Brazing - General Principles

The successful joining of components by the brazing process depends on the selected brazing filler metal,
1. Wetting the base metal without melting it,
2. Flowing into a controlled joint gap by capillary flow,
3. Creating a adequately strong bond with the joint faces after solidification.

The accepted definition of Brazing is met with the above criteria being achieved with a filler metal having a melting point above 450°C (generally accepted demarcation between brazing and soldering).

To assist capillary flow, the joint must be designed to ensure that the mating surfaces of the components are
1. Clean,
2. Parallel,
3. Close enough together to assist capillary attraction (adhesive force between solid and liquid being greater than the cohesive forces within the liquid).

Most brazing alloys melt over a temperature range rather than a single temperature – the lower temperature, which is the temperature below which the alloy is fully solid, is called the solidus while the upper temperature, above which the alloy is fully molten, is called the liquidus.

Flowability is the property of the brazing filler metal that determines the distance it will travel away from its original position, under the action of capillary forces. To flow well, a filler metal must not gain appreciable increase in its liquidus temperature even though its composition may be altered by the addition of metal it has dissolved.
Interactions with the base metal are minimized by selecting the proper brazing filler metal, keeping the brazing temperature as low as possible but high enough to produce flow, keeping the time at brazing temperature short and cooling the brazed joint as quickly as possible without causing cracking or distortion.
Silver brazing alloys will not usually flow through a capillary gap to a length of more than about 20mm for single point application of brazing alloy, longer overlap joint lengths can be achieved using brazing alloy ring preforms.
A realistic rule-of-thumb for lap joints and tube insert brazing is: "joint overlap length should normally be between 3 and 4 times thickness of the thinner component; it should not be less than 3 mm nor more than 20 mm for single point application of brazing alloy."

Brazing Temperature: Narrow melting range filler metals do not have much tendency to coexist as a mixture of solid and liquid phases or to liquate. They flow readily and should be used with small joint clearances. As the solidus and liquidus temperatures diverge, the tendency to liquate increases, requiring greater precautions in brazing filler metal application. The necessity for the brazing filler metal to melt below the solidus of the base metal is one of the factors affecting its selection. The brazing temperature is usually 10 to 90°C above the liquidus of the filler metal.

Fluxes: For most manual brazing in air using gas torches, a flux is essential to prevent oxidation and continue to maintain oxide free joint faces essential for wetting and flowing of the filler metal. For manual brazing, flux is applied by brushing on the flux paste liberally on the joint faces and some distance from the joint – it is better to use an excess of flux rather than too little. Fluxes are intended to prevent oxidation during brazing and not to remove dirt and contamination already present, these should be removed prior to brazing.
Flux compositions have been designed to be active over a specific temperature range, and selection of the appropriate flux for an application is based on ensuring that the flux is active at least 50°C below the solidus of the alloy and remains active at least 50C higher than the alloy liquidus