2.0 THERMAL-HYDRAULIC ANALYSIS

Analysis were to performed to evaluate thermal-hydraulic characteristics of spent fuel stored in the spent fuel pools (SFPs) of decommissioning and determine the times available for plant operators to take actions to prevent occurrence of a zirconium fire and discussed in Appendix 1. Particular attention was focused on the times available prior to reaching any fuel uncovery and the times available prior to a zirconium fire if the fuel was completely uncovered. These times were then utilized in performing the risk assessment discussed in Section 3.

To establish times available prior to any fuel uncovery, calculations were performed to determine the time to heat the SFP coolant to a point of boiling and then boil the coolant down to 3 feet above the top of the fuel. As seen in the Table below, the times available to take actions prior to any fuel uncovery would be 100 hours or greater for a SFP with PWR fuel which had decayed 60 days. Additional decay times would extend the available time.

Table 2.1 Time to Heat Up and Boil Off SFP Inventory Down to 3 Feet Above Top of Fuel (60 GWd/MT)

DECAY TIME	PWR	BWR
60 days	100 hours	145 hours
1 year	195 hours	253 hours
2 years	272 hours	337 hours
5 years	400 hours	459 hours
10 years	476 hours	532 hours

The analysis in Appendix 1, determined that the amount of time available prior to a zirconium fire depends on a variety of factors that include fuel burn-up, fuel storage configuration, building ventilation rates/air flow paths, and fuel cladding oxidation rates. While the February 2000 report indicated that for the cases analyzed a required decay time of 5 years would preclude a zirconium fire, the new analysis show that the decay time to preclude a zirconium fire could exceed 5 years, particularly in instances of high burnup fuel with little or no ventilation due to blockages of air flow around the fuel. Blockage of the air flow around the fuel could be caused by collapsed structures and/or a partial draindown of the SFP coolant due to a seismic event or loss of SFP building ventilation which could preclude or inhibit effective cooling. As discussed in Appendix 1, air flow blockage could result in near adiabatic fuel heatup leading to a zirconium fire beyond 5 years. Figures 2.1 shows heatup times for fuel with air cooling fuel from 30 °C to 800 °C in hours for PWR and BWR fuels versus time since reactor shutdown in years. Even after 4 years, the figure shows that PWR fuel could reach the point of fission product release in about 40 hours. Figure 2.2 shows a comparison of the air cooled calculations to an adiabatic heatup calculation for PWR fuel with a burnup of 60 GWD/MTU. It shows that up to 2 years the air cooled heatup rates are shorter than the adiabatic heatup rates. This result is discussed in detail in Appendix 1.

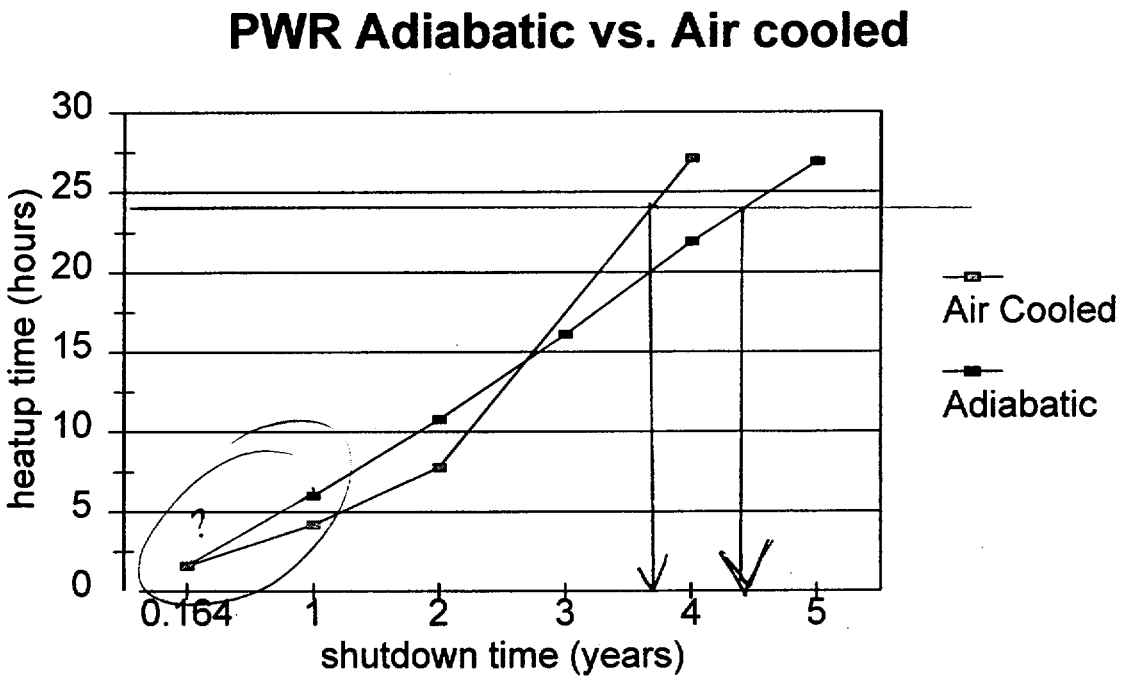

Figure 1: PWR heatup times for air cooling and adiabatic heatup.

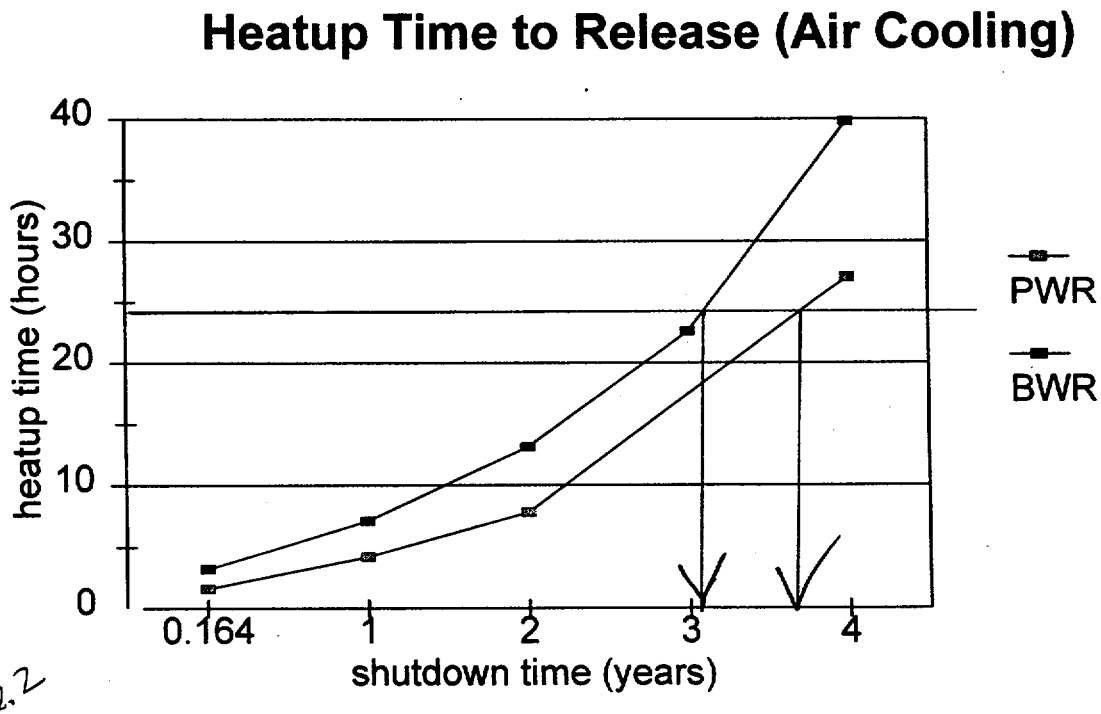

Figure 2: Heatup time from 30 C to 800 C

In summary ~~the analysis of Appendix 1, documents that~~ there is considerable time to take action to preclude a fission product release or zirconium fire prior to uncovering the top of the fuel even 60 days after reactor shutdown. However, ~~the appendix also shows that~~ if the fuel is uncovered, even with a partial draindown, the time to preclude a fission product release or zirconium fire can extend beyond 5 years. Applications of these results and how they affect SFP risk and decommissioning regulations are discussed in Section 3 and 4 of this report .

if no recovery actions are taken

Need a paragraph which makes clear the important variables and why a definitive generic "no fire" number is NOT ~~not~~ feasible.

Do we need any research in this area?