

Titanium Brazing, Inc.

Our company supplies Ti- or Zr-based foils or powders, Heat-resistant brazing alloys, Silver-free active powders, and Al-Mg-based foils and wires as brazing filler metals for joining titanium alloys, titanium to aluminum, copper, or steel, titanium aluminides, refractory metals, ceramics, graphite, and carbon-carbon composites in various applications such as heat exchangers, honeycomb structures, compressor vanes, tubing, electronics, medical devices, heat insulation, and reactors.

1. Filler metals for brazing titanium alloys and titanium aluminides
2. Heat-resistant brazing filler metals for brazing refractory metals
3. Silver-free active filler metals for brazing ceramics, graphite, and diamonds
4. Low-temperature filler metals for brazing thin-wall titanium articles
5. Filler metals for brazing magnesium at 600-630°C (1110-1166°F)

We also provide **consulting** and **brazing service** in both the manufacture and research aimed to support (a) existing production that customers have going (b) as well as new developments.

Contact us to order and discuss your requirements.

1. Filler metals for brazing titanium alloys and titanium aluminides

Table 1-1

Amorphous Foils for Brazing Titanium Alloys, Ceramics, Graphite, Carbon Composites

| Tradename | AWS Designation | Composition, wt. % | Melting range °C (°F) | Recommended brazing range °C (°F) |
|------------------|------------------------|---|----------------------------------|--|
| TiBraze200 | BTi-5 | Ti-20Zr-20Cu-20Ni | 848-863 (1558-1585) | 890-920 (1634-1685) |
| TiBraze590 | | Zr-(16.5-18.5)Ti-(19-24)Ni-(0.1-1.5)Hf | 796-813 (1464-1495) | 850-870 (1562-1598) |
| TiBraze800 | | Zr-(14-16)Ti-(12-14)Ni-(7-8)Cu-(0.1-1.5)Hf | 772-786 (1421-1446) | 810-840 (1490-1544) |
| TiBraze620 | | Zr-(10-12)Ti-(19-21)Ni-(6-8)Nb-(1-2)Hf | 791-808 (1456-1486) | 830-850 (1526-1562) |
| TiBraze1050 | BNi-2 | Ni-(6-8)Cr-(4-5)Si-(2.5-3.5)Fe-(2.75-3.50)B | 970-1000 (1778-1832) | 1020-1100 (1868-2012) |

Standard supply of amorphous foils:

Thickness 65-75 microns (0.0026-0.0030 inch)

Width 65-75 mm (2.6-3.0 inches)

Customized supply of amorphous foils:

Thickness 55-65 microns (0.0022-0.0026 inch)

Width 25.4-100 mm (1.0-3.94 inches)

1. Filler metals for brazing titanium alloys and titanium aluminides (cont.)

Table 1-2

**Powders or pastes for brazing Titanium, Ceramics, Graphite,
Carbon Composites, or Diamonds ***

Our company is supplying the following powders or pastes:

| Tradename | AWS Designation | Composition, wt. % | Melting range °C (°F) | Recommended brazing range °C (°F) |
|------------------|------------------------|--|------------------------------|--|
| BTi-1 | BTi-1 | Ti-15Cu-15Ni | 902-950 (1655-1742) | 1000-1050 (1832-1922) |
| BTi-2 | BTi-2 | Ti-15Cu-25Ni | 901-915 (1653-1679) | 930-960 (1705-1760) |
| TiBraze200 | BTi-5 | Ti-20Zr-20Cu-20Ni | 848-863 (1558-1585) | 890-920 (1634-1685) |
| TiBraze200Nb | - | Ti-17Zr-17Cu-17Ni-17Nb | 848-1020 (1558-1868) | 1030-1100 (1886-2012) |
| TiBraze375 | BTi-3 | Ti-37.5Zr-15Cu-10Ni | 825-835 (1510-1535) | 860-880 (1580-1652) |
| TiBraze900V | - | Cu-(19-21)Sn-(17-19)Ti-(1-3)V | 870-901 (1598-1654) | 890-920 (1634-1685) |
| TiBraze920 | - | Ti-(14-16)Zr-(18-20)Cu-(18-20)Ni-(10-12)Nb | 860-905 (1580-1662) | 920-1040 (1688-1904) |
| TiBraze1050 | BNi-2 | Ni-(6-8)Cr-(4-5)Si-(2.5-3.5)Fe-(2.75-3.5)B | 971-999 (1780-1830) | 1010-1180 (1850-2150) |

* The powder form brazing filler metals have particle sizes -140 mesh (-106 microns) or -170 mesh (-90 microns).

2. Heat-resistant brazing filler metals

We supply new filler metals for brazing molybdenum, niobium, tantalum, titanium aluminides, nickel aluminides, graphite, and ceramics at 1100-1450°C (2012-2642°F) to provide reliable work of brazed joints at 600-1000°C.

Compositions, melting ranges, and service temperatures are showed in Tables 2-1 and 2-2.

Table 2-1

**Heat-resistant filler metals for brazing titanium, TiAl alloys, graphite,
and refractory metals at 1050-1450°C**

| Tradename | Composition, wt.% or at.% | Brazing range °C (°F) | Maximum Service Temperature °C (°F) | Supplied in the form of |
|------------------|---|----------------------------------|--|------------------------------------|
| TiBraze1450 | Ni-(14-17)Cr-(6-10Fe)-(0.9-1.2)Mn wt.% | 1430-1450 (2606-2642) | 1000 (1832) | Foil 80 microns (0.0030 inch) |
| TiBraze1201 | Co-13Ni-16.4Cr-12.8Si-13Mo-1W-3B-1.5C at.% | 1180-1220 (2156-2228) | 900 (1652) | Powder -140 mesh |
| TiBraze1203 | Co-13Ni-16.4Cr-12.8Si-13Nb-1W-3B-1.4C at.% | 1180-1220 (2156-2228) | 900 (1652) | Powder -140 mesh |
| TiBraze200Nb | Ti-17Zr-17Nb-17Cu-17Ni wt.% | 1030-1100 (1886-2012) | 800 (1472) | Powder -140 mesh |
| TiBraze202 | Ti-10Zr-10.7Nb-11Mo-14.4Cu-15.6Ni at.% | 1030-1100 (1886-2012) | 850 (1562) | Powder -140 mesh |
| TiBraze920 | Ti-(14-16)Zr-(18-20)Cu-(18-20)Ni-(10-12)Nb wt.% | 920-1040 (1688-1904) | 800 (1472) | Powder -140 or -170 mesh |
| TiBraze1100 | Ni- 6.3Cr-2.7Fe-4Si-2.7B-9Nb wt.% | 1080-1100 (1976-2012) | 800 (1472) | Powder -140 mesh |

Our company supplies the following powders or pastes:

Table 2-2

**"High Entropy Alloy" filler metals for brazing titanium, TiAl alloys, graphite,
and refractory metals at 1050-1220°C**

| Tradename | Composition, at. % | Melting range °C (°F) | Recommended brazing range °C (°F) |
|------------------|---|------------------------------------|--|
| TiBraze200Nb | Ti ₄ Zr ₁ Nb ₁ Cu _{1.5} Ni _{1.5} | 848-1020 (1558-1868) | 1030-1100 (1886-2012) |
| TiBraze920 | Ti ₃ Zr _{1.5} Nb ₁ Cu ₂ Ni ₂ | 860-905 (1580-1662) | 920-1040 (1688-1904) |
| TiBraze202 | Ti ₄ Zr ₁ Nb ₁ Mo ₁ Cu _{1.5} Ni _{1.5} | 848-1050 (1558-1922) | 1030-1100 (1886-2012) |
| TiBraze1201 | Co ₃ Ni ₁ Si ₁ Mo ₁ Cr _{1.3} | 1120-1150 (2050-2100) | 1180-1220 (2156-2228) |
| TiBraze1203 | Co ₃ Ni ₁ Si ₁ Nb ₁ Cr _{1.3} | 1120-1150 (2050-2100) | 1180-1220 (2156-2228) |
| TiBraze1212 | Ni ₅ Mo ₁ Nb ₁ Cr _{1.5} Si _{1.5} | 1079-1160 (1975-2075) | 1160-1220 (2120-2228) |
| TiBraze1215 | Ti ₆ Cu ₁ Ni ₁ Mo ₁ Co ₁ | 902-1060 (1655-1940) | 1100-1140 (2012-2084) |

3. Silver-free active filler metals for brazing ceramics, graphite, and diamonds

Table 3

| Tradename | Composition, wt. % | Brazing range °C | Supplied in the form of |
|------------------|---|--------------------------|--------------------------------|
| TiBraze900V | Cu-(19-21)Sn-(17-19)Ti-(1-3)V | 890-920 (1634-1685) | Powder -140 mesh |
| TiBraze200Nb | Ti-17Zr-17Cu-17Ni-17Nb | 1030-1100 (1886-2012) | Powder -140 mesh |
| TiBraze920 | Ti-(14-16)Zr-(18-20)Cu-(18-20)Ni- (10-12)Nb wt. % | 920-1040 (1688-1904) | Powder -140 or -170 mesh |
| TiBraze1040NT | Ni-7Cr-4Si-3Fe-3B foil 17% Ti foil 83% | 1040-1080 (1904-1976) | Foil sandwich |

4. Low-temperature filler metals for brazing titanium

We also have experience in the application of **aluminum-based filler metals for brazing titanium** at low temperature in vacuum or in air (Table 4-1) either for manufacturing structural joint or for repair purposes. These brazing filler metals are supplied in the form of wire or foil (Table 4-2).

The approximate strength of titanium brazed joints, according to our testing, is presented in Table 4-3.

Aluminum-based brazing filler metals are based on Al-Cu, Al-Mg, Al-Cu-Si eutectics, and modified with Cr and Ti to refine microstructure of brazing joints, and with Beryllium to suppress an ignition during the torch brazing. These filler metals can be used for torch brazing of thin-wall titanium or aluminum articles, for example, for brazing tubing, and repairing fin-plate heat exchangers or honeycomb structures. Torch brazing is carried out with proprietary non-toxic fluxes TiBF-19 based on fluoride and chloride systems.

Brazing filler metals listed in Tables 4-1 and 4-2 are suitable for vacuum brazing of titanium at the temperatures significantly lower than conventional silver-based and titanium-based filler metals. For new applications and for brazing dissimilar metals, we still recommend evaluation of wetting and gap filling abilities of these **new filler metals**, as well as testing the strength of brazed joints.

Table 4-1**Low-temperature Aluminum-based filler metals for brazing at 590-720°C (1095-1328°F) ***

| Brazing filler metal | Composition, wt. % | Brazing Temperature, °C (°F) | Melting temperature, °C | |
|----------------------|--|------------------------------|-------------------------|----------|
| | | | Solidus | Liquidus |
| TiBrazeAl-600 | Al-12Si-0.8Fe* | 590-620 (1094-1148) | 577 | 582 |
| TiBrazeAl-665 | Al-2.5Mg-0.2Si-0.4Fe-0.2Cr | 645-690 (1193-1274) | 610 | 645 |
| TiBrazeAl-635 | Al-4.5Cu-1.4Mg-0.6Mn-0.4Si | 660-700 (1220-1292) | 510 | 635 |
| TiBrazeAl-645 | Al-(4.3-5.5)Mg-0.2Si-0.4Fe-0.2Ti-0.2Cr * | 640-680 (1184-1256) | 550 | 620 |
| TiBrazeAl-655 | Al-6.3Cu-0.3Mn-0.2Si-0.2Ti-0.2Zr * | 650-680 (1202-1256) | 545 | 645 |

* Filler metals contain (0.0006-0.0008) wt.% of Be to prevent self-ignition

Table 4-2**Foils and wires of low-temperature Aluminum-based filler metals**

| Brazing Alloy | UNS (ISO R209) | Wire diameter, inch (mm) | Foil thickness, inch (mm) | Brazing Temperature, °C |
|---------------|------------------|--------------------------|--|-------------------------|
| TiBrazeAl-600 | A94047 (BA1Si-4) | 1/16 (1.6 mm) | 0.003" (80 microns) 0.016" (0.4 mm) | 590-620 |
| TiBrazeAl-665 | A95052 | - | 0.032" (0.8mm) | 650-690 |
| TiBrazeAl-635 | A92024 | - | 0.020" (0.5 mm) | 660-700 |
| TiBrazeAl-645 | A95356 | 0.030" (0.8 mm) | - | 640-680 |
| TiBrazeAl-655 | A92319 | 0.030" (0.8 mm) | - | 650-680 |

Table 4-3

Shear strength of titanium lap joints manufactured by brazing using foils of new aluminum-based filler metals (the bottom values are averages)

| Brazing Filler metal | Titanium base metal | Shear strength of brazed joints (at room temperature) | |
|----------------------|---------------------|--|--------------------------|
| | | MPa | ksi |
| TiBrazeAl-600 | Grade 2 | <u>63.4-71.7</u> 69.6 | <u>9.2-10.4</u> 10.1 |
| | Ti-6Al-4V | <u>68.5-78.8</u> 74.2 | <u>9.9-11.4</u> 10.8 |
| TiBrazeAl-665 | Grade 2 | <u>92.0-99.8</u> 97.6 | <u>13.3-14.5</u> 14.1 |
| | Ti-6Al-4V | <u>97.7-114.0</u> 110.4 | <u>14.2-16.5</u> 16.0 |
| TiBrazeAl-635 | Grade 2 | <u>78.7-117.4</u> 100.8 | <u>11.4-17.0</u> 14.6 |
| | Ti-6Al-4V | <u>114.4-158.7</u> 136.6 | <u>16.6-23.0</u> 19.8 |
| TiBrazeAl-645 | Grade 2 | <u>71.8-89.6</u> 82.9 | <u>10.4-13.0</u> 12.0 |
| TiBrazeAl-655 | Grade 2 | <u>117.5-152.3</u> 131.4 | <u>17.0-22.1</u> 19.0 |

5. Filler metals for brazing magnesium at 600-630°C

Table 5

| Brazing filler metal | Composition, wt.% * | Brazing Temperature, °C (°F) | Melting temperature, °C | |
|---|---|------------------------------|-------------------------|----------|
| | | | Solidus | Liquidus |
| TiBrazeMg-600 (AWS BMg-1) UNS M19001 | Mg-(8.3-9.7)Al-(1.7-2.3)Zn-(0.15-1.5)Mn | 605-630 (1120-1160) | 443 | 599 |

* Magnesium-based filler metal contains (0.0006-0.0008) wt.% of Be to prevent self-ignition