7.6.5 Fuel coolant interaction

A fuel coolant interaction (FCI) event is a modified vapor explosion in which a second material (a "hot" liquid or solid) is brought into close proximity to the vaporizing liquid interface and provides the supply of latent heat of vaporization that generates vapor bubble growth. It belongs to a class of vaporization phenomena caused by the mixing of a very hot liquid or solid with a volatile liquid that then experiences vaporization as a result of the heat transfer from the injected material. Of course, the result may be either relatively benign thermally-inhibited vapor bubble growth or it may be explosive, non-thermally-inhibited growth. Both have been observed in a wide range of different technological and natural contexts, the latter often being described as an *energetic* fuel/coolant explosion. Examples of such energetic explosions have been observed as a result of the injection of molten lava into water (Colgate and Sigurgeirsson 1973) or of molten metal into water (Long 1957). The key to energetic fuel/coolant explosions is the very rapid transfer of heat that requires substantial surface area of the injected liquid (or solid): fragmentation of the "hot" liquid (or solid) can provide this necessary surface area. The studies by Witte *et al.* (1973) and their review of prior research showed that such energetic explosions always appear to be associated with fragmentation of the injected "hot" material. Research suggests that an energetic fuel/coolant interaction consists of three phases: (1) an initial mixing phase in which the fuel and coolant are separated by a vapor film (2) breakdown of the vapor film leading to greater heat transfer and vaporization rates and (3) an explosive or energetic phase in which the fluid motions promote even greater heat transfer and vaporization. In this last phase the explosive behavior appears to propagate through the fuel/coolant mixture like a shock wave.

Examples of reviews of the wide range of experiments on fuel/coolant interactions can be found in Witte *et al.* (1970) and Board and Caldarola (1977) among others. However, none of the experiments and analyses on sodium and uranium dioxide showed any significant energetic interaction and most of the experts agree that energetic fuel/coolant interactions will not occur in liquid-sodium LMFBRs (Fauske 1977, Board and Caldarola 1977, Dickerman *et al.* 1976).