Summary of Issues/Problems for Spent Fuel Pool Decommissioning

Breakaway Oxidation / Hydriding / Fuel Fines Effect on 10 Hour Delay and Critical Decay Time

Breakaway oxidation occurs when the oxide layer cracks or breaks away leaving exposed a thin stable layer of ZrO_2. The thin stable layer can range from 2-20 microns in thickness. The limited experimental data shows that breakaway oxidation may occur for exposure times longer than 60 minutes. The impact of breakaway oxidation was studied by transforming the parabolic oxidation rate equation into a linear oxidation rate equation for a constant oxide layer thickness. The oxidation rate is limited by the diffusion of oxygen through the oxide layer. Parabolic kinetics is equivalent to a oxide layer growing in time. Linear kinetics is equivalent to a constant thickness oxide layer. Calculations performed using a constant oxide layer thickness of 2 microns have a significant impact on the heatup times and the critical decay time.

Rapid clad ballooning and rupture that occurs at 700 C can lead to local autoignition of the cladding due the exposure of bare zirconium hydride and /or zirconium metal to an air environment. The reaction rate will be far greater than the reaction rate with a protective oxide layer. The propagation of the reaction is not known.

Accepting the possible release of fuel fines and associated fission products (Ruthenium) as an acceptance criteria will lower the maximum cladding temperature to approximately 600 C. This will extend the critical decay time and decrease the time to fission product release.

Building Ventilation Effect on 10 Hour Delay and Critical Decay Time

All calculations performed to date to determine a critical decay time and the heatup time to fission product release used either a perfect (infinite) ventilation assumption (GSI-82) or a nominal building ventilation flow rate of 2 building volumes per hour along with an intact fuel rack geometry. The ventilation assumption has long been known to have a substantial impact on the heatup calculations. Reducing the ventilation flow rate will increase the heatup rate and also increase the critical decay time. The heatup time to a fission product release can be significantly less than 10 hours and the critical decay time can be extended well beyond 5 years by lowering the building ventilation flow rate. The assumed building ventilation rates are not defensible since the accident initiator is a well beyond design basis seismic event. The intact rack geometry assumption is also not defensible since it is not unlikely that part of the building may collapse onto the fuel racks.

Partial Draindown Scenario

Present calculations show that a partial draindown can result in cladding temperatures well above the threshhold for fission product release at 5 years after shutdown. The partial draindown scenario may also cause the time to fission product release to be significantly less than 10 hours at 1 year.

Conclusions

The time to fission product release can be significantly less than 10 hours at 1 year and there is no well defined critical dacay time beyond which a substantial fission product release can not occur.

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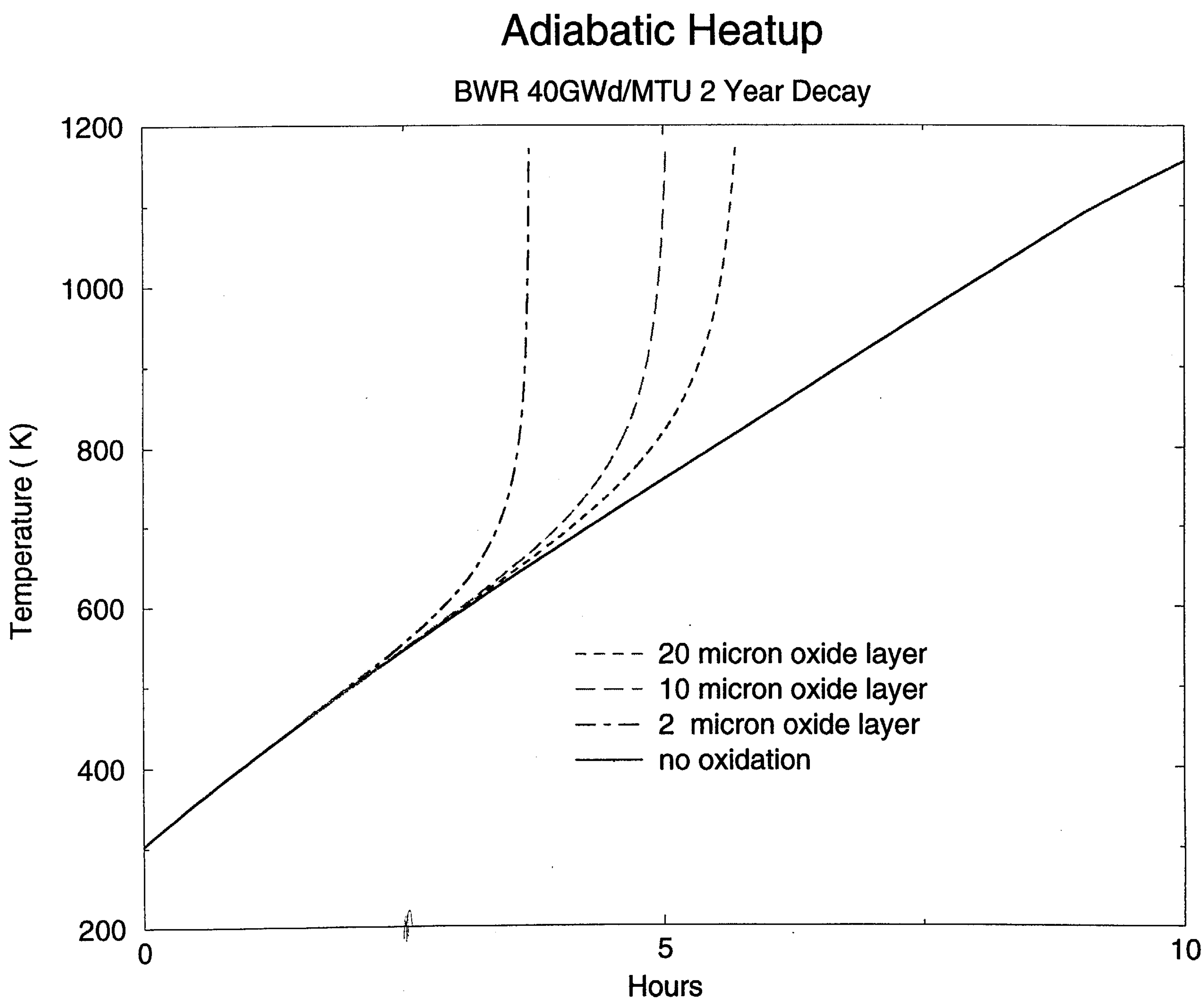
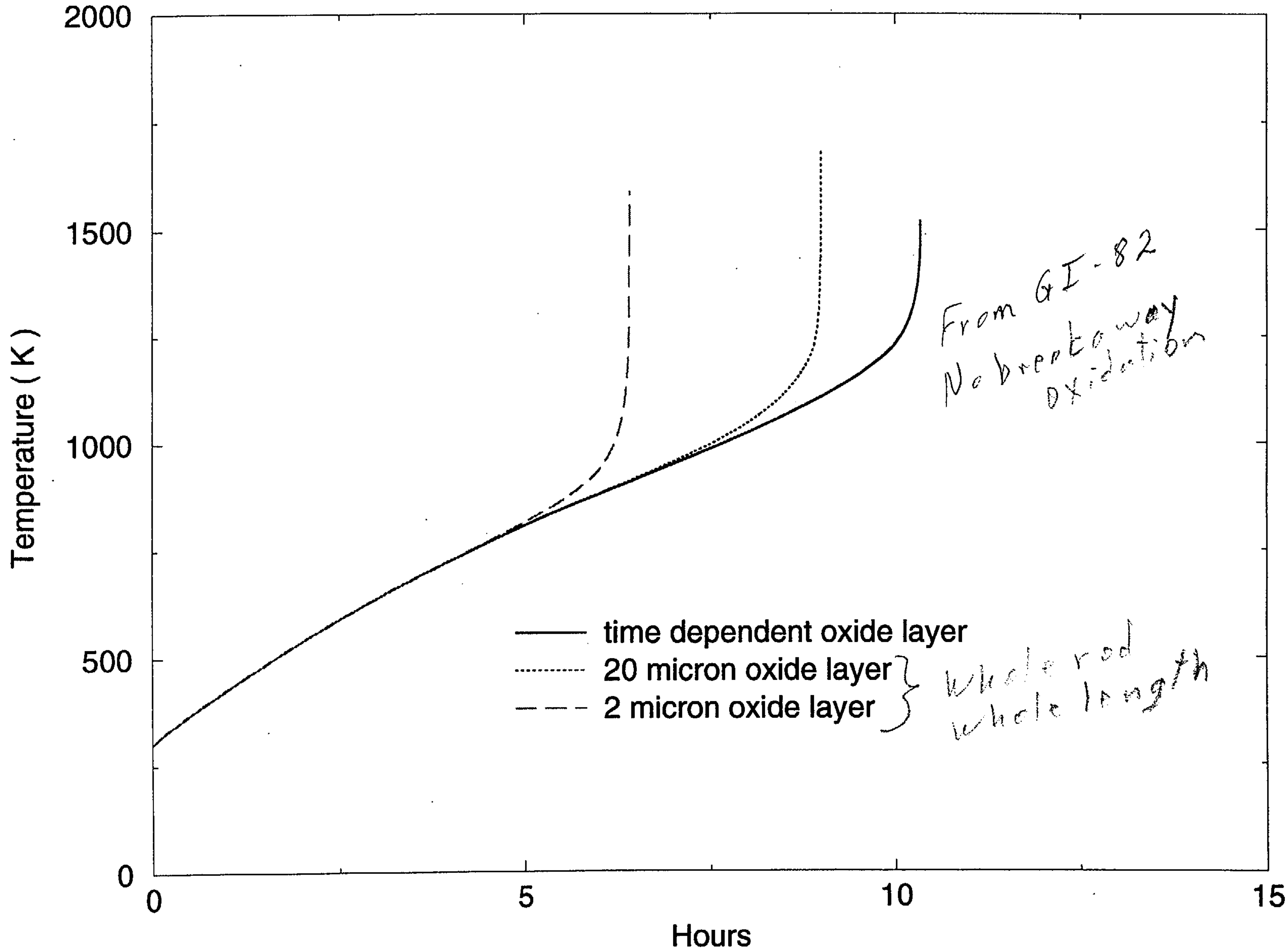

Adiabatic Heatup
BWR 40GWd/MTU 2 Year Decay
Temperature (K)
1200
1000
800
600
400
200
0
5
10
Hours
20 micron oxide layer
10 micron oxide layer
2 micron oxide layer
no oxidation

GSI 82 case PWR high density

1 year after shutdown, perfect ventilation



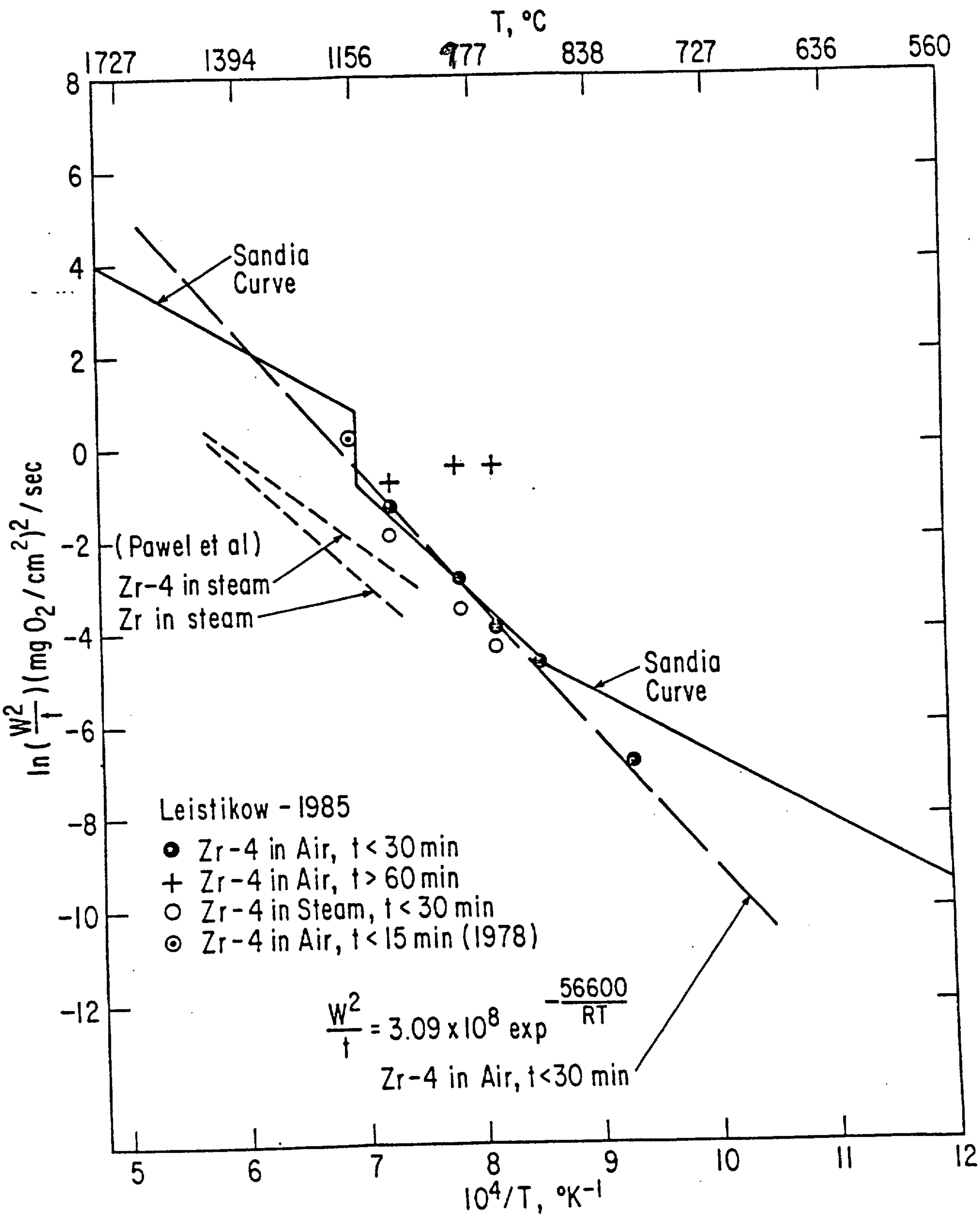


Figure B.3 Comparison of recent Zircaloy oxidation data with suggested correlations.

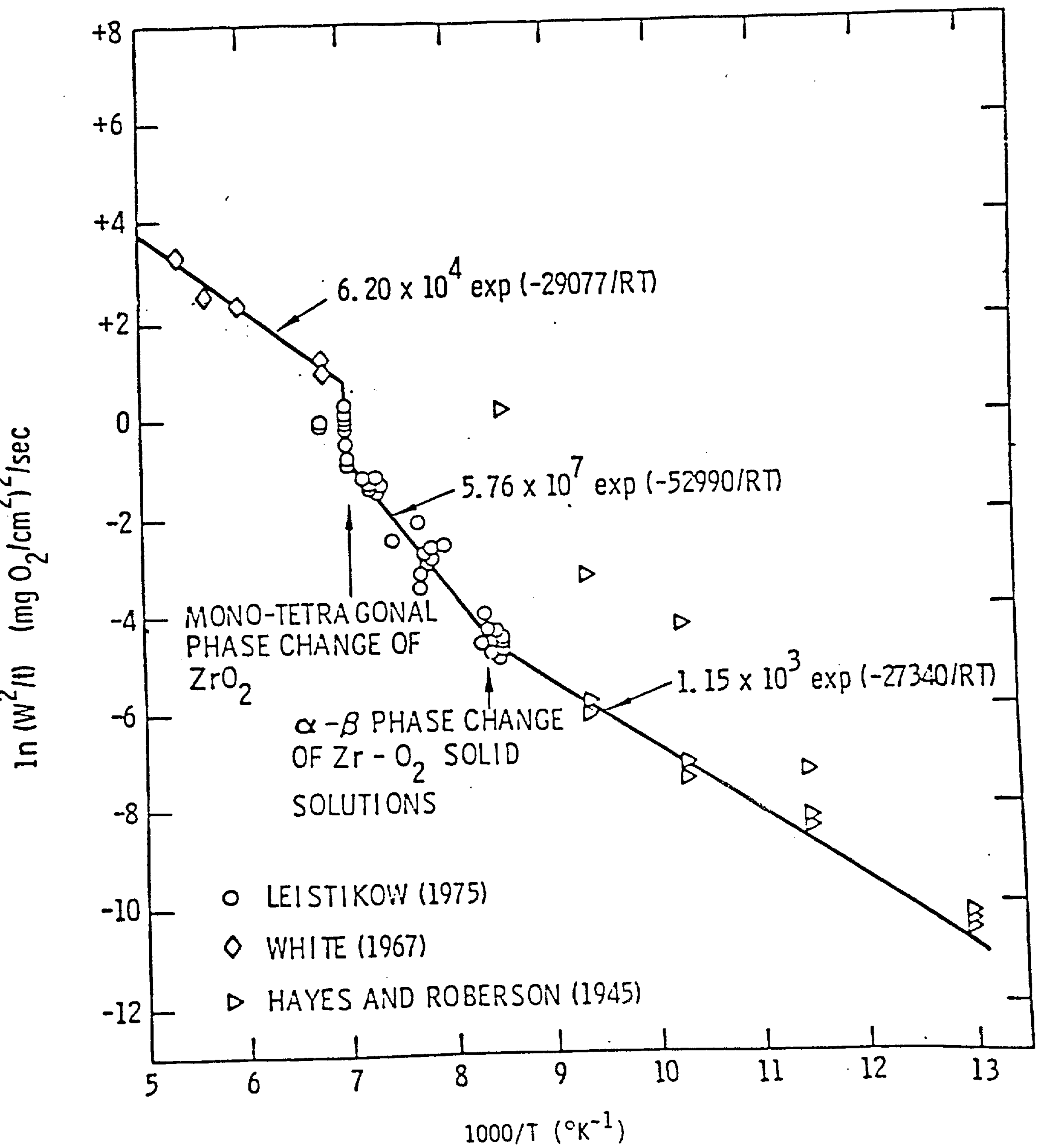


Figure B.1 Correlations for zirconium and Zr-4 oxidation in air (from Ref. 1).

Flow through each of the fuel regions shows a similar pattern. No clear trend is observed with decay time variation. The noticeable exception is the reduced flow rate predicted for the 2 year case. Predictions for the 3, 4, and 6 year cases show nearly identical flow rates through each of the fuel types. The similar flow rates indicate that the increases in velocity for the lower decay times (higher T) are offset by similar decreases in density.

7.4 Ventilation Rate Sensitivity

An important input parameter is the ventilation rate. The base ventilation rate assumes 2 building volumes of cool air enter the building each hour. Additional predictions are made with 1, 1.5, and 2.5 building volumes per hour. Each case assumes a 4 year decay time and all external walls are adiabatic. Predicted temperatures are plotted in Figure 16.

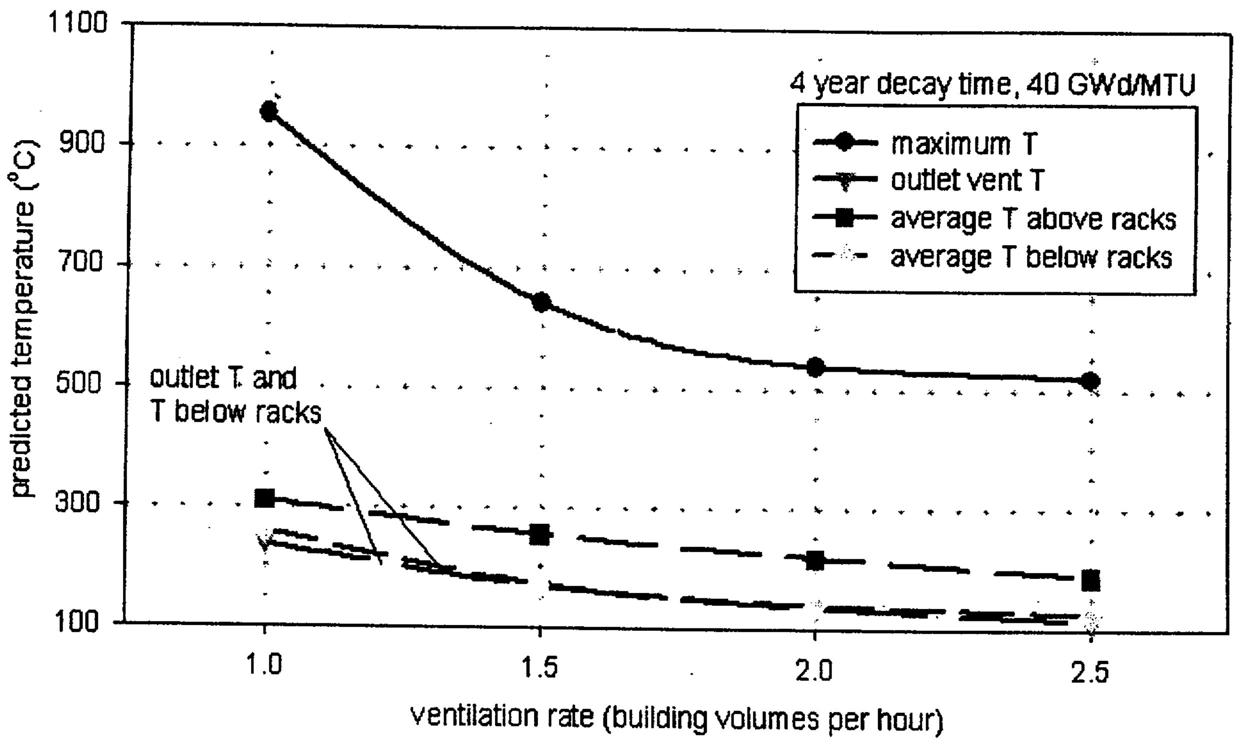


Figure 16. Sensitivity of Temperatures to the Ventilation Rate

The maximum temperature is significantly affected by the ventilation rate. The largest affect occurs when the ventilation rate is reduced from 1.5 to 1 building volume per hour. This trend suggests that reducing the ventilation rate below the 1 building per hour rate would significantly increase the temperature. This is not done because the model is not accurate at higher temperatures. The difference in the maximum predicted temperature between 2 and 2.5 buildings per hour is 19 °C. This is nearly equal to the difference in the predicted exit vent temperature for these two cases. It appears that the effect of increasing the ventilation rate beyond 2 buildings per hour can be approximated by globally adjusting the temperatures to the change in the outlet temperature determined from a global energy balance.