## Extract from Course F4: *Vacuum brazing stainless steel*

……………………………..As already mentioned, a vacuum is created when the molecules of gas are removed from a closed space until as few as possible remain. Clearly, an obvious means of removing the molecules is by pumping! When a suitable pump is applied to a system held at atmospheric pressure gas flows from the space being evacuated into and through the pump. As pumping proceeds the number of molecules in the enclosed space is reduced and the pressure eventually becomes so low that there is insufficient gas remaining to provide a flow. Clearly, further evacuation can only occur by trapping individual molecules that 'drift' into the vicinity of the pump and dragging them out of the enclosed space. Where the pressure in the enclosed space is very low this effect can only be achieved by the use of a diffusion pump. Thus in order to produce very-high vacuum or better, the use of both a mechanical pump and a diffusion pump is a fundamental necessity.

*Even where this ideal is practised it has to be recognised that a vacuum furnace chamber still contains a significant amount of residual gases.* It is very important to understand that the nature of these residual gases that remain in the furnace chamber have a very marked influence upon the degree of protection afforded to the surfaces of the parent metals that are to be brazed.

The residual gases are derived from two primary sources:

1. From leaks in the furnace system; no vacuum chamber can be perfectly leak-tight! Clearly, a major component of any leakage that occurs will be air, and *might* be water derived from externally mounted cooling jackets or via leaks in a heat exchanger associated with a rapid cooling gas recirculatory system. In either case **the main contaminant will, effectively, be oxygen**.

2. From the out-gassing of heat shields, fixtures and fittings, the job itself, condensate on the inner walls of the furnace, and so on…! It is a fact that every time a furnace is opened to ambient atmosphere, gases, especially water vapour, are adsorbed and so has to be driven off during the next process cycle. The distillation of these extraneous materials can be quite troublesome, particularly if the furnace interiors are lined with refractory cloth, which is acting as the insulation. In such situations evolution only begins to diminish as the temperature rises beyond about 800ºC. All-metal furnaces offer significant advantages in this regard, but due to their substantially higher capital, running, and maintenance costs, such equipment is normally only found in factories that are deeply involved in brazing aerospace components.

The significance of the residual atmosphere is indicated by practical experience when brazing austenitic 304 stainless steel. In a heavily pumped vacuum-brazing furnace that contains a significant leak one might well manage to attain an indicated vacuum of, say, $0.76 \times 10^{-3}$ torr. This might be insufficient to ensure effective wetting and flow by a molten filler material, particularly at the lower end of the normal range of brazing temperatures, say 980 - 1020ºC. On the other hand, in a substantially leak-free furnace, effective brazing would almost certainly occur once the degree of vacuum reached a level of about $0.76 \times 10^{-2}$ torr!…………………………..