BRAZING FILLER METAL SELECTOR CHART

WALLCOLMONOY CORP. (USA) v2.2e

NICROBRAZ®

(nickel-based)

	B (No P)									Si (No B)				P (No B)			Co
	125	L.C.	L.M.	130	135	150	160	170	171	33	30	31	152	10	50	51	210
AWS A5.8:	BNi-1	BNi-la	BNi-2	BNi-3	BNi-4	BNi-9		BNi-10	BNi-11		BNi-5	BNi-14		BNi-6	BNi-7	BNi-12	BCo-1
AMS:	4775	4776	4777	4778	4779						4782					4783	
RECOMMENDATIONS FOR SPECIFIC APPLICATIONS																	
For high temperature, high-stress moving engine components	A	A	B	B	C	A	C	A	A	A	A	A	A	C	C	B	A
For heavy, non-moving structures (variable gaps)	A	A	A	B	B	A	A	A	A	A	B	B	B	C	C	C	B
For honeycomb and other thin materials	C	C	B	B	B	B	C	C	C	B	A	A	A	A	A	A	A
For nuclear reactor core assemblies	●	●	●	●	●	●	●	●	●	A	A	A	A	B	A	A	●
For large, machinable or softer fillets	B	B	C	C	A	C	A	B	B	B	C	C	B	C	C	C	C
Use for contact with NaK	A4	A	A4	A4	B4	A	B	B	A	A	A4	A	A	C	A4	A4	A
For use with tight or deep joints	C	C	B	B	C	B	C	C	C	A	B	B	A	A	A	A	B

A = Best B = Satisfactory C = Least Satisfactory ● = Contains boron; has high neutron absorption. May be used in nuclear plant equipment, but not in core.

COMPARATIVE PHYSICAL AND METALLURGICAL PROPERTIES From 1 (highest) to 10 (lowest)	125	L.C.	L.M.	130	135	150	160	170	171	33	30	31	152	10	50	51	210
Joint strength[2]	1	1	1	2	2	1	2	1	1	1	1	1	1	4	2	2	1
Solution and diffusion with base metal	1	1	1	1	2	1	2	2	2	3	3	3	3	4	4	4	4
Fluidity	3	3	2	2	3	2	4	4	3	2	2	2	2	1	1	2	2
Oxidation resistance[3] of joints, up to	1	2	2	2	3	1	4	1	1	2	2	2	2	5	5		1
°F:	2200	2200	2000	2000	1800	2200	1700	2200	2200	2000	2200	2000	2000	1400	1575	1575	2200
°C:	1205	1205	1090	1090	980	1205	925	1205	1205	1095	1205	1095	1095	775	860	855	1205
Brazing range °F from:	1950	1950	1850	1850	1950	1950	1900	2100	2100	1925	2100	2000	1922	1700	1800	1800	2100
to:	2200	2200	2150	2150	2150	2200	2050	2200	2200	2150	2200	2200	2050	2000	2000	2000	2250
°C from:	1065	1065	1010	1010	1065	1065	1056	1150	1150	1050	1150	1093	1050	925	980	980	1150
to:	1205	1205	1175	1175	1175	1205	1121	1205	1205	1177	1205	1204	1121	1095	1095	1095	1230
Suggested brazing temps. °F:	2050	2050	1950	1900	2050	2150	1950	2150	2150	2050	2175	2050	1976	1800	1950	1950	2150
°C:	1120	1120	1065	1040	1120	1065	1065	1175	1175	1120	1190	1120	1080	980	1065	1065	1175
Recommended joint gaps (clearance) in. from:	0.002	0.002	0.001	contact	0.002	0.001	0.005	0.004	0.003	0.001	0.001	0.001	0.001	contact	contact	contact	0.001
to:	0.005	0.006	0.004	0.002	0.004	0.004	0.010	0.010	0.008	0.008	0.004	0.004	0.004	0.001	0.001	0.002	0.004
mm from:	0.05	0.05	0.03	contact	0.05	0.03	0.12	0.10	0.08	0.025	0.03	0.03	0.025	contact	contact	contact	0.03
to:	0.12	0.15	0.10	0.05	0.10	0.10	0.25	0.25	0.20	0.203	0.10	0.10	0.102	0.03	0.03	0.05	0.10

Corrosion Resistance: All Nicrobraz filler metals have good corrosion resistance in a wide variety of corrosive media. Corrosion resistance depends on type of base metal, brazing filler metal, and their interaction during the brazing process. Tests are required for specific information.

[1] Recommendations and comparisons given are based on information from our laboratory testing program, our processing plants, and processing plants of our customers.

[2] Joint strength depends on brazing cycle, joint design, joint clearance, base metal, etc. See Technical Data Sheet on evaluating the strength of brazing joints.

[3] Tests conducted on Inconel base metal joints. Exposed 500 hours in still air temperature indicated. No deterioration of fillet. Nicrobraz 170 tests conducted on Hastelloy X.

[4] This filler metal has been tested and approved by DOE laboratories and by private industry manufacturers of nuclear reactors. Tests were conducted on brazed joints of type 304 and 301 stainless steel, and Inconel base metals.

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NICROBRAZ®

(nickel-based)

WALLCOLMONOY
HI TEMP BRAZING ALLOYS

	125	L.C.	L.M.	10	30	31	33	152
DESCRIPTION	For well diffused, high strength, heat resistant joints, and highly stressed structures, such as jet engine parts.	Low-carbon filler metal, similar to Nicrobraz 125. Good chemical corrosion resistance.	Low-melting filler metal, similar to Nicrobraz 125 in properties and uses. Lower brazing temperatures.	Free-flowing, low melting, chromium-free filler metal, good for marginal atmospheres. Minimizes base metal erosion.	Used similar to Nicrobraz 125, plus nuclear reactor uses where boron cannot be used. High strength with low base-metal penetration.	Enhanced flow characteristics over typical high Cr alloys. Provides higher burst strength in heat exchanger applications than typical Ni alloys.	Similar to Nicrobraz 152, with higher silicon content to improve resistance to oxidation and corrosion.	Similar to Nicrobraz 31, with higher Cr and P content to narrow the melting range and reduce atmosphere sensitivity, while maintaining high resistance to oxidation and corrosion.
SPECIFICATIONS AWS A5.8 AMS & OTHERS[7,8]	BNi-1 4775	BNi-1a 4776 PWA 996	BNi-2 4777 B50TF204	BNi-6 PWA 36100	BNi-5 4782 B14Y3 B50TF81	BNi-14		
NOMINAL COMPOSITION [%]	Cr 14.0 B 3.0 Si 4.5 Fe 4.5 C 0.7 Ni Bal.	Cr 14.0 B 3.0 Si 4.5 Fe 4.5 C 0.06 max. Ni Bal.	Cr 7.0 B 3.1 Si 4.5 Fe 3.0 C 0.06 max. Ni Bal.	P 11.0 C 0.06 max. Ni Bal.	Cr 19.0 Si 10.2 C 0.06 max. Ni Bal.	Cr 22.0 Si 6.5 P 4.5 Ni Bal.	Cr 29.0 Si 6.5 P 6.0 Ni Bal.	Cr 30.0 Si 4.0 P 6.0 Ni Bal.
MELTING POINT[2] SOLIDUS/LIQUIDUS °F / °C	1780 / 1900 970 / 1040	1780 / 1970 970 / 1075	1780 / 1830 970 / 1000	1610 875	1975 / 2075 1080 / 1135	1730 / 1960 943 / 1071	1770 / 1910 970 / 1045	1730 / 1875 943 / 1024
BRAZING RANGE °F / °C	1950-2200 1065-1205	1950-2200 1065-1205	1850-2150 1010-1175	1700-2000 925-1095	2100-2200 1150-1205	2000-2200 1093-1204	1925-2150 1050-1177	1922-2050 1050-1121
SUGGESTED BRAZING TEMP.3 [°F / °C]	[2050 / 1120]	[2050 / 1120]	[1950 / 1065]	[1800 / 980]	[2175 / 1190]	[2050 / 1120]	[2050 / 1121]	[1976 / 1080]
RECOMMENDED ATMOSPHERE[4]	A, B	A, B	A, B	A, B, C, D	A, B, C	A, B, C	A, B, C	A, B, C
OXIDATION RESISTANCE UP THROUGH[5] °F / °C	2200 1205	2200 1205	2000 1085	1400 760	2200 1205	2000 1095	2000 1095	2000 1905
DENSITY LB/CU. IN. [SPECIFIC GRAVITY]	0.282 [7.80]	0.282 [7.80]	0.288 [7.97]	0.294 [8.13]	0.276 [7.65]	0.278 [7.65]	0.275 [7.61]	0.280 [7.75]
FOR MORE INFORMATION, SEE TECHNICAL DATA SHEET NUMBER	2.1.2	2.1.5	2.1.3	2.1.6	2.1.7	2.1.7.1 Rev D	2.1.7.3	2.1.11.1

	50*	51	130	135	150	160	170	171	210	CuBraz
DESCRIPTION	Low-melting, free-flowing filler metal for honeycomb structures and thin-walled tube assemblies. Has low solubility.	Similar to Nicrobraz 50, except for greater strength, and heat and corrosion resistance.	Good general purpose filler metal. It flows freely in marginal atmospheres, in deep or tight joints. Applications similar to Nicrobraz 125.	Wide melting range, free-flowing properties, machinability, and low diffusion with most base metals.	Excellent for jet engine parts and similar highly stressed components. Good strength at lower brazing temperatures.	For wide clearance joints where heavier fillits or greater joint ductility and machinability are desired.	Extra high strength at high temperatures. Good for brazing base metals containing cobalt, tungsten, and molybdenum.	Applications similar to Nicrobraz 170 except for better flow.	High elevated temperature strength and low base metal penetration. Especially good for brazing cobalt based alloys.	Copper powder mixed in a gel-type binder, for air-powered applications. For brazing iron or steel assemblies.
SPECIFICATIONS AWS A5.8 AMS & OTHERS[7,8]	BNi-7	BNi-12	BNi-3 4778 B50TF205	BNi-4 4779 B50TF206	BNi-9 B50TF207		BNi-10 PWA 693	BNi-11	BCo-1 4783 B50T56 PWA 713	BCu-1a 4740
NOMINAL COMPOSITION [%]	Cr 14.0 P 10.0 C 0.06 max. Ni Bal.	Cr 25.0 P 10.0 Ni Bal.	B 3.1 Si 4.5 C 0.06 max. Ni Bal.	B 1.9 Si 3.5 C 0.06 max. Ni Bal.	Cr 15.0 B 3.5 C 0.06 max. Ni Bal.	Cr 11.0 B 2.25 Si 3.5 Fe 3.5 C 0.5 Ni Bal.	Cr 12.0 B 2.5 Si 3.5 W 16.0 Fe 3.5 C 0.50 Ni Bal.	Cr 10.0 B 2.5 Si 3.5 W 12.0 Fe 3.5 C 0.4 Ni Bal.	Ni 17.0 Cr 19.0 B 0.8 Si 8.0 W 4.0 C 0.40 Co Bal.	Cu 99 min.
MELTING POINT[2] SOLIDUS/LIQUIDUS °F / °C	1630 890	1620 / 1740 880 / 950	1800 / 1900 980 / 1040	1810 / 1935 990 / 1055	1930 1055	1780 / 2120 970 / 1160	1780 / 2020 970 / 1105	1780 / 2000 970 / 1095	2025 / 2100 1108 / 1150	1981 1083
BRAZING RANGE °F / °C	1800-2000 980-1095	1800-2000 980-1095	1850-2150 1010-1175	1950-2150 1065-1175	1950-2200 1065-1205	1900-2050 1036-1121	2100-2200 1150-1205	2100-2200 1150-1205	2100-2250 1150-1230	2000-2100 1093-1150
SUGGESTED BRAZING TEMP.3 [°F / °C]	[1950 / 1065]	[1950 / 1065]	[1900 / 1040]	[2050 / 1120]	[2150 / 1175]	[1950 / 1065]	[2150 / 1175]	[2150 / 1175]	[2150 / 1175]	[2050 / 1120]
RECOMMENDED ATMOSPHERE[4]	A, B, C	A, B, C	A, B	A, B	A, B	A, B	A, B	A, B	A, B	A, B, C, D
OXIDATION RESISTANCE UP THROUGH[5] °F / °C	1575 855	1575 855	2000 1090	1800 980	2050 1120	1700 925	2200 1205	2200 1205	2200 1205	800 427
DENSITY LB/CU. IN. [SPECIFIC GRAVITY]	0.285 [7.90]	0.285 [7.90]	0.294 [8.13]	0.303 [8.38]	0.295 [8.16]	0.297 [8.22]	0.307 [8.50]	0.305 [8.45]	0.284 [7.87]	0.324 [8.96]
FOR MORE INFORMATION, SEE TECHNICAL DATA SHEET NUMBER	2.1.8	2.1.8.5	2.1.10	2.1.17	2.1.11	2.1.12	2.1.13	2.1.13.1	2.1.19	2.1.16.1

Powders are -140 mesh size, U.S.S.S. [105 micron] unless otherwise specified [140F mesh, AWS A5.8]

* U.S. Patent Nos. 2,868,639 and 3,188,203 and 5,183,636 respectively.

[1] All filler metals available as powder, flux-powder paste, in gel-suspension, and plastic-bonded sheet or transfer tape. Some are also available as cast rod.

[2] This data was taken from cooling curves prepared in Wall Colmonoy Corporation Laboratories.

[3] The exact brazing temperature for any specific joint depends on the joint and base metal properties desired. It will also depend on the different base metal, brazing filler metal, and joint design combinations. Consequently it may sometimes be necessary to determine the ideal brazing temperature by experiment.

[4] Recommended atmospheres for brazing filler metals [stainless steels and high-chromium base metal require class A, B, or C].
A. Pure dry hydrogen or inert gases. B. Vacuum. C. Dissociated ammonia, nitrogen atmosphere - 60 F [-50C] dew point or drier.
D. Exothermic; rich, unpurified 6:1 air to gas ratio, or purified and dried.

[5] All oxidation-resistance tests were conducted on Inconel except Nicrobraz 170 which was conducted on Hastelloy X. Exposed 500 hrs. in still air. No deterioration of fillet.

[6] Brazed joint hardness is always less than the as-cast filler metal hardness. It will depend on base metal composition, joint clearance, brazing temperature, and time at heat.

[7] To get materials to these specifications you must order by spec number. [Chemistry and lot mesh size may have tighter limits than standard product and require special ordering.]

[8] ASME Boiler and Pressure Vessel Code, Sec II-C, SFA5.8 is met by filler metal designations BNi-1 through BNi-13 and BCo-1. Ask for information on additional specs met by Nicrobraz filler metals.

WALLCOLMONOY
HI TEMP BRAZING ALLOYS

NICROBRAZ® Special Purpose Filler Metals

New Nicrobraz filler metals are continually being developed, many of them for specific customer requirements. The table below includes several such materials.

Brazing Filler Metal	Specifications	Nominal Composition	Melting Point Solidus / Liquidus °F / °C	Brazing Range °F / °C	Remarks
3002	B50TF143	Cr 15.0 Ni Bal. Si 8.0	1975 / 2075 1080 / 1135	2150-2200 1175-1205	A modified Nicrobraz 30, for thin-gauge honeycomb
3003	B50TF142 PWA 797	Cr 17.0 B 0.10 Si 9.0 Ni Bal.	1980 / 2080 1080 / 1140	2100-2150 1150-1175	A modified Nicrobraz 30, with greater flow than 3002

Nicrobraz 5000-series filler metals:

These free flowing metals are designed to braze thin-walled and delicate structures where heavier and more ductile fillets are desired. Alloys form strong, relatively ductile joints with a minimum of aggression. May be used with cast iron where temperatures must be below normal range.

They can be used in pure dry hydrogen or inert gases and hard vacuum (down to 1 x 10^{-4} Torr = 133 x 10^{-4} mbar). Note: Greater vacuums are not recommended as chromium and other elements may be removed from the filler metal or base metal at specific temperatures.

Brazing temperatures as low as 1700°F (925°C) can be used if the atmosphere is pure enough to keep austenitic stainless steel clean. The exact brazing temperature depends on flow and size of fillet required.

5007		Cr 11.2 C 0.06 P 8.0 Ni Bal.	1630 / 1805 890 / 985	1850-2050 1010-1120	See above
5025		Cr 7.0 Cu 50.0 P 5.0 Ni Bal.	1630 / 1980 890 / 1080	1950-2100 1065-1150	See above
5027		Cr 4.9 Cu 65.0 P 3.5 Ni Bal.	1630 / 1980 890 / 1080	1950-2100 1065-1150	See above

LARGE CLEARANCE JOINTS (.010 to .100-in. = .25 to 2.5 mm) are most effectively brazed using one of our NICROGAP® alloys to fill the gap, plus a suitable brazing filler metal to induce bonding. The use of a Nicrogap alloy helps prevent conditions of underfill, voids, erosion, and excessive filler metal flow in the brazed joint. See Technical Data Sheet.

JOINT STRENGTH & DUCTILITY (fracture toughness) The exact joint strength and ductility of any assembly brazed with Nicrobraz filler metal depends on joint design, joint clearance, brazing cycle, and base metal composition, as well as filler metal composition. See Technical Data Sheet on evaluating the strength of brazed joints.

Most base metals brazed with Nicrobraz filler metals can have a joint strength above the base metal yield if the brazement is properly designed, and if the brazing operation is properly conducted. Also, under the same conditions, the joint ductility can be sufficient to withstand cyclic loading and thermal fatigue.

CORROSION RESISTANCE All Nicrobraz filler metals have good corrosion resistance in a wide variety of corrosive media. Corrosion resistance will depend on the type of base metal, brazing filler metal, and the interaction during the brazing process. Tests are required for specific information.

REMELT TEMPERATURE depends on brazing cycle, joint clearance, and filler metal used. In most cases, remelt temperature is higher than filler metal melting range.

The information provided herein is given as a guideline to follow. It is the responsibility of the end user to establish the process information most suitable for their spe cific application(s). Wall Colmonoy Corporation assumes no responsibility for failure due to misuse or improper application, or for any incidental damages arisingout of the use of this material or process.

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