



Updated Thermal Response during LOCA/LOFA Event in ARIES-ACT-1

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ARIES Project Meeting

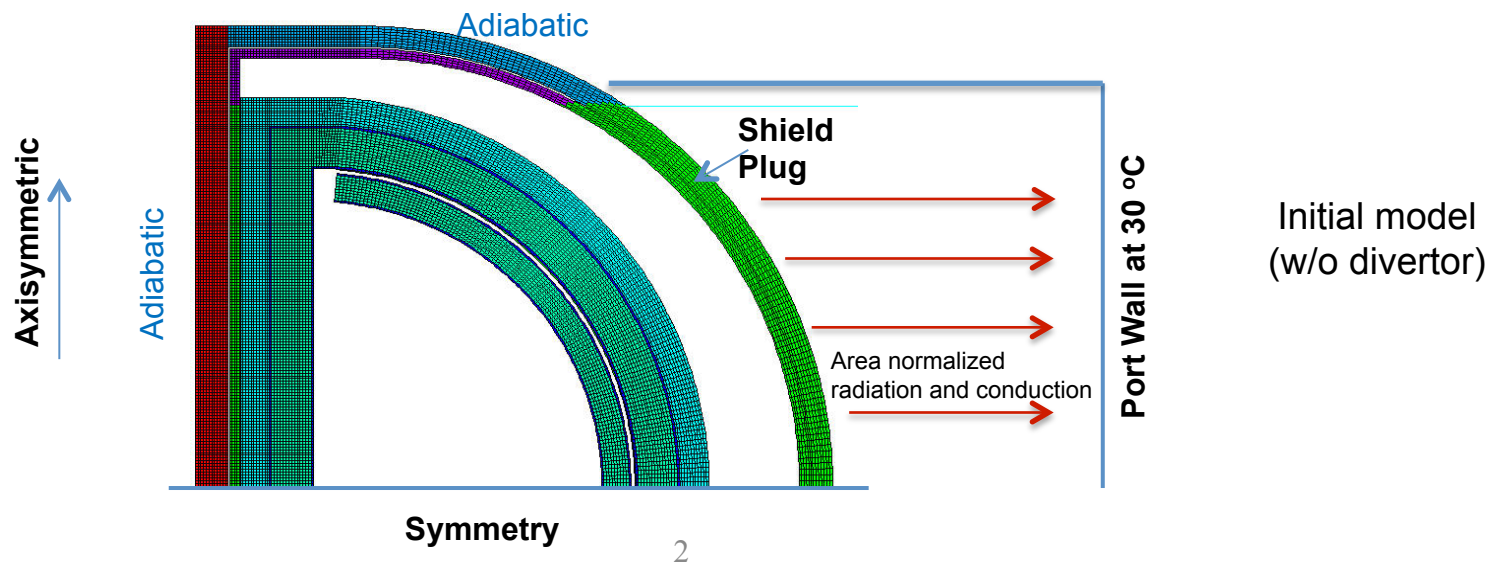
May 21 - 22, 2013

Germantown, MD



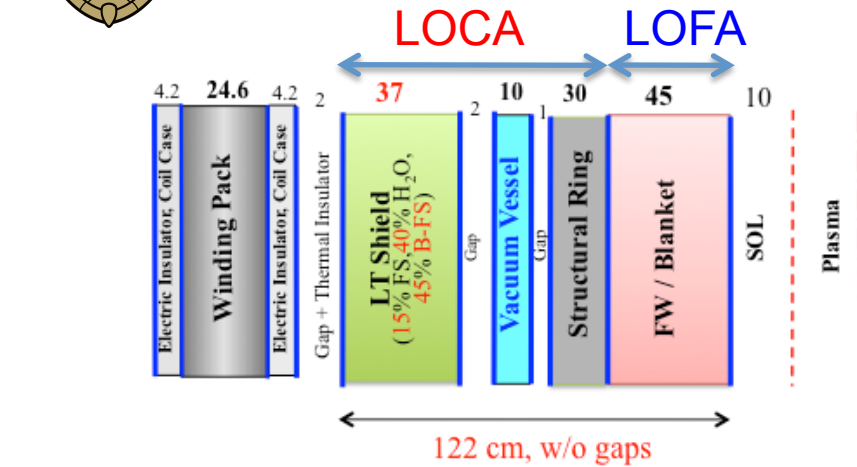
LOCA/LOFA Analysis Assumptions

- Analysis assumes full loss of water and helium and loss of flow in the LiPb (worst case scenario).
- Plasma heating included for 3 sec. After onset of LOCA.
- Emissivity of 0.9 assumed for all radiating surfaces. This is a best case scenario that would require coating of metallic materials.
- Radiation across plasma channel modeled approximately.
- Divertors are not included in the initial model, but added later.
- Heat removed by conduction and radiation from shield plug to port door at 30 °C. Other surfaces assumed to be adiabatic (insulated).

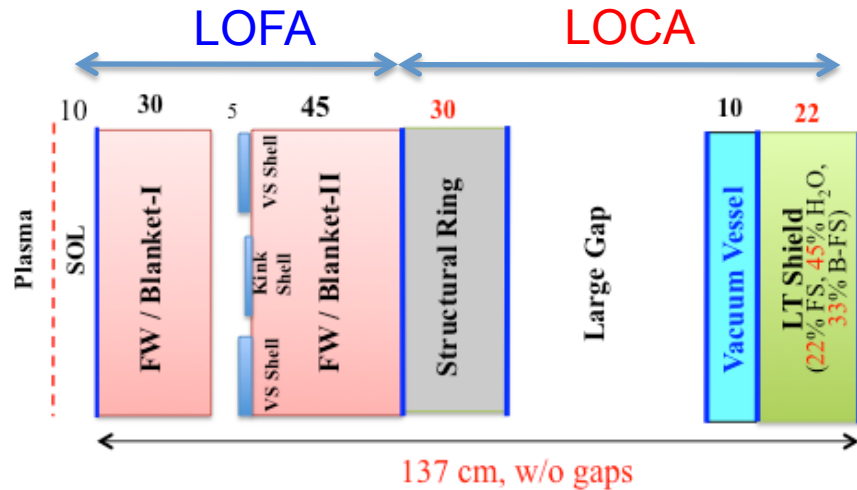




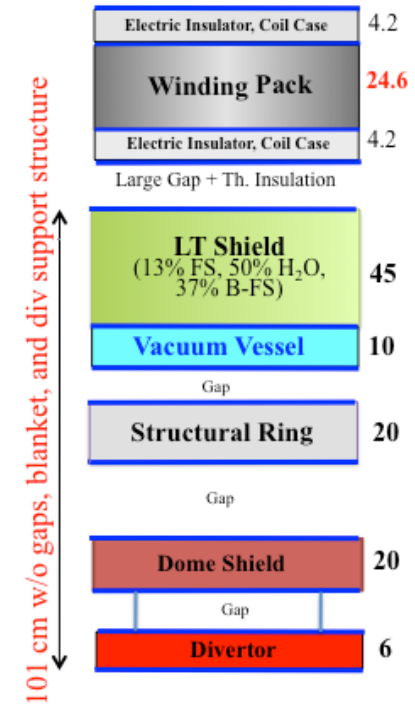
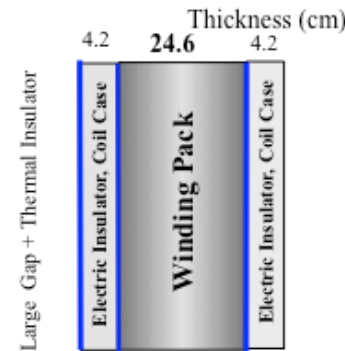
ARIES-ACT-1 Radial/Vertical Build Definition



Inboard



Outboard

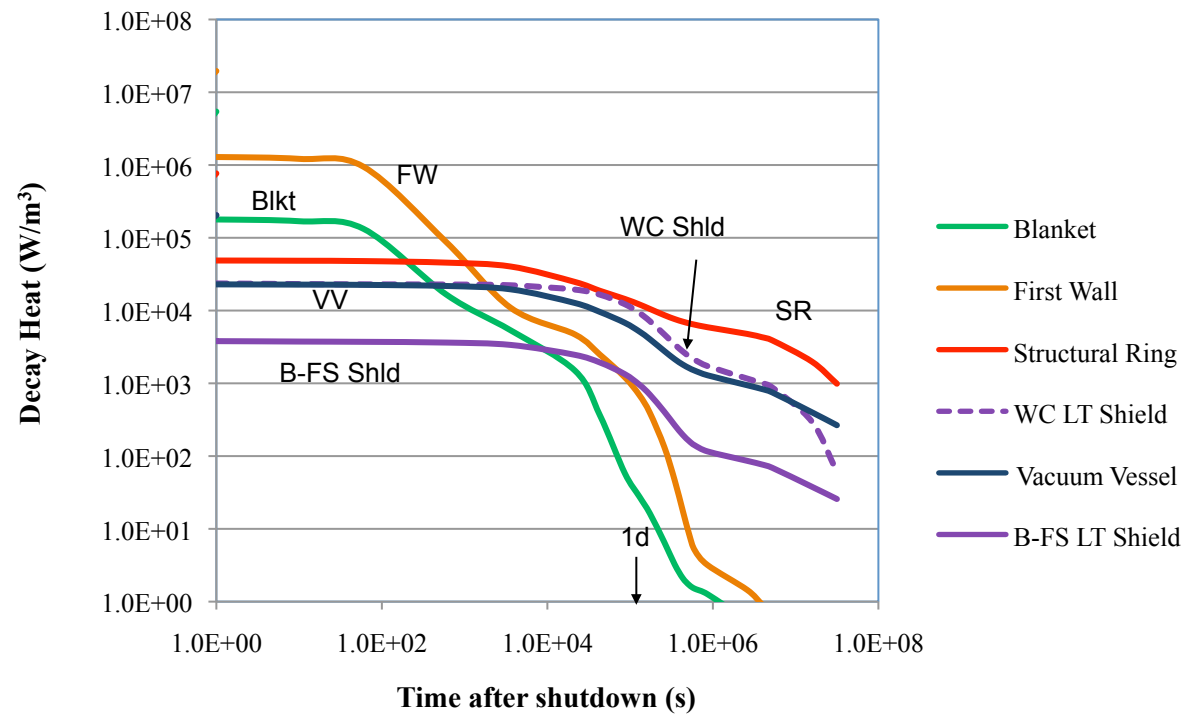


Vertical



Inboard Decay Heats

- Includes data for both WC and B-FS fillers in IB LT Shield
- B-FS reduces decay heat by more than a factor of 5 compared to WC.



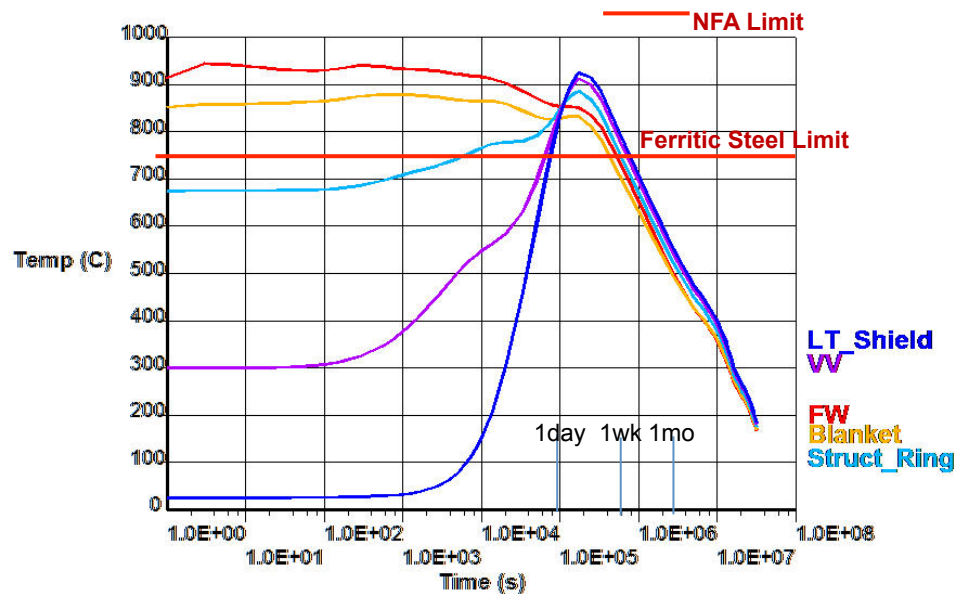


Effect of Material Change on Inboard Temperatures

- Maximum inboard temperature dropped by 46 °C due to changing inboard shield filler from W-C to B-FS
- After material change, maximum shield, VV, and SR temperatures are nearly the same, but exceed FS reusability limit (750 °C).

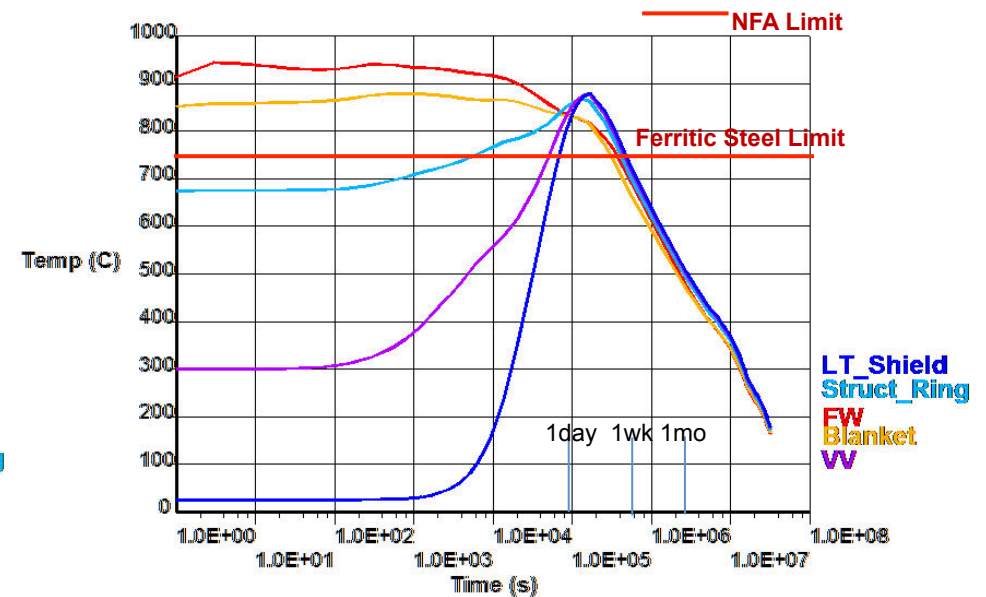
WC Inboard Shield

Max Shield Temperature **924 °C**



B-FS Inboard Shield

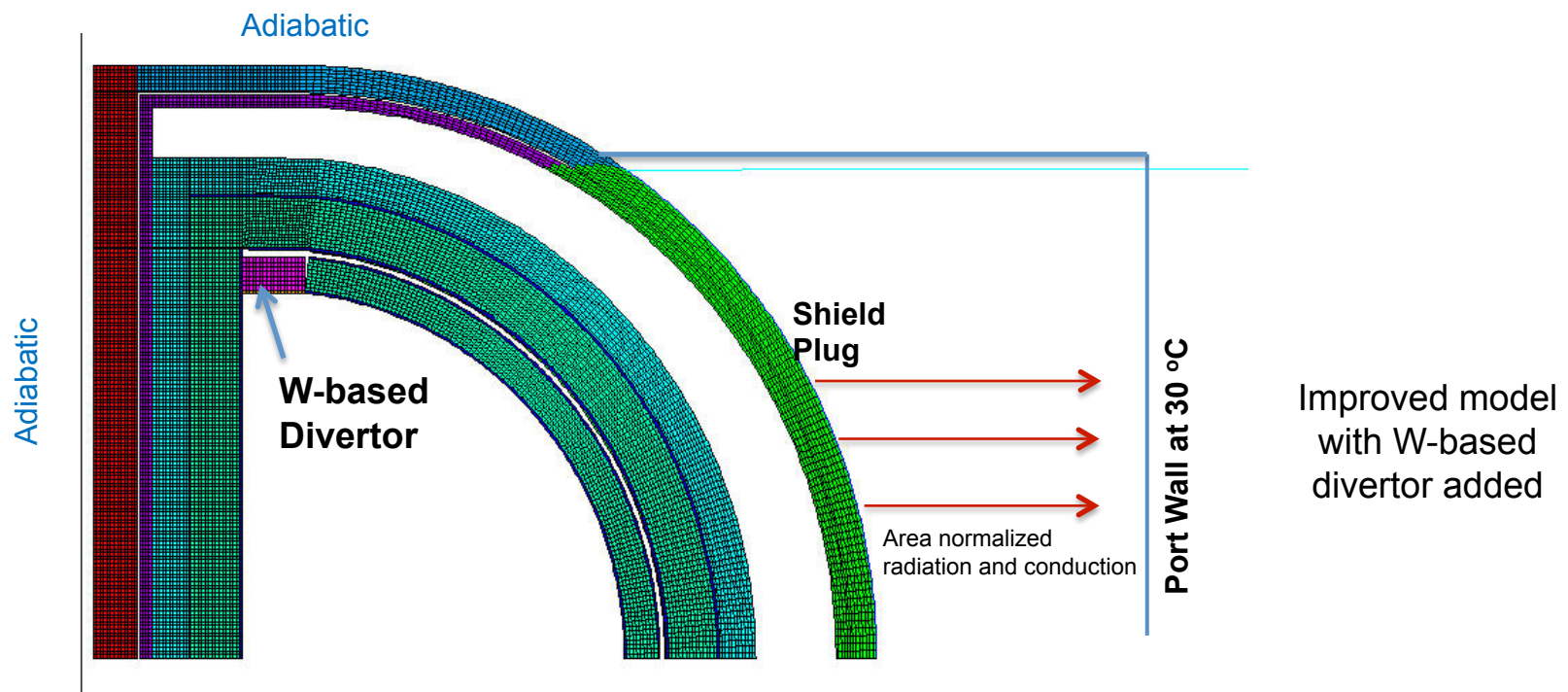
Max Shield Temperature **878 °C**





Divertors and Enhanced Cross-Channel Radiation using Computed View Factors Added to Model

- Divertor structure and heat loads included in this model.
- Radiation view factor calculation for cross-channel radiation replaces the approximate method of previous analyses, greatly enhancing model fidelity.

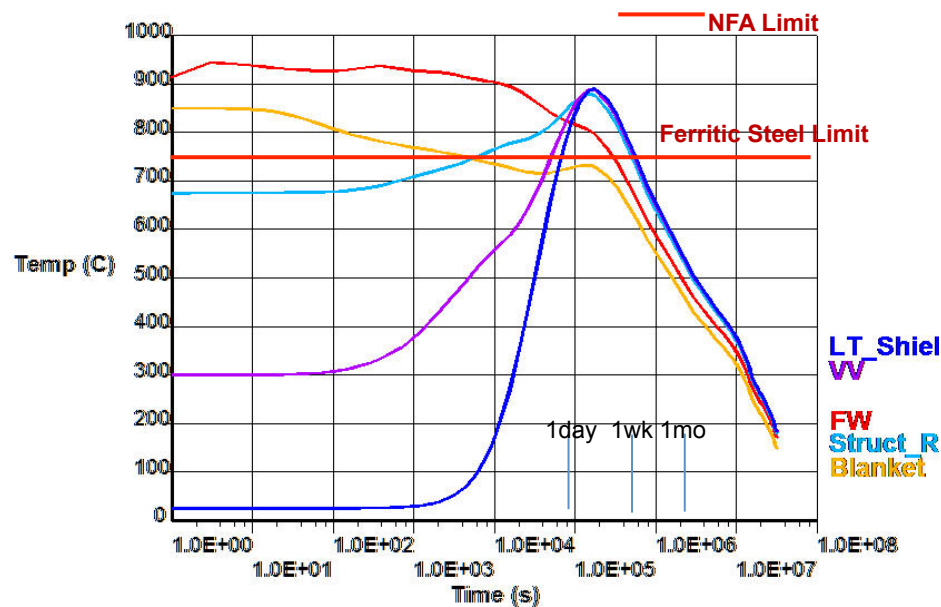




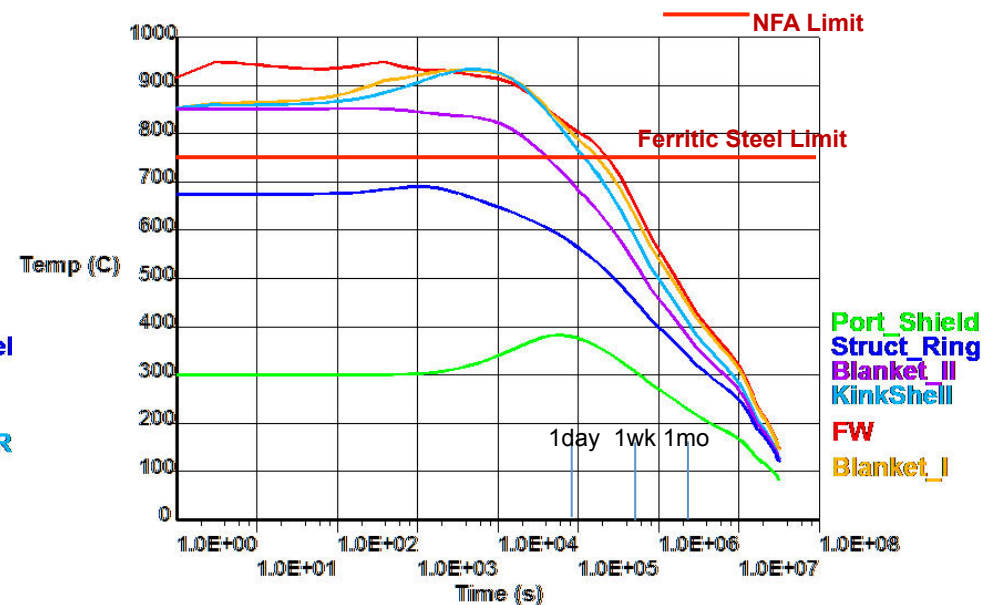
Inboard and Outboard Temperatures with Divertor

- Emissivity of 0.9 assumed for all surfaces
- Divertor included
- Improved cross-channel radiation modeling

IB Temperatures with IB B-FS LT Shield.
Max LT Shield, VV, SR Temp $\sim 900^\circ\text{C}$



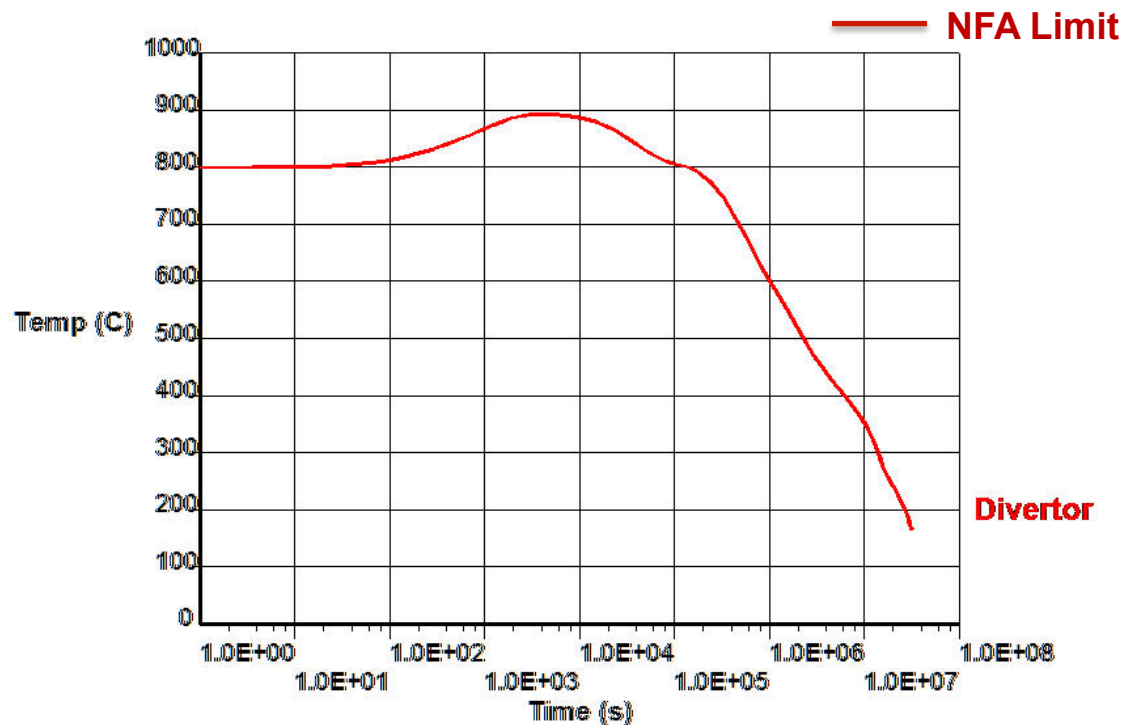
OB Temperatures with IB B-FS LT Shield.
Structural Ring Remains Below 700°C





Divertor Temperature Reaches 900 °C

- Crude lumped model of divertor shows temperatures reaching 900 °C
- Detailed model incorporating complex divertor and support structure geometry required to predict temperatures more accurately.





Conclusions

- Material change from WC to B-FS shield reduced inboard temperatures by ~ 50 °C.
- Inclusion of divertor heating has only a slight impact (13 °C) on overall IB structural temperatures. ODS FS temperature in divertors may reach 900 °C.
- Computed inboard maximum temperature of ~ 900 °C exceeds the reuse temperature of ferritic steel (750 °C).
- Potential solutions:
 - Improved inboard heat removal mechanism during LOCA/LOFA,
 - Use Nano-structured Ferritic Alloy (NFA) in IB LT-shield, VV, and SR to survive this kind of severe accident, or
 - Replace IB LT-shield, VV, and SR after accident.