Horizontal Film Boiling

At or near boiling crisis a film of vapor is formed that coats the surface and substantially impedes heat transfer. This vapor layer presents the primary resistance to heat transfer since the heat must be conducted through the layer. It follows that the thickness of the layer, δ, is given approximately by

$$\delta = \frac{\Delta T k_V}{\dot{q}} \tag{Nid1}$$

However, these flows are usually quite unsteady since the vapor/liquid interface is unstable to Rayleigh-Taylor instability (see sections (Njo) and (Nqe)). The result of this unsteadiness of the interface is that vapor bubbles are introduced into the liquid and travel upwards while liquid droplets are also formed and fall down through the vapor toward the hot surface. These droplets are evaporated near the surface producing an upward flow of vapor. The relation (Nid1) then needs modification in order to account for the heat transfer across the thin layer under the droplet.

The droplets do not normally touch the hot surface because the vapor created on the droplet surface nearest the wall creates a lubrication layer that suspends the droplet. This is known as the Leidenfrost effect. It is readily observed in the kitchen when a drop of water is placed on a hot plate. Note, however, that the thermal resistance takes a similar form to that in equation (Nid1) though the temperature difference in the vicinity of the droplet now occurs across the much thinner layer under the droplet rather than across the film thickness, δ.