Girish P. Kelkar, Ph.D.
(562) 743-7576
girish@welding-consultant.com
www.welding-consultant.com

A Eutectic Composition

Pure metals, in contrast to glass, go directly from solid to liquid as they are heated through their melting point, very similar to how ice melts and forms water at 0°C. However, when metals are mixed in ratios that do not form compounds, such mixtures go through a melting range. Some part of solid alloy starts to melt and becomes a viscous sludge which then completely melts at a higher defined temperature.

Understanding the dynamics of melting of metal mixtures is key to selecting and using braze or solder alloys. We can use the Pb-Sn system as an example of typical solder alloy system. Lead (Pb) and tin (Sn) do not react with each other and hence there are no intermetallic compounds in this system. Figure 1 shows the Pb-Sn phase diagram with Pb on the left and Sn on the right; the horizontal axis shows a mixture of Pb and Sn in various ratios. At all compositions and temperatures below the solidus line the alloy mixture will be solid; above the liquidus line, the alloy will be in liquid form. In the region between solidus and liquidus (shown by the shaded region), the alloy will be pasty or viscous and will be partly solid and partly liquid. Such behavior is true at all compositions except when the Sn weight percentage is 61.9% where the Pb-Sn mixture goes directly from a solid phase to a liquid and does not have a pasty region. At this unique ratio, where the Sn-Pb solder melts at 183°C (or 361°F), the alloy behaves like a pure metal and is defined as a eutectic composition. The word eutectic originates from the greek word eutektos, which means easily melted. Note that commercial eutectic solders are sold at a 63/37 ratio which is slightly different from the 61.9/38.1 ratio of Sn/Pb shown on the phase diagram.

So how does it help you to know the eutectic alloy behavior? Selecting an alloy composition will allow you to control the soldering process by controlling the melting characteristics and temperature of soldering. Say for example if you have to make a solder connection where there is a very small gap between parts being soldered, you will need a very fluid alloy to get into that gap, and should select the eutectic composition. A eutectic alloy will be become fluid at slightly above eutectic temperature and quickly flow between the parts and form a bond at the lowest possible soldering temperature. If you are trying to bridge a bigger gap, then you should select a non-eutectic Sn-Pb composition, such as a 60-40 ratio or even a 50-50 ratio which will become pasty above the solidus and will be viscous enough to fill bigger gaps. Keep in mind that even a non-eutectic composition, if heated to temperature above the liquidus, will become very fluid and will not be able to bridge big gaps, so temperature control is very important in non-eutectic alloy soldering/brazing.

The same logic of eutectic melting holds true in braze alloys systems such as Ag-Cu. Most commercially available solder and braze alloys are usually multi-element systems that are not easily represented on a two-dimensional phase diagram. A user should carefully evaluate solidus and liquidus temperatures for each alloy provided by the alloy manufacturers before selecting any particular composition.

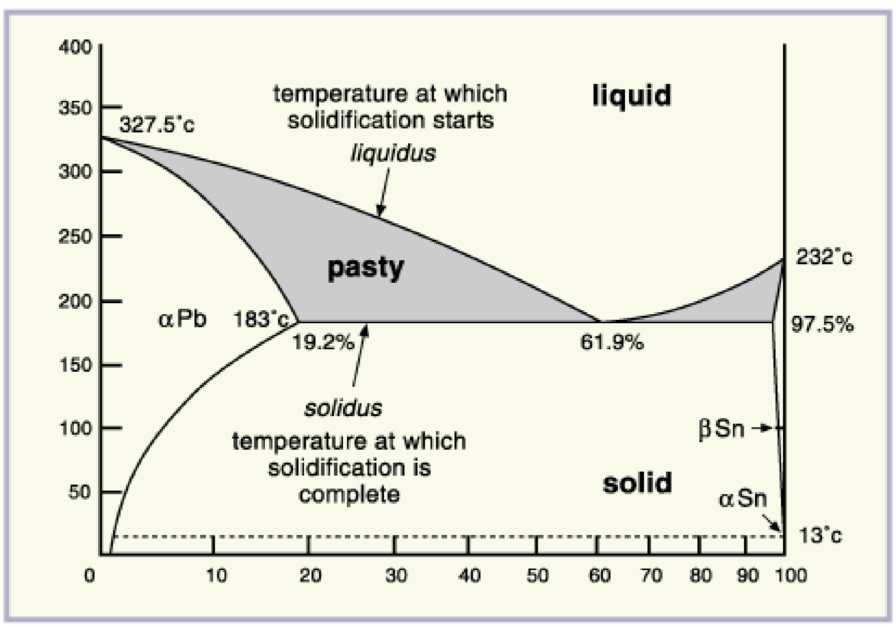

Figure 1. Sn-Pb phase diagram showing solidus, liquidus, and eutectic composition. The horizontal axis shows weight percentage of Sn. The pasty region is shown shaded and is the region where the alloy will be sluggish.