439 9336
Fax +852 2530 4511

India

Special Metals Services Ltd.
No. 60, First Main Road, First Block
Vasantha Vallabha Nagar
Subramanyapura Post
Bangalore 560 061
Phone +91 (0) 80 2666 9159
Fax +91 (0) 80 2666 8918

Italy

Special Metals Services SpA
Via Assunta 59
20054 Nova Milanese (MI)
Phone +390 362 4941
Fax +390 362 494224

The Netherlands

Special Metals Service BV
Postbus 8681
3009 AR Rotterdam
Phone +31 (0) 10 451 44 55
Fax +31 (0) 10 450 05 39

Singapore

Special Metals Pacific Pte. Ltd.
24 Raffles Place
#27-04 Clifford Centre
Singapore 048621
Phone +65 6532 3823
Fax +65 6532 3621

Affiliated Companies

Special Metals Welding Products
1401 Burriss Road
Newton, NC 28658, U.S.A.
Phone +1 (828) 465-0352
+1 (800) 624-3411
Fax +1 (828) 464-8993

Canada House
Bidavon Industrial Estate
Waterloo Road
Bidford-On-Avon
Warwickshire B50 4JN, U.K.
Phone +44 (0) 1789 491780
Fax +44 (0) 1789 491781

Controlled Products Group
590 Seaman Street, Stoney Creek
Ontario L8E 4H1, Canada
Phone +1 (905) 643-6555
Fax +1 (905) 643-6614

A-1 Wire Tech, Inc.
A Special Metals Company
4550 Kishwaukee Street
Rockford, IL 61109, U.S.A.
Phone +1 (815) 226-0477
+1 (800) 426-6380
Fax +1 (815) 226-0537

Rescal SA
A Special Metals Company
200 Rue de la Couronne des Prés
78681 Epône Cédex, France
Phone +33 (0) 1 30 90 04 00
Fax +33 (0) 1 30 90 02 11

DAIDO-SPECIAL METALS Ltd.
A Joint Venture Company
Daido Shinagawa Building
6-35, Kohnan 1-chome
Minato-ku, Tokyo 108-0057, Japan
Phone +81 (0) 3 5495 7237
Fax +81 (0) 3 5495 1853