P B M R

THE PBMR'S SAFETY FEATURES

In all existing power reactors, safety objectives are achieved by means of custom-engineered, active safety systems. In contrast, the Pebble Bed Modular Reactor (PBMR) is inherently safe as a result of the design, the materials used, the fuel and the natural physics involved This means that, should a worst case scenario occur, no human intervention is required in the short or medium term.

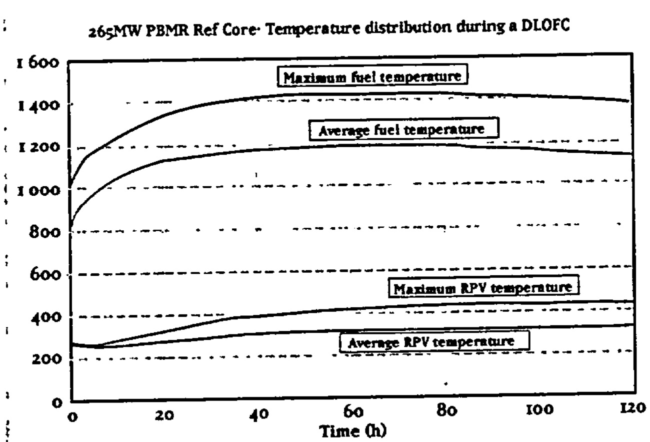
Nuclear accidents are principally driven by the residual power generated by the fuel after the chain reaction is stopped (decay heat) caused by radioactive decay of fission products If this decay heat is not removed, it will heat up the nuclear fuel until it loses its integrity and therefore releases its radioactivity

In "conventional" reactors, the heat removal is achieved by active cooling systems (such as pumps) and relies on the presence of the heat transfer fluid (e g water) Because of the potential for failure in these systems, they are duplicated to provide redundancy. Other systems, such as a containment building, are provided to mitigate the consequences of failure and provide a further barrier to radioactive release.

In the PBMR, the decay is such that the removal of the decay heat is achieved by radiation, conduction and convection, independent of the reactor coolant The combination of the very low power density of the core (1/20th of the power density of a Pressure Water Reactor), and temperature resistance of fuel in billions of independent particles, underpins the superior safety characteristics of this type of reactor.

The helium, which is used to transfer heat from the core to the power-generating gas turbines, is chemically and radiologically inert. It cannot combine with other chemicals, it is non-combustible and it cannot become radioactive when passed through the core. Because oxygen cannot penetrate the helium, oxygen in the air cannot get into the high temperature core to corrode the graphite used in the reaction.

Loss of Coolant Event



The figure shows the performance of the fuel under extended periods at high temperatures.

Why a core melt-down is not possible

The peak temperature that can be reached in the core of the reactor (1 600°C under the most severe conditions) is below any sustained temperature that may cause damage to the fuel. This is because the fuel is made partly from ceramic materials like graphite and silicone carbide, which makes it extremely robust.

Even if a reaction in the core cannot be stopped by the small absorbent spheres (that perform the same function as control rods) or cooled by the helium, the reactor will stop any nuclear fission and cool down naturally and in a very short time

The size of the core is such that it has a high surface area to volume ratio This means that the heat that it loses through its surface (via the same process that allows a cup of tea to cool down) is more than the heat generated by the decay of fission products in the core. Hence the reactor never reaches the temperature at which meltdown could occur. The plant can never be hot enough for long enough to cause damage to the fuel.

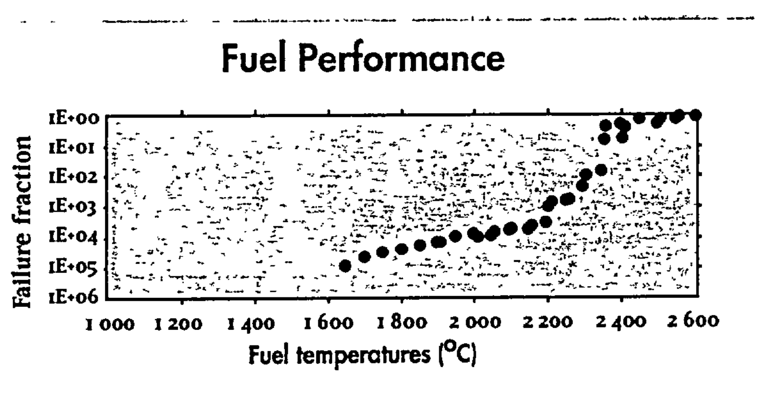
If, through some accident, both the inlet and the outlet gas pipes were ruptured, it would take some nine hours for natural air to circulate through the core. Even if this could happen, it would only lead to less than 10^6 (one millionth) of the radioactivity in the core being released per day. That means that the amount of activity released in 24 hours under this very severe (and recoverable) situation would be some 10 000 times less than that requiring any off-site emergency actions

To avoid such a double failure of the main gas ducting, the piping is designed to leak before it breaks, so that the depressurisation will be gradual and cannot lead to such a rupture. The physical construction of the building is such that no external missile can cause a common failure of both pipes The helium pressure inside the closed cycle gas turbine is higher than the air pressure outside it, so nothing can get inside the nuclear circuit to contaminate it.

This inherently safe design of a PBMR renders obsolete the need for safety grade backup systems and most aspects of the off-site emergency plans required for conventional nuclear reactors and is fundamental to the cost reduction achieved over other nuclear designs Emergency plans related to aspects such as the transport of fuel will still be required, albeit modified to suit the specific characteristics of the fuel and the transport mode.

The concept is based on the well-tried and proven German AVR power plant that ran for 21 years. This safe design was proven during a public and filmed plant safety test, when the flow of coolant through all cooling to the reactor core was stopped and the control rods were left withdrawn just as if the plant was in normal power generation mode.

It was demonstrated that the nuclear reactor core shut itself down within a few minutes. It was subsequently proven that there was no deterioration of the nuclear fuel. This proved that a reactor core meltdown was impossible and that an inherently safe nuclear reactor design had been achieved.



The figure shows the temperature of the hottest part of the fuel and overall average after a total loss of coolant.