7.6.4 Vapor Explosions

One of the accident scenarios that is of concern and that has been studied in the context of both LMFBRs and LWRs is the possibility of a *vapor explosion*. In order to assess the potential for and consequences of a vapor explosion (or of a fuel coolant interaction as described in the section that follows) note must first be made of the basic classes of vaporization identified in section 6.4.1. A vapor explosion is defined as the explosive growth of a vapor bubble(s) within a liquid due to the presence of a large, nearby heat source. As described in section 6.4.1, explosive growth of this kind only occurs under a set of particular conditions when the growth is not limited by thermal or heat transfer effects but only by the inertia of the surrounding liquid that is accelerated outward during the bubble(s) growth. Vapor explosions can occur in a number of other technological circumstances. Cavitation at normal pressures is an example of a vapor explosion caused by depressurization of a liquid (Brennen 1995). Vapor explosions also occur when one, highly volatile liquid mixes with another at a higher initial temperature. One example of this occurs when liquid natural gas (or methane) is spilled into water at normal temperatures (Burgess *et al.* 1972) (this is a particular issue in LNG transportation accidents).

In other circumstances the thermal boundary layer at the interface of the bubble(s) inhibits the supply to the interface of the necessary latent heat of vaporization. This is what happens when water is boiled on the stove at normal pressures and this effect radically slows the rate of vaporization and the rate of bubble growth as described in section 6.4.2, in effect eliminating the *explosion*. Such thermally-inhibited growth is manifest in many technological contexts, for example in the growth of bubbles in the liquid hydrogen pumps of liquid-propelled rocket engines (Brennen 1994). Thermally-inhibited growth tends to occur when the liquid/vapor is at higher saturation pressures and temperatures, whereas non-thermally-inhibited growth tends to occur closer to the triple point of the liquid/vapor.

As described in section 6.4.3, other factors that can effect whether explosive growth or thermally-inhibited growth occurs are the conditions at the interface. If the thermal boundary layer is disrupted by instability or by substantial turbulence in the flow then the rate of vaporization will substantially increase and explosive growth will occur or be re-established. Indeed in a cloud of bubbles the growth itself can cause sufficient disruption to eliminate the thermal inhibition. The vapor explosion would then be self-perpetuating.

However, at the kinds of normal operating temperatures for the water coolant in a LWR or the sodium coolant in an LMFBR, all bubble growth (in the absence of other effects as described in the following section) would be strongly thermally inhibited (Brennen 1995) and highly unlikely to cause a self-perpetuating vapor explosion. To the author's knowledge no such event has been identified in any nuclear reactor for power generation (see Fauske and Koyama 2002).