Electronics Materials-The 'homologous' temperature

Figure 1 shows how the strength and hardness of a metal varies with temperature: note that the temperature is measured on the Kelvin scale, whose origin is absolute zero (–273ºC). Provided that the curves are scaled correctly, and referenced to the melting temperature of the material (Tm), this is actually a generic relationship: the pattern follows a similar pattern for most metals , reducing to zero at the melting point, and reducing markedly as that temperature is approached.

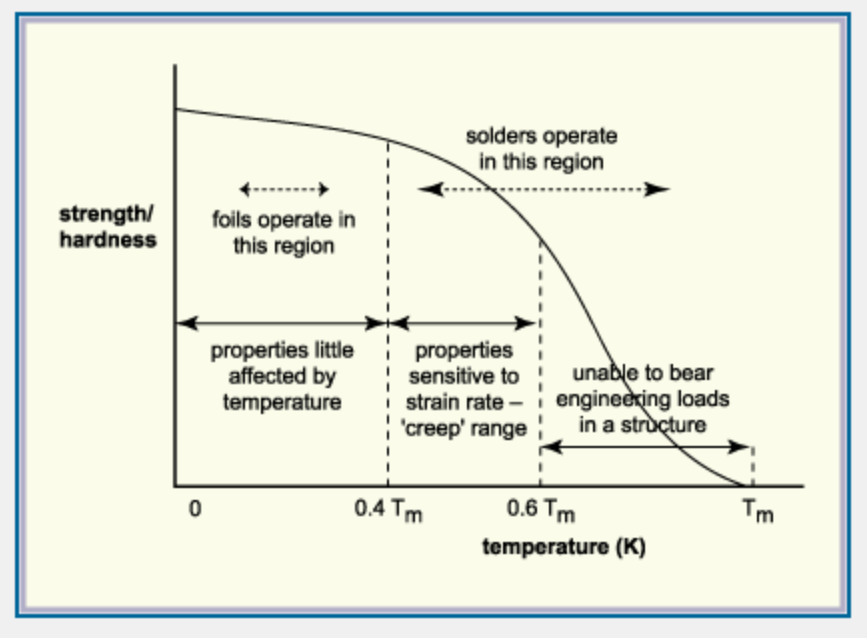

Figure 1: Strength/hardness of a metal related to its melting temperature

Metallurgists refer to the idea of a 'homologous temperature', where the actual temperature of a material is expressed as a fraction of its melting temperature expressed in Kelvin. Solder (m.pt 183°C = 456K) at 0.85Tm or 115ºC (= 388K), would thus be expected to have comparable properties to copper (m.pt 1085°C = 1358K) at 0.85Tm or 881ºC (= 1154K).

In electronics applications, where circuits typically operate over a –55ºC®+125ºC range, eutectic tin-lead (Sn63) solder is working at 0.48®0.87Tm. From this we can deduce that solder will have limited mechanical strength (as a bulk material) and be within the 'creep range'. This is borne out by its comparatively low values for tensile strength, shear strength and modulus of elasticity.

Copper, on the other hand, has a much higher melting point, so foils are working at only 0.16®0.29Tm, and their properties are little affected by temperature.

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Source: http://www.ami.ac.uk/courses/topics/0164_homt/index.html