LOCA/LOFA Analyses for Blanket and Shield Only Regions – LiPb/FS/He System

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LOCA/LOFA Analysis Update

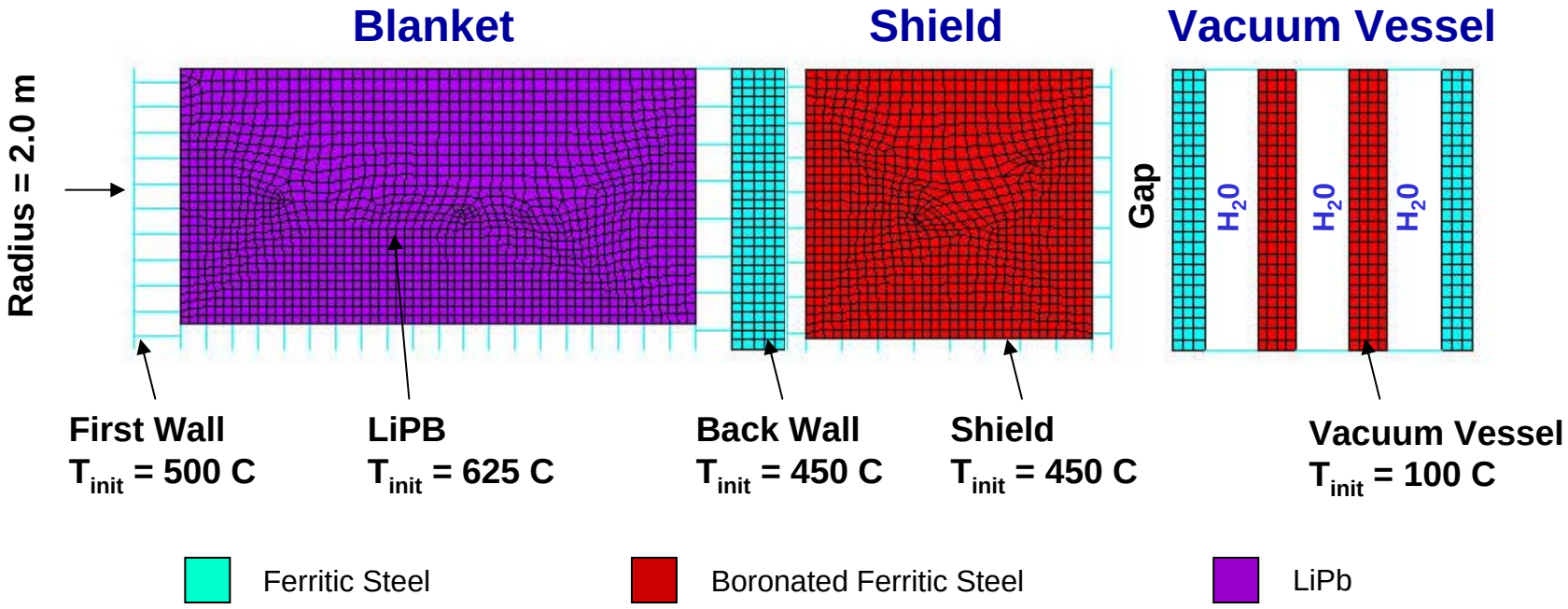
1. **Results from LOCA/LOFA models with the gap between blanket and shield removed. The interface has been replaced with a perfect contact condition.**

2. **Maximum temperatures for LOCA and LOFA as a function of $\overline{\Gamma}$ are presented to help establish thermal operating limits.**

3. **Preliminary results for the shield only regions will be discussed.**

ANSYS FE Model and Boundary Conditions for Thermal Analyses

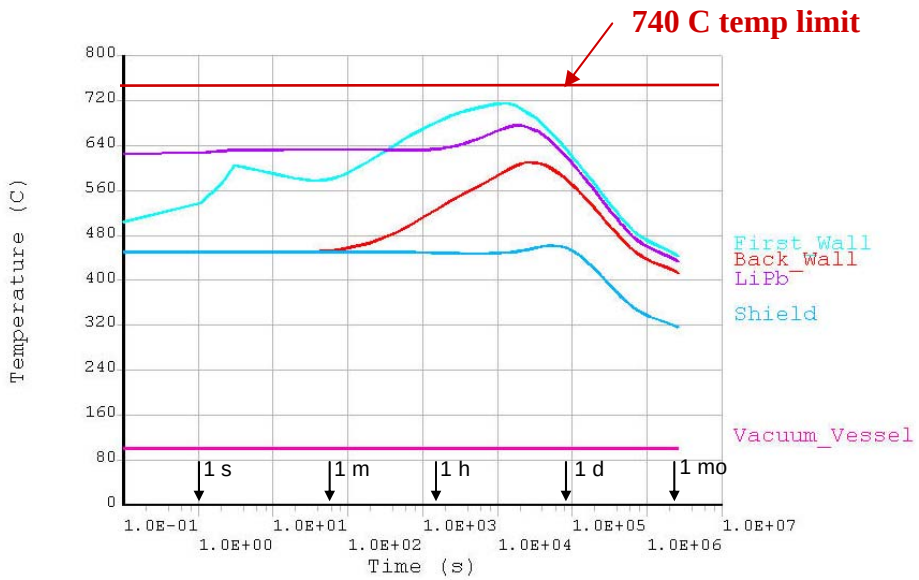
- Adiabatic boundary at back of vacuum vessel.
- Model is axisymmetric about plasma centerline and symmetric on sides. Gap between blanket and shield replaced with perfect contact condition.
- Emissivity of 0.3 assumed across vacuum gap and vacated cooling channels.
- All analyses assume there is no helium in channels.



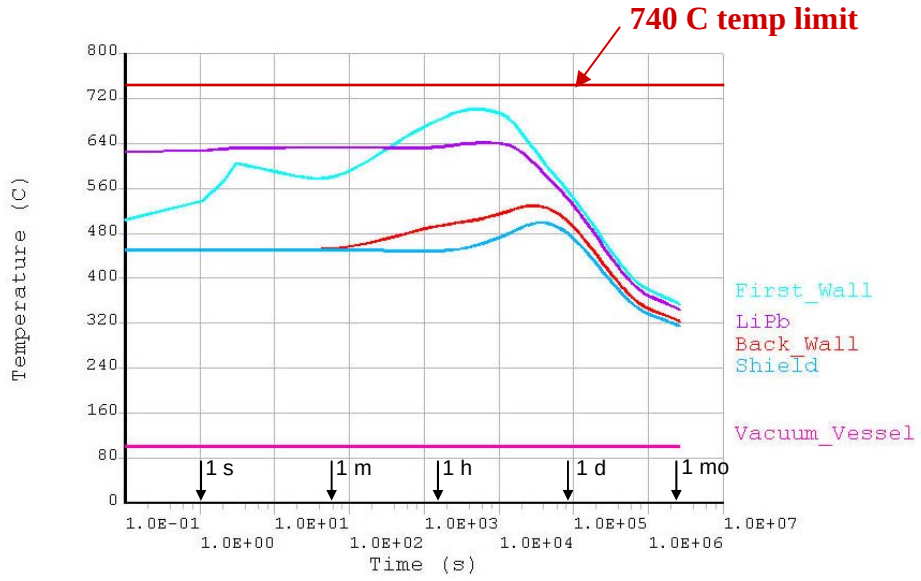
Thermal Results LOFA for LiPb and Water and LOCA for He

- Model modified to remove vacuum gap between blanket and shield to agree with current configuration.
- Maximum temperature is 14 C lower with gap removed and perfect contact assumed.

1 cm Gap Between Blanket and Shield
Maximum temperature – 715 C



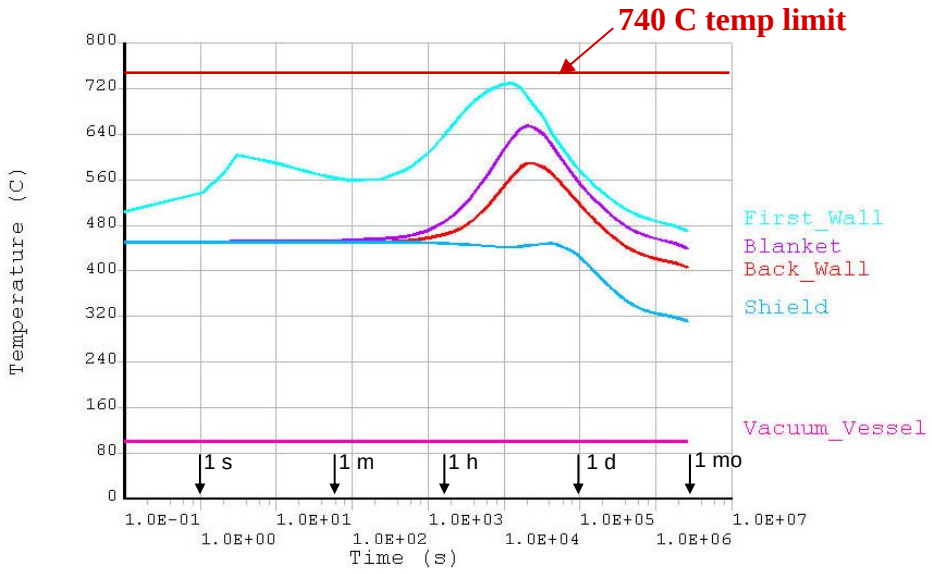
Perfect Contact Between Blanket and Shield
Maximum temperature – 701 C



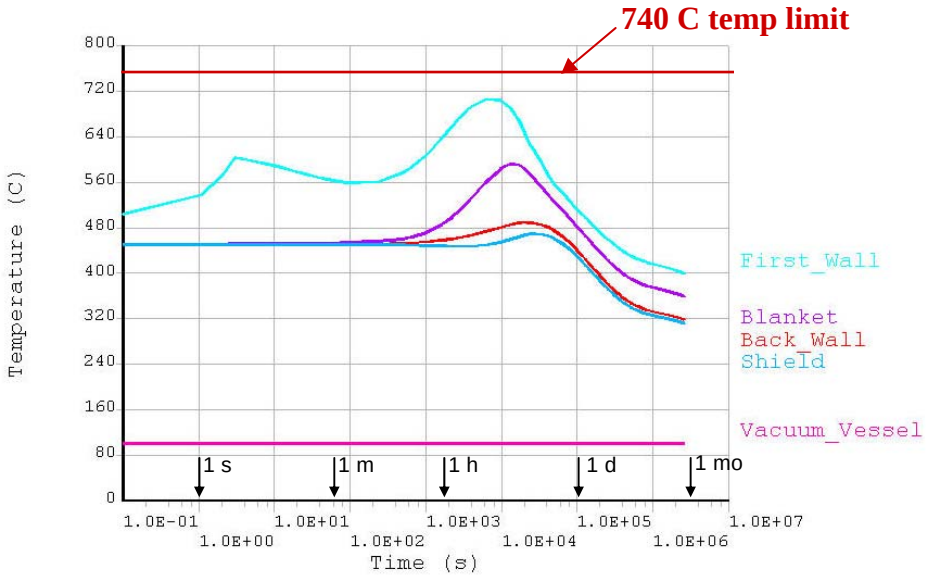
Thermal Response for LOCA in Blanket/Shield and LOFA in Vacuum Vessel

- Maximum temperature is 23 C lower with ideal contact between blanket and shield compared to 1 cm vacuum gap case.
- Maximum temperature is higher for LOCA (706 C) compared to LOFA (701 C).

1 cm Gap Between Blanket and Shield
Maximum temperature – 729 C



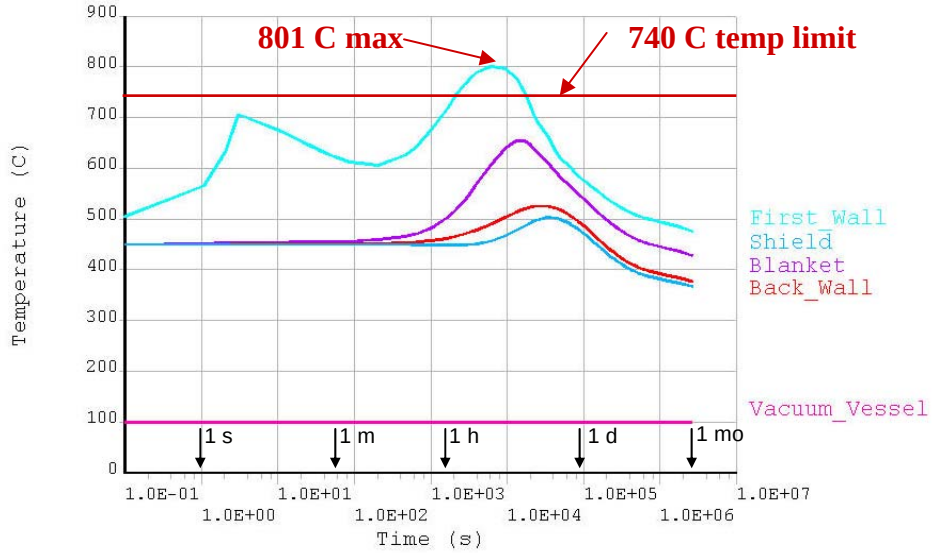
Perfect Contact Between Blanket and Shield
Maximum temperature – 706 C



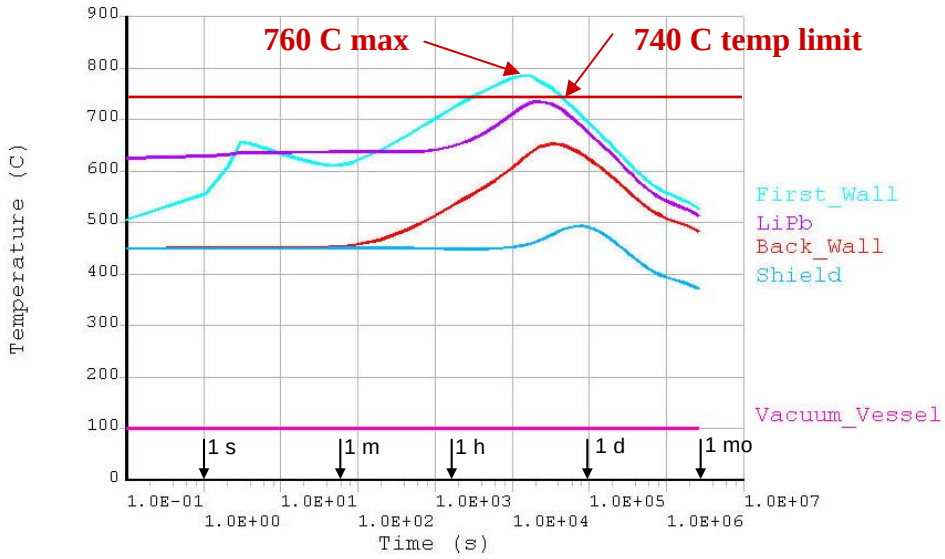
Thermal Results for Fusion Power Scaled by 1.5

- Maximum temperatures for ratio Γ=1.5 exceed 740 C FS limit.
- Again, maximum temperature is higher for LOCA than LOFA.

LOCA for LiPb

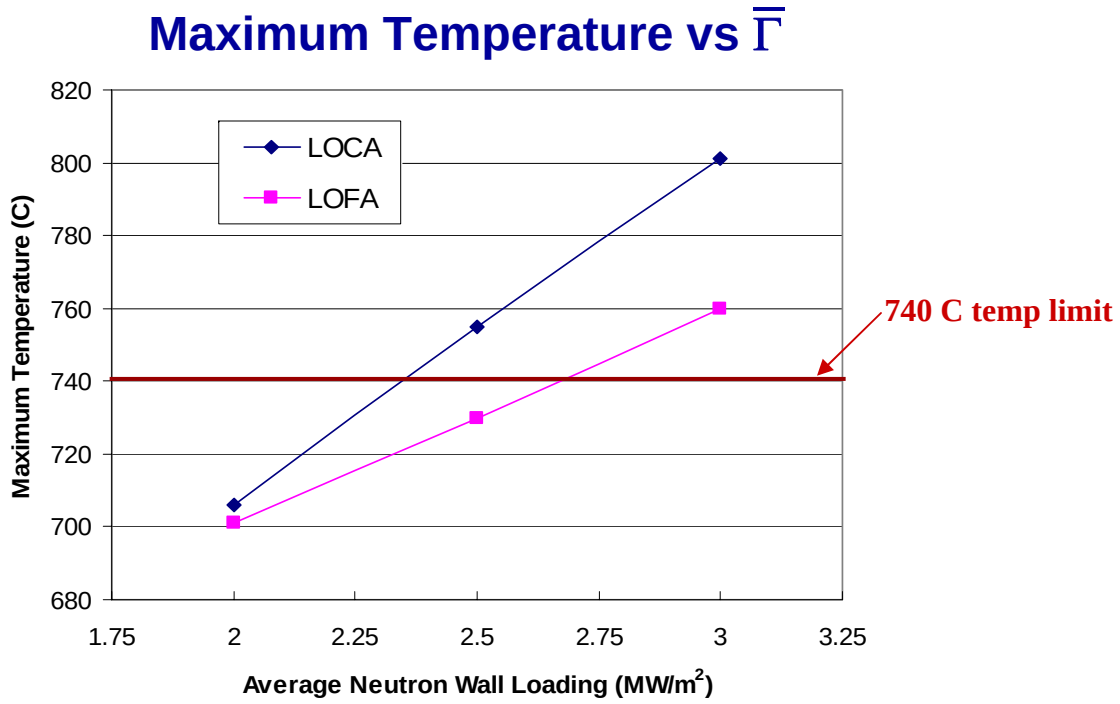


LOFA for LiPb

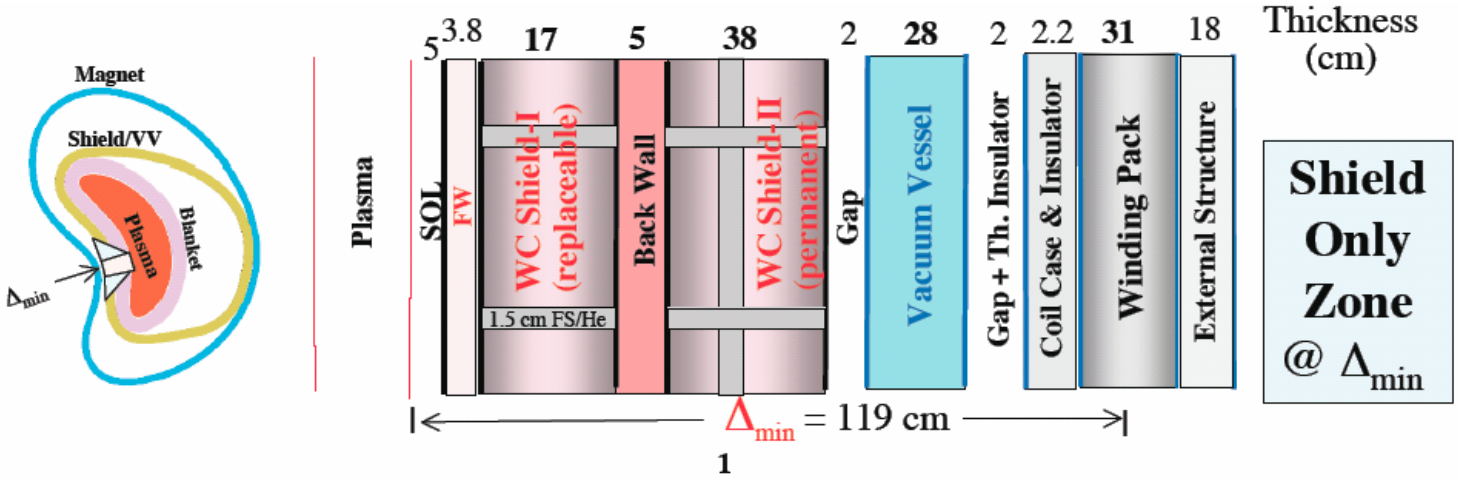


Variation of Maximum Temperature with $\overline{\Gamma}$

- 740 C FS limit exceeded for $\overline{\Gamma}$ > 2.3 MW/m^2 with current configuration

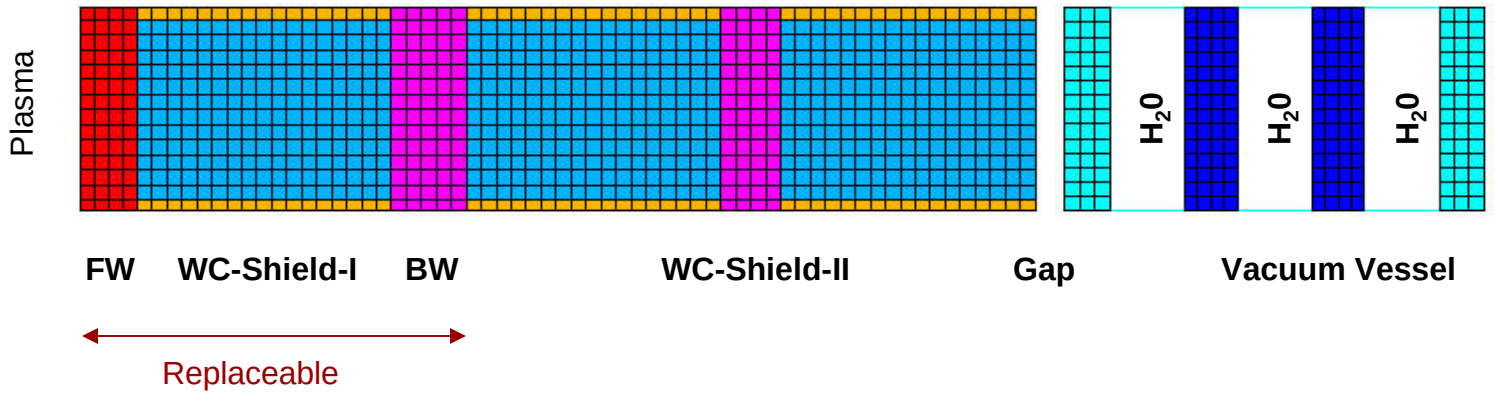


Shield Only Zone Analysis



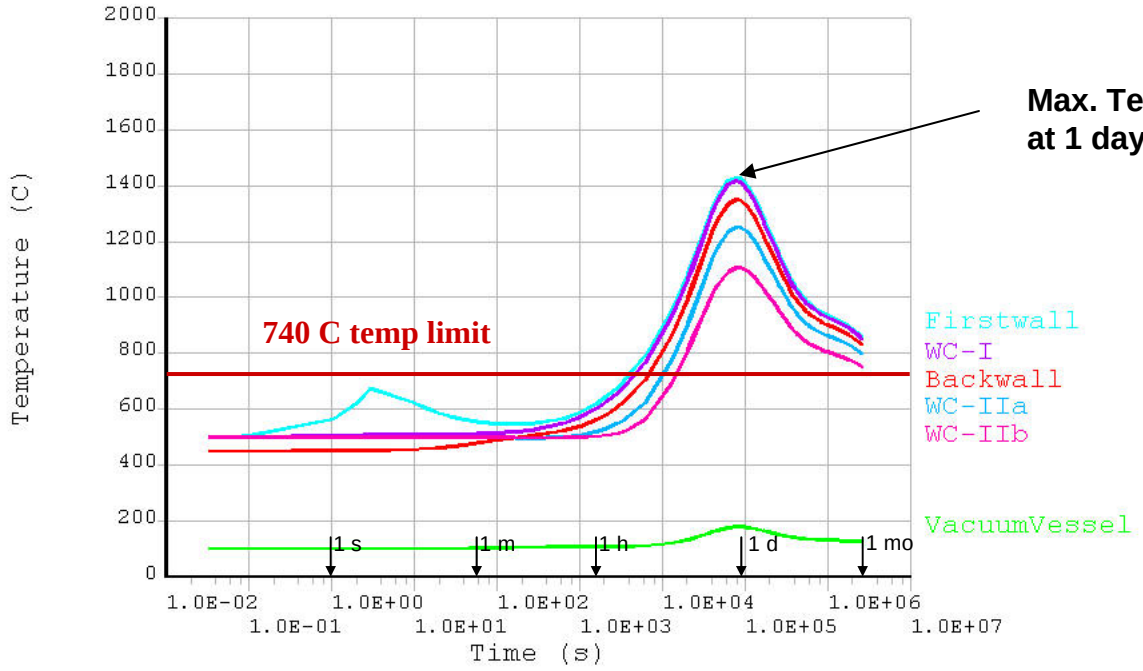
FEA Model

Assumes shield only region about entire radius (conservative temperature estimate)



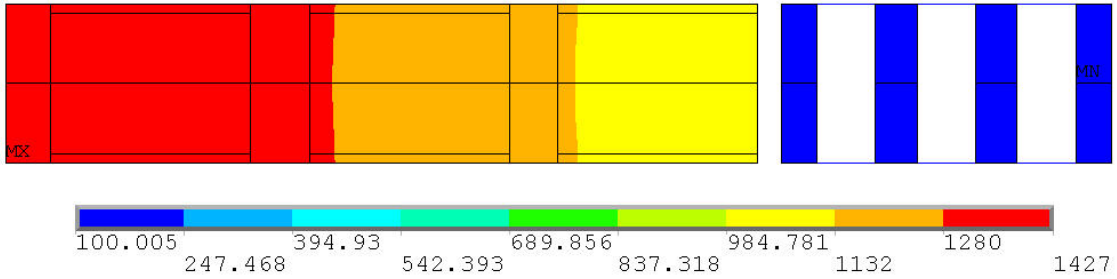
LOCA Thermal Results for Shield Only Region

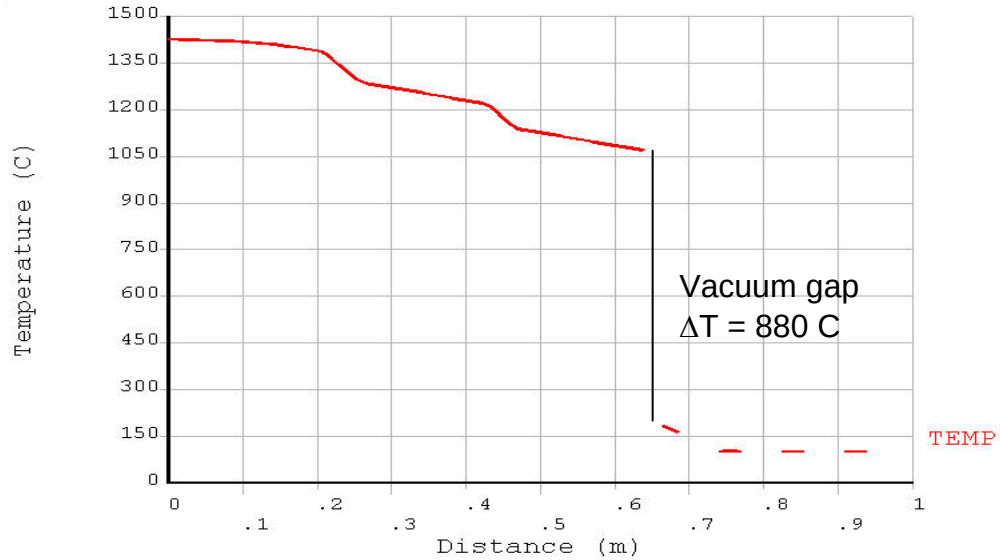
- **Maximum temperature of 1427 C occurs after 24 hours.**
- **Natural convection to water in vacuum vessel included.**
- **Emissivity of 0.3 assumed for radiation in vacuum gap.**
- **Initial temperatures of 500 C assumed for 1st wall and WC, 450 C for cooling channels, and 100 C for vacuum vessel.**



Temperature Distribution at t = 1Day

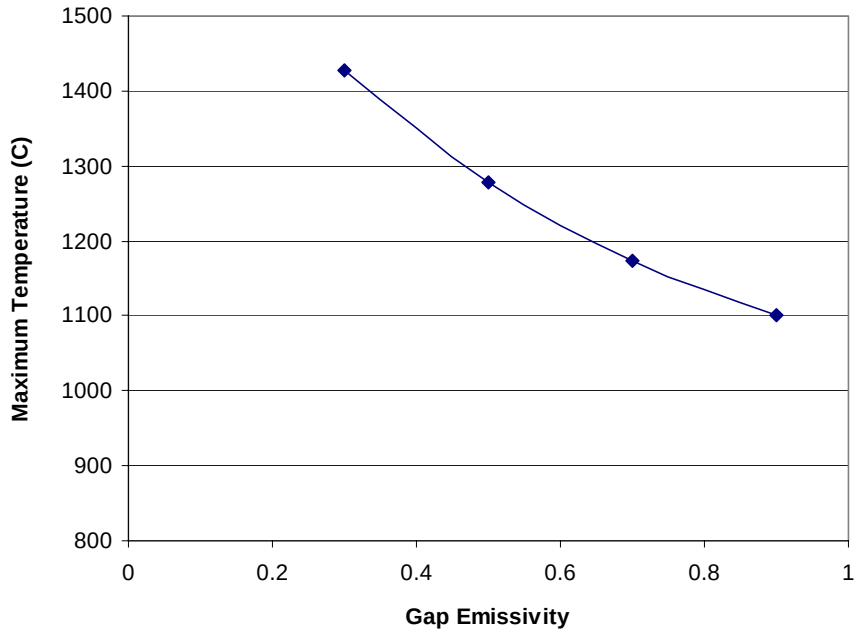
- **Large gradient occurs across vacuum gap (ε=0.3 assumed).**
- **Temperature gradients across Shield II and gap confirmed with hand calculations.**





Variation of Maximum Shield Temperature with Gap Emissivity

- **Increasing emissivity across can not reduce temperatures to acceptable levels.**
- **3-D analysis with transition regions are required to properly analyze region.**
- **Passive system may be required to achieve temperature limits.**



Summary and Future Plans

1. **Removal of the gap between the vacuum and shield reduced the maximum temperatures by 14-23 C for LOCA/LOFA cases.**

2. **$\overline{\Gamma}$ should not exceed 2.34 MW/m^2 to keep blanket FS temperature below 740 C during LOCA/LOFA for current configuration.**

3. **Blanket and shield model is to be updated to latest configuration and temperature limits/design sensitivity will be further evaluated.**

4. **Shield only region temperatures greatly exceed limits. Increasing emissivity does not solve problem. Passive safety system may be needed.**

5. **A full 3-D model of shield only and transition regions will be developed to further investigate this problem.**