How to Select a Brazing Flux

Brazing fluxes remove oxides and contaminants from base materials to ensure good-quality brazed joints. Flux selection depends on the base-material and filler-metal type, heat source, and application method.

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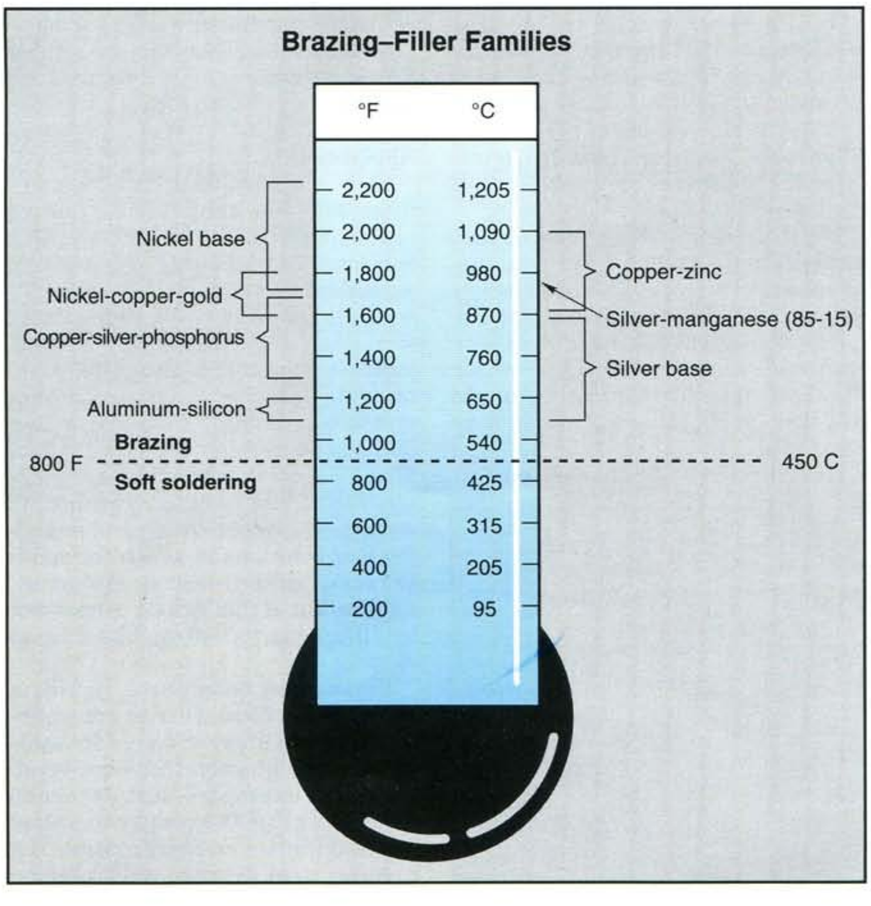
Brazing joins similar and dissimilar materials by heating them in the presence of filler metal having a liquidus above 840 F and below the solidus of the base material. During brazing, filler metal flows between fitted surfaces of the joint by capillary action. Brazing permits the joining of dissimilar materials. Also, heat from brazing is less damaging than that from welding, causing little or no metal vaporization, grain growth, intergranular precipitation, stress corrosion, or distortion. Further, brazed joints have higher strength than do soft-soldered joints.



Flux plays an important role in nearly all air-brazing processes. Use of the wrong flux can compromise joint quality. This article offers information on selecting the right brazing flux.

What fluxes do

When heated, fluxes dissolve surface oxides and protect the cleaned surfaces from re-oxidation; transfer heat from the heat source to the joint; and remove oxidation products, allowing filler metal to contact and wet the base materials.

Brazing fluxes—pastes or powders—fuse at temperatures below those needed to melt filler metals. Because fluxes must be in close contact with the joint surfaces, they are liquid or gaseous at brazing temperatures. They remove only surface oxides and tarnish; other contaminants—oil, grease, lubricants, lacquer, and paint—must be removed either mechanically or chemically before brazing.

Fluxes classify by form (powder, liquid, or paste), base materials and filler metals they can be used with, heat source, application method, and active temperature range. The five categories: aluminum, aluminum-bronze, silver, magnesium, and high-temperature flux. With few exceptions, fluxes from one category will not work with base materials and filler metals of another category.

Aluminum- and magnesium-brazing fluxes contain alkaline chlorides

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or fluorides. Lithium salts give these fluxes low melting points, 1,000-1,140 F, and high chemical activity, enabling the fluxes to dissolve stubborn aluminum oxide.

Silver-brazing fluxes contain boric acid and potassium borates, combined with complex potassium fluoborate and fluoride compounds. Fluorides, up to 40 percent in flux content, give these fluxes their characteristically low melting points, 1,050 F, and high activity for dissolving metal oxides. Silver-brazing fluxes that contain elemental boron offer improved protection on carbides and on materials that form refractory oxides such as chromium, nickel, and cobalt.

High-temperature fluxes, based on boric acid and alkaline borates, sometimes contain small additions of elemental boron or silicon dioxide to increase activity and protection, good up to 2,200 F. Fluoride content of these fluxes is usually low, at most 2 to 3 percent. These fluxes braze ferrous and high-temperature alloys and carbides.

Factors influencing flux selection

Base-material type determines flux selection more than any other factor. To braze aluminum alloys, coat parts with aluminum brazing fluxes. Too, aluminum-bronze and magnesium fluxes braze only with their respective base metals. To braze ferrous and nickel alloys, two flux types can be used: silver-brazing or high-temperature fluxes. Which of the two is better depends on base and filler material type, brazing conditions, and cost. Fabricators call on silver-brazing fluxes, more expensive than high-temperature fluxes, to minimize heat input and distortion to the work. These also braze copper alloys. To braze carbides—tungsten carbide infiltrated with cobalt to impart high strength and toughness—coat with boron-modified fluxes and fill the joint with silver-brazing alloys containing nickel. High-temperature fluxes and fillers also braze carbides, when the carbide-steel combination can tolerate the high brazing temperatures, near 2,000 F.

Base-material type determines flux selection more than any other factor. To braze ferrous alloys, coat with silver-brazing or high-temperature fluxes.

Specifying flux-temperature range

To be effective, flux must be molten and active before the filler metal melts, and it must remain active until the filler metal flows through the joint and solidifies on cooling.

Therefore, filler-metal solidus determines minimum working temperature of the flux and filler-metal liquidus dictates maximum brazing temperature that the flux must withstand. Generally, select a flux that is active at least 100 degrees Fahrenheit below the solidus of the brazing filler metal and that remains active at least 200 degrees Fahrenheit above the filler-metal liquidus.

If overheating is likely to occur during brazing, as when torch brazing, select a flux active at 250-350 degrees Fahrenheit above the filler-metal liquidus. This gives the flux a wide temperature range to remove surface oxides before the filler metal melts and will keep it effective at brazing temperatures.

Brazing time affects flux performance. Molten flux forms a semi-protective blanket that prevents oxidation only for a finite period—oxygen will eventually diffuse through the flux to the base materials. Flux must continue to remove newly formed oxide until the end of the heating cycle. Because flux can dissolve only a limited amount of oxide, the longer the heating cycle the greater the likelihood that the flux will become saturated with oxide, a condition called flux exhaustion.

Rated temperature range of a flux, which depends on brazing temperature, flux type and volume, and base-material type, assumes a brazing cycle of 15-20 seconds. With a longer heating cycle, flux exhaustion may occur even when brazing below the maximum operating temperature, because over time the flux becomes saturated with metal oxide. To avoid flux exhaustion over prolonged heating cycles, switch to a flux with a higher working temperature range. When the heating cycle is short, a fabricator can braze with a flux above its maximum rated working temperature. Using a low-temperature flux above the maximum working temperature eases flux removal, since these fluxes are more soluble in water than are high-temperature fluxes.

Applying flux

Ideally, apply flux to both joint surfaces; for some applications, coating only one surface suffices—the flux will transfer to the mating surface on assembly.

Application method depends on joint design, production volume, and joint-heating technique. Operators brush to apply paste flux to the joint and to surrounding surfaces, or they may dip parts into a container of flux. Flux for dipping is of a thinner consistency than that used for brushing. In some cases, parts are dipped in boiling flux solutions in which the solids are completely dissolved. Automatic application of flux can be carried out by spraying, pumping, blotting, or dipping.

Fluxes may be in paste, liquid, or slurry form. Most slurries are water-based; some organic-based fluxes—petroleum- or polyethylene-glycol-based for example—suit precision dispensing due to lower evaporation rates and better viscosity control. Hot rodding, used to braze-weld, plunges

BRAZING-FLUX SPECIFICATIONS

Category	Federal Specification	American Welding Society (AWS)	Aerospace Material Specification (AMS)
Aluminum brazing	—	FB1A	3412B
Aluminum dip brazing	—	FB1C	3415A
Aluminum dip brazing	—	FB1C	3416A
Aluminum-bronze brazing	O-F-499D, Type A	FB4A	—
High-temperature brazing	—	FB3D	3417
Silver brazing	O-F-499D, Type B	FB3A	3410G
Silver brazing	—	FB3C	3411B

No. 554—Classifying Brazing Fluxes

per AWS *Brazing Handbook* and A5.3-92–*Specification for Fluxes for Brazing and Braze Welding*

AWS SPEC.	FLUX CATEGORY	FORM	BASE MATERIALS	FILLER METALS	APPLICATION METHOD	HEAT SOURCE	ACTIVE TEMP. RANGE F	C
FB1A	Aluminum brazing	Powder	Aluminum alloys	BAlSi	Manual	Torch, furnace	1,080-1,140	580-615
FB1B	Aluminum brazing	Powder	Aluminum alloys	BAlSi	Manual	Furnace	1,040-1,140	560-615
FB1C	Aluminum brazing	Powder	Aluminum alloys	BAlSi	Dip brazing	Salt bath	1,000-1,140	540-615
FB4A	Aluminum bronze	Paste	Aluminum bronze	BAg, BCuP[1]	Manual	Torch, furnace, induction	1,100-1,600	595-870
FB3D	High-temperature brazing	Paste[2]	Copper, ferrous & nickel alloys, carbides	BAg, BCu, BNi, BAu, RBCuZn	Manual, automatic	Torch, furnace, induction	1,400-2,200	760-1,205
FB3I	High-temperature brazing	Slurry[2]	Copper, ferrous & nickel alloys, carbides	Bag, BCu, BNi, Bau, RBCuZn	Automatic	Torch	1,400-2,200	760-1,205
FB3J	High-temperature brazing	Powder[2]	Copper, ferrous & nickel alloys, carbides	Bag, BCu, BNi, BAu, RBCuZn	Manual	Torch, furnace	1,400-2,200	760,1,205
FB3K	High-temperature brazing	Flammable liquid	Copper, ferrous & nickel alloys, carbides	BAg, RBCuZn	Manual, automatic	Torch	1,400-2,200	760-1,205
FB2A	Magnesium brazing	Powder	Magnesium alloys	BMg	Dip brazing	Salt bath	900-1,150	480-620
FB3A	Silver brazing	Paste	Copper, ferrous & nickel alloys, carbides	BAg, BCuP[1]	Manual, automatic	Torch, induction	1,050-1,600	565-870
FB3C	Silver brazing	Paste[3]	Copper, ferrous & nickel alloys, carbides	BAg, BCuP[1]	Manual, automatic	Torch, induction	1,050-1,700	565-925
B3E	Silver brazing	Water-base liquid	Copper, ferrous & nickel alloys, carbides	BAg, BCuP[1]	Manual, automatic	Torch, furnace	1,050-1,600	565-870
B3F	Silver brazing	Powder	Copper, ferrous & nickel alloys	BAg, BCuP[1]	Manual	Torch, furnace	1,200-1,600	650-870
B3G	Silver brazing	Slurry	Copper, ferrous & nickel alloys, carbides	BAg, BCuP[1]	Automatic	Torch	1,050-1,600	565-870
B3H	Silver brazing	Slurry[3]	Copper, ferrous & nickel alloys, carbides	BAg	Automatic	Torch	1,050-1,700	565-925

1. Used with copper and copper-alloy base metals only. 2. May contain elemental boron or silicon dioxide. 3. Boron-modified.

Note: Pastes have high viscosities and are typically applied by brushing. Slurries have low viscosities and can be sprayed or automatically dispensed.

a hot brazing rod into powder flux. Heat from the rod causes a small amount of flux to adhere to the rod surface. This method is best suited to brazing of shallow joints, up to 1/4 inch in steel, as it results in poor capillary penetration in deep joint areas.

Torches apply one of the high-temperature fluxes, FB3K. This flux is a flammable liquid containing trimethyl borate. A dispenser installed in the fuel-gas line feeds flux vapor into the flame.

How much to apply

Apply enough flux to coat the joint faces and adjacent surfaces with a thin layer. Excess flux will not compromise joint quality and may even assist flux removal since residues will be less loaded with metal oxide and more soluble in water. Also, applying flux to surfaces adjacent to the joint helps to prevent oxidation of the workpiece and may act as a flux reservoir, draining flux into the joint. Using too little flux, however, can lead to premature flux exhaustion and inadequate coverage, producing unsound or unsightly brazed joints. Better to err on the side of too much rather than too little flux.

Applying excess flux will not compromise braze-joint quality and may assist flux removal since residues will be less loaded with oxide.

The choice of heat source has little effect on flux selection. Exceptions include salt-bath heating, which requires dip-brazing fluxes; specialized high-temperature torches using a flammable-liquid flux; and furnace brazing, which often calls for a powder flux to minimize the amount of vapor. Boron-modified fluxes are often preferred for induction heating.

Post-braze cleanup

Remove flux residues after brazing—they can hydrolyze when exposed to moisture, causing corrosion. Avoid overheating of the joint—excess heat impairs flux removal. Spent flux residues, saturated with metal oxides, are the most difficult to remove. To avoid flux exhaustion, apply excess flux to ease removal of residues from the base material.

When practical, after brazed assemblies have cooled to black heat, quench them in water to crack off most of the flux by thermal shock. Remaining flux residues can be removed by one of the following treatments:

- Many flux residues are water soluble—the hotter the water and the greater the agitation the better. Soak the parts in water immediately after brazing to soften residues; brushing the parts also helps.
- High-pressure steam jets remove water-soluble residues.
- When residues are saturated with metal oxides or component surfaces are discolored, remove flux with an aqueous solution containing 5-10-percent sulfuric acid, preferably heated to 140 F. This works for nonferrous metals and mild steels. More-aggressive solutions are needed for stainless steels and high-temperature alloys.

Filler metal-flux combinations

...can be either a brazing paste or flux-coated rod. Pastes, mixtures of filler-metal powder and flux, and sometimes an organic binder to ease dispensing, work well for automated processes; aluminum, silver, and high-temperature brazing pastes are most popular. Flux-coated rods perform brazing and braze welding. The most common flux-coated filler-metal rods are silver-brazing and low-fuming bronze, used primarily to braze-weld.

Safety precautions

Try to prevent brazing fluxes from contacting skin. Occasional contact is not dangerous, but all flux should be thoroughly washed off before eating or smoking. Cuts or breaks in the skin must be properly covered by a dressing. Flux, especially if it contains fluorides or chlorides, can delay the healing of wounds.

Fluxes produce fumes when heated, especially above the temperatures given as their maximum. Braze in work stations with large air space into which fumes can escape. Ventilate with fans or exhaust hoods to carry fumes away from workers, or equip operators with air-supplied respirators. Consult manufacturers' Material Safety Data Sheets for specific safety and health procedures connected with flux use. ■