Appendix B

Diffusion can be defined as a mechanism whereby a concentration of an element at one spot in a material slowly spreads across the whole world until the concentration is the same everywhere. In theory, this would make a homogenous composition of the earth's crust and waters. The diffusion speed of most materials is, however, both very low and very temperature dependent and not applicable to f.i. crystals. For the coated particle, the effect is that some fission products diffuse through the SiC layer and out into the gas stream. While most of the fission products are firmly held within the uranium kernel or stopped by the coatings, few materials like Caesium, Strontium and Silver which all have radioactive nuclides formed in the fission process, are more mobile than most. This is one reason why the maximum fuel temperature for normal operation is fixed at <1150 ˚C, thereby preventing undue contamination of the coolant circuit. Measuring the diffusion constant is very difficult and not necessarily a good predictor of what will happen in the real application. By determining the fuel temperature and the gas activity, the predictions for PBMR can be verified and operating parameters may be adjusted upwards later, as the initial conditions for operation are chosen conservatively. There are also known ways to improve the retention capability of the fuel, but these need to be proven in long-term research efforts.

The main measurable temperatures for PBMR are the outlet gas and the Reactor Pressure Vessel (RPV) temperatures. For the first reactor, there will be additional thermocouples placed in the reflector. From these measurements, a temperature profile across the reactor can be constructed. It will be impossible to determine the exact temperatures of individual kernels as these are location, burn-up and coolant flow dependent. With modern computational tools, however, the prediction will be accurate enough to ensure that no fuel exceeds the specified normal operating temperature, including the uncertainties assumed in the safety analysis.
It should be noted that for LWR fuel the same conditions apply. The coolant temperature is around 290 ˚C, but the centre fuel temperature can be as high as 2000 ˚C. This is a very steep slope and in-core flux measurements are regularly taken to ensure there are no unexpected deviations from the predicted temperature.