Thermal Analysis of Various LOCA/LOFA scenarios for ARIES-ACT-1

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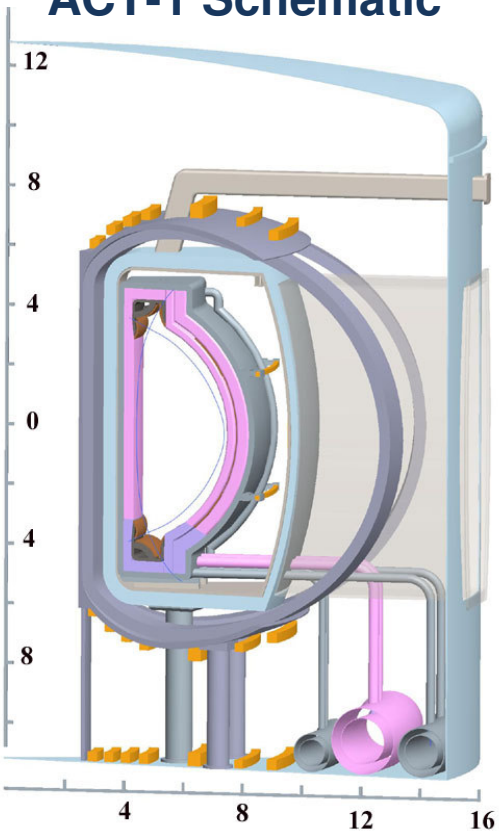
Loss of Water and Helium Accident

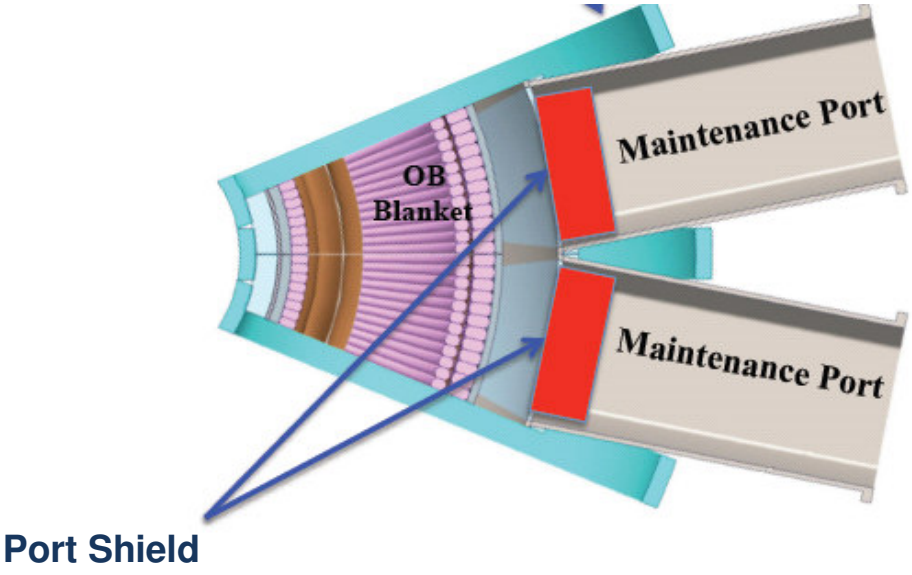
With Loss of LiPb Flow

- Superinsulation on the low-temperature shield will limit heat removal.
- Maintenance ports assumed to be primary avenues for removal of decay heat in the event of such an incident.
- Heat removal from inboard region expected to be a challenge.

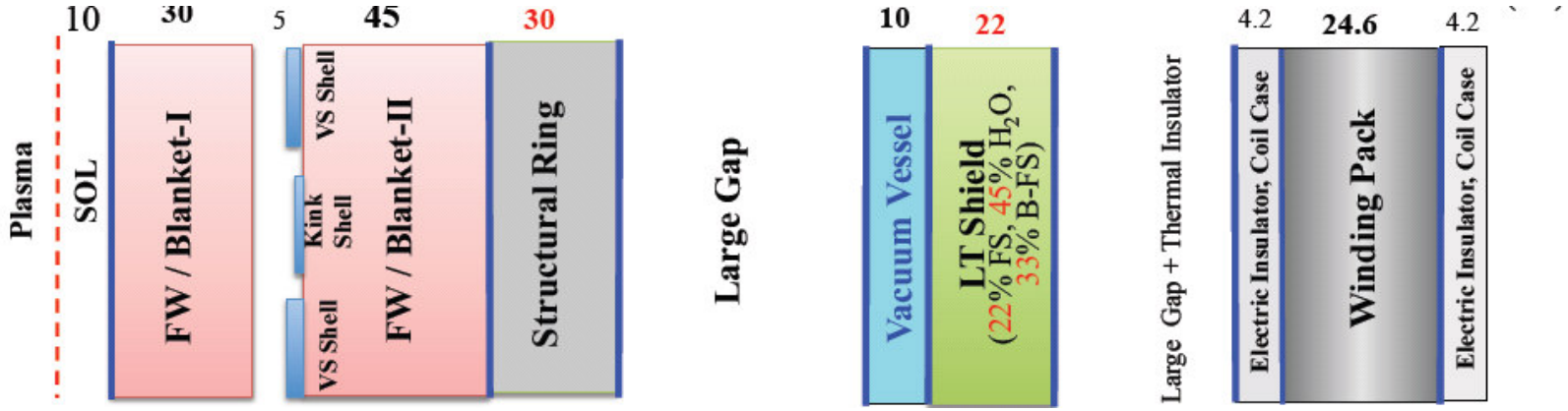
ACT-1 Schematic

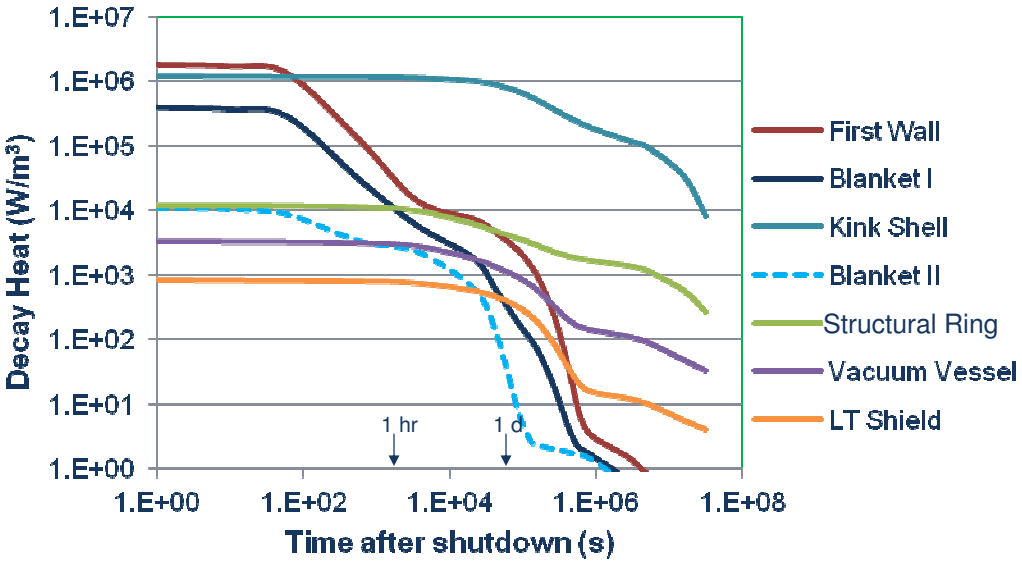


Maintenance Port Details



Outboard Radial Build and Decay Heats





OB Blanket-I
16% SiC/SiC Composites,
84% LiPb (50% Li-6 enrichment)

OB Blanket-II
19.3% SiC/SiC Composites,
80.7% LiPb (50% Li-6 enrichment)

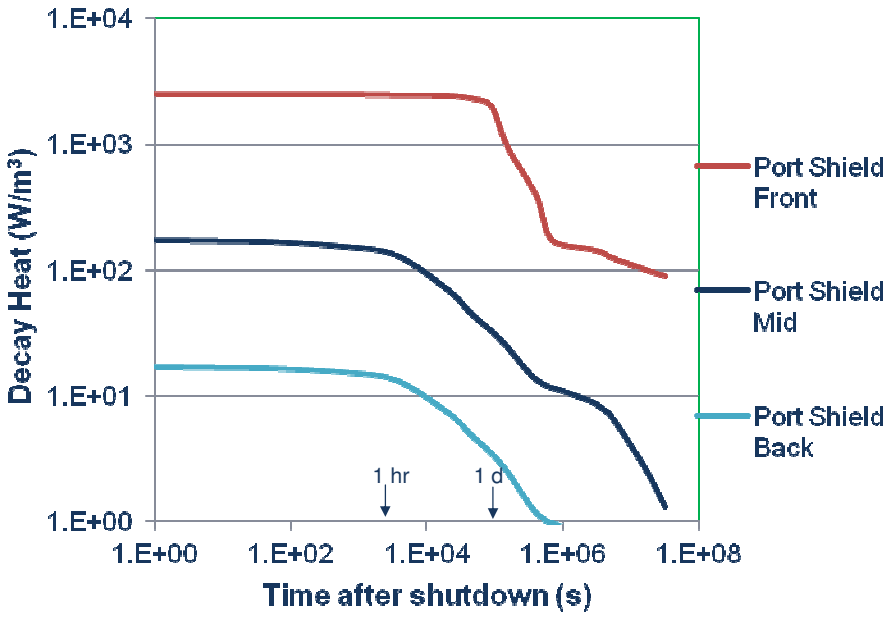
IB and OB Structural Rings
80% ODS-FS, 20% He

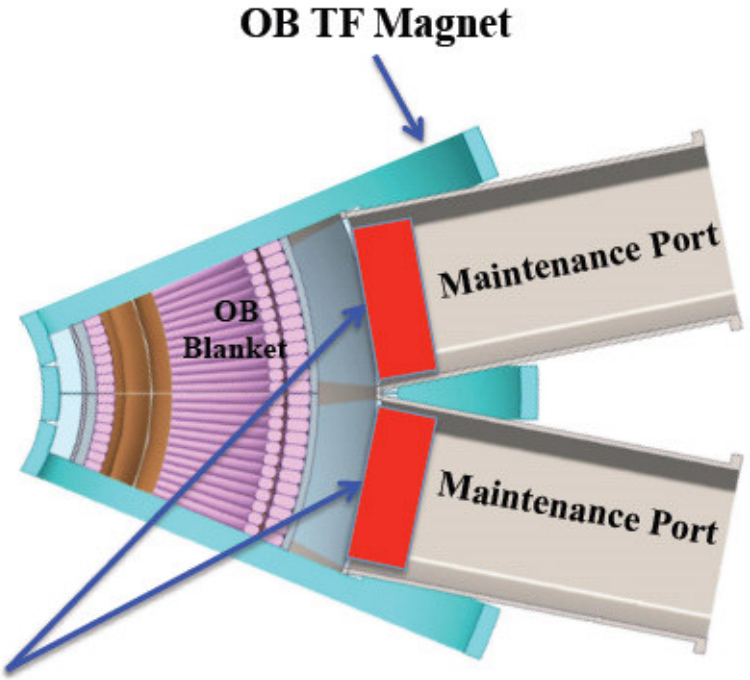
Vacuum Vessel
60% 3Cr-3WV FS, 40% He

OB LT Shield
22% FS, 45% H_2O, 33% B-FS

Decay Heating in Maintenance Port Shield Plug

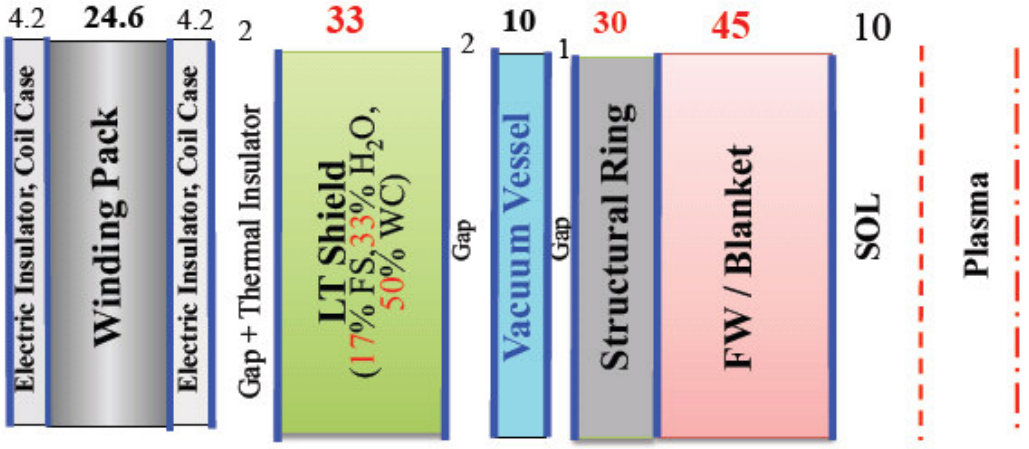
- Majority of outboard region is covered by maintenance port plug shield rather than vacuum vessel / low temperature shield.
- Shield plugs are helium cooled and operate at 300 ºC like the vacuum vessel.





47 cm Thick Shield Plug
at entrance of Maintenance Ports
(22% 3Cr-3WV FS, 73% B-FS, 5% He)

Inboard Radial Build and Decay Heats

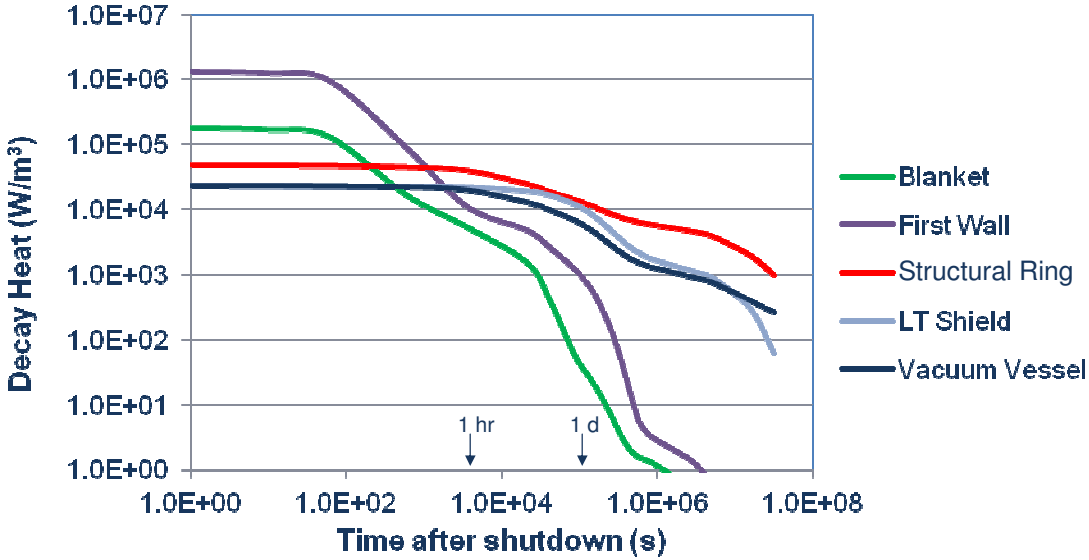


IB Blanket
17% SiC/SiC Composites,
83% LiPb (50% Li-6 enrichment)

IB and OB Structural Rings
80% ODS-FS, 20% He

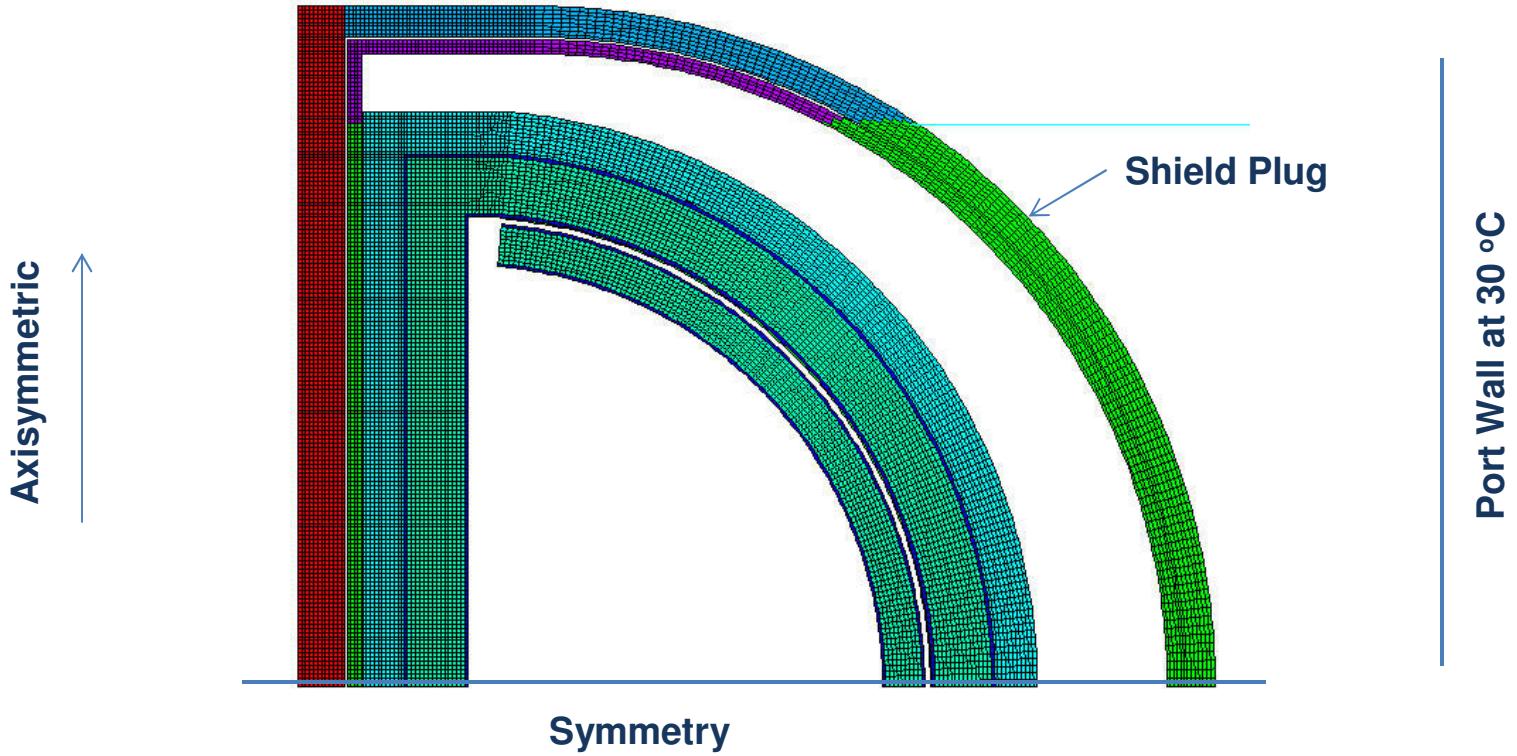
Vacuum Vessel
60% 3Cr-3WV FS, 40% He

IB LT Shield
17% FS, 33% H_2O, 50% WC



FEA Model and Analysis Assumptions

- Plasma heating included for 3 sec. after LOCA.
- Model at present does not include divertors.
- Emissivity of 0.2 assumed for all radiating surfaces in baseline.
- No radiation across plasma channel assumed initially.
- Heat removed by conduction and radiation from shield plug to cryostat and bioshield at 30 C to roughly simulate port area.

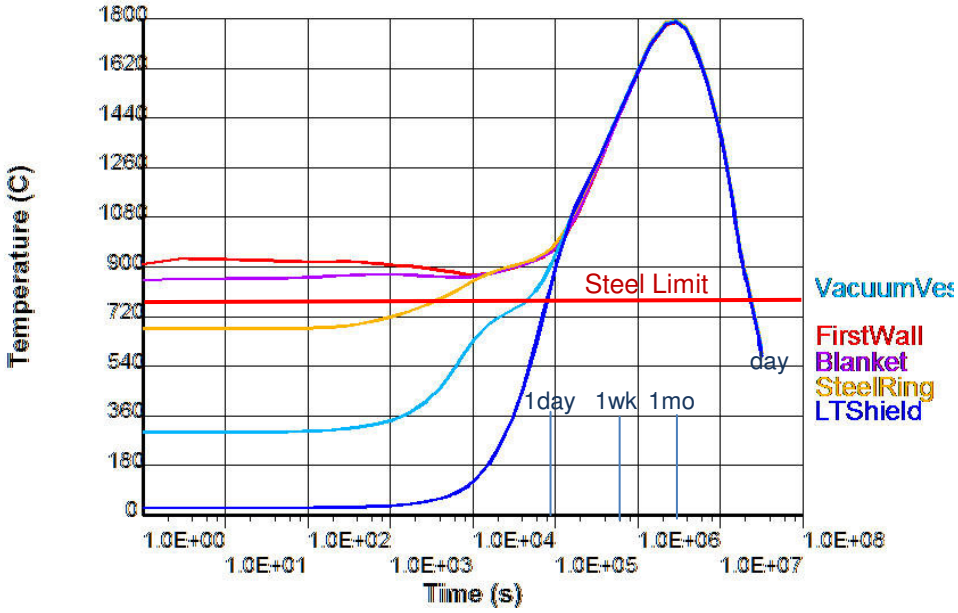


Structural Temperatures after LOCA

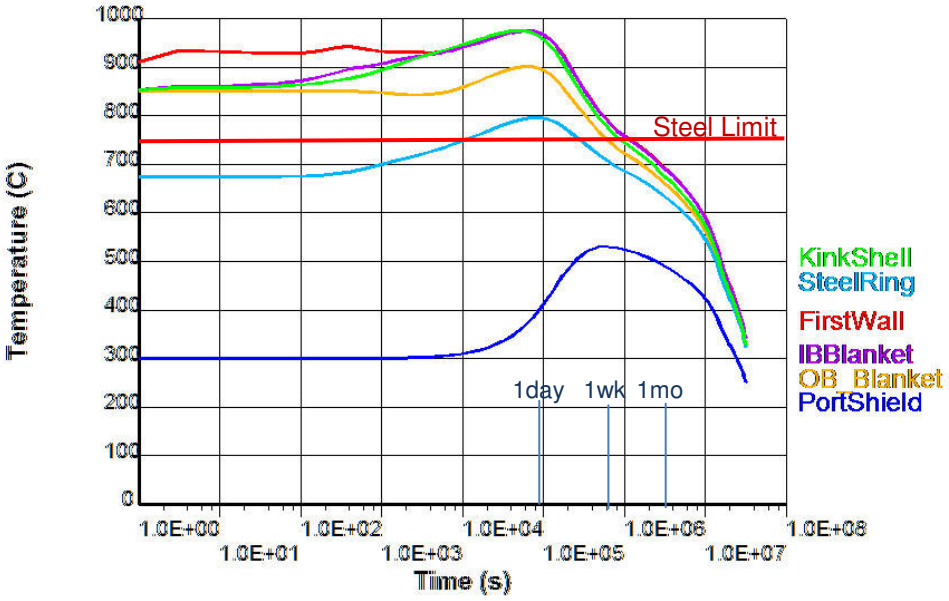
- Steel structures in both inboard and outboard regions exceed reuse limits.
- Inboard temperature peaks occur over much longer time frame (weeks).

Recommended Temperature Limits (per A. Rowcliffe):
750 °C for MF82H and 3Cr-3WV ferritic steels (used in VV and LT shield)
750 °C for ODS FS (used in Structural Ring)

Inboard Temperatures



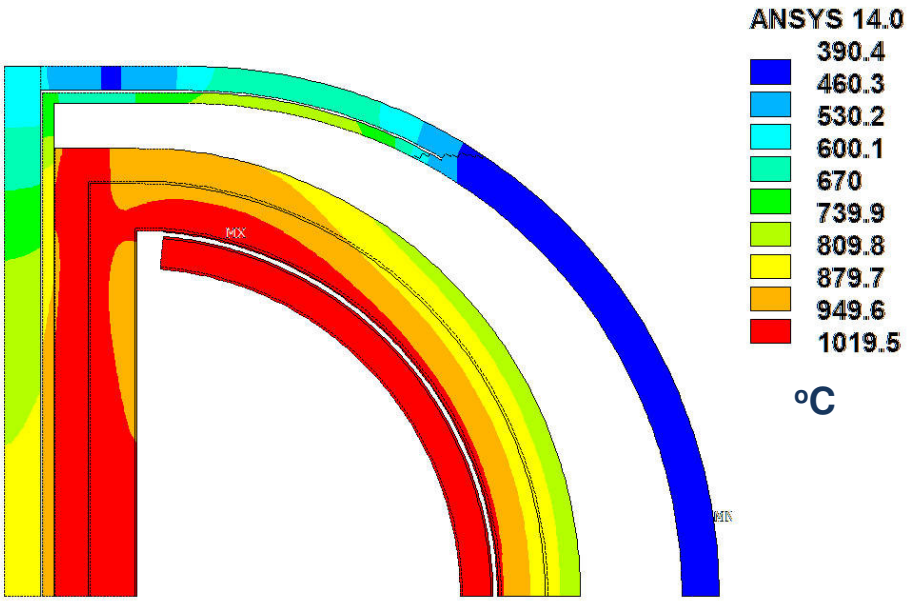
Outboard Temperatures



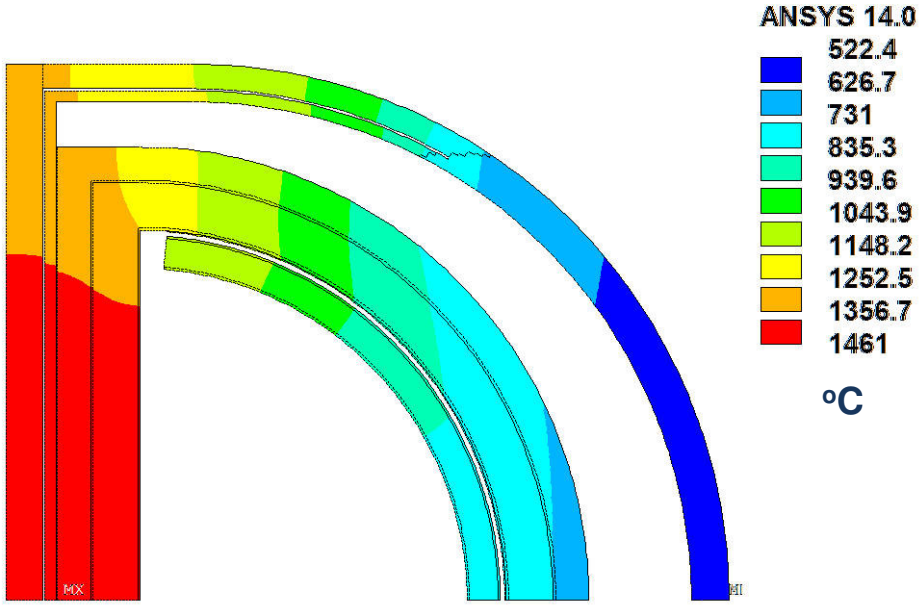
Temperature Distribution Indicates Cross Channel Radiation May be Significant

- At longer time intervals inboard region becomes significantly hotter.
- Radiation across the plasma channel should cool inboard region.

Temperatures After 1 Day

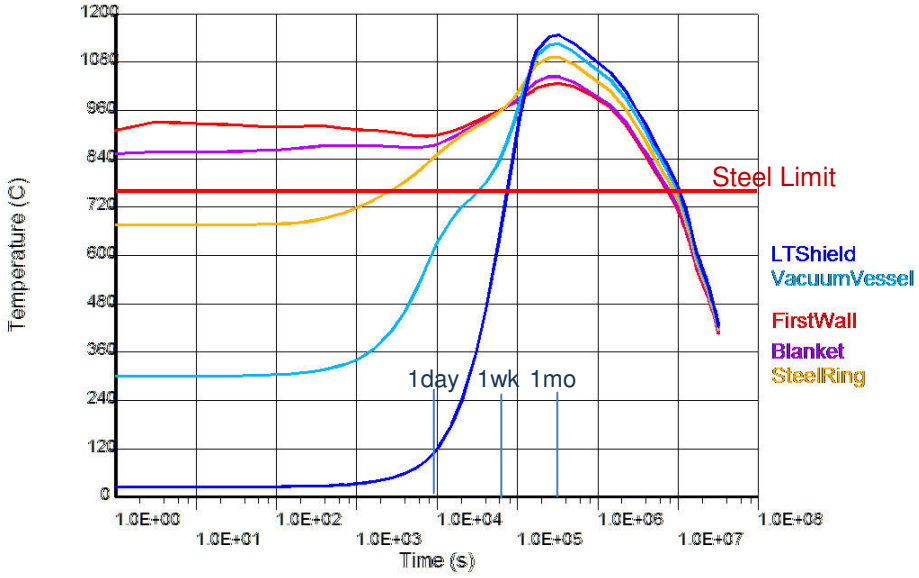


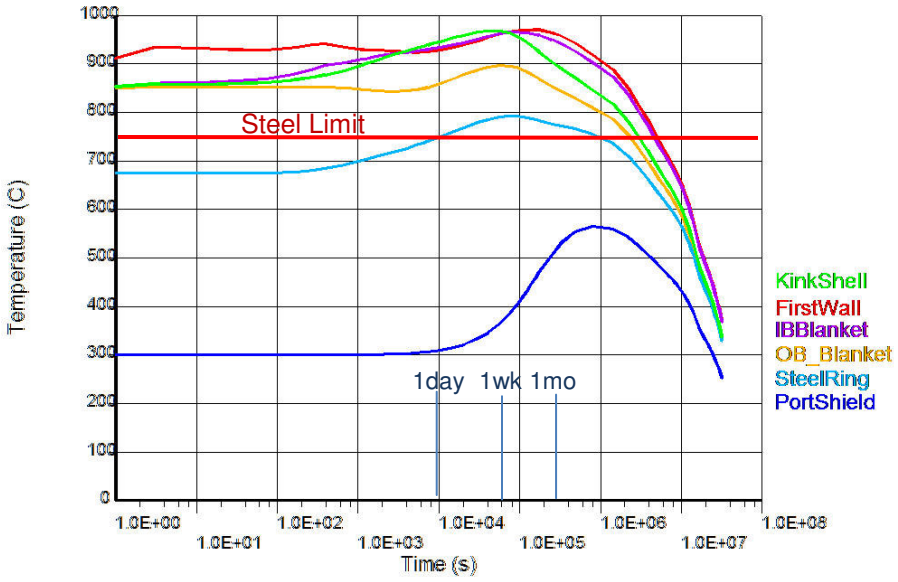
Temperatures After 1 Week



Structural Temperatures after LOCA with Approximate Across Channel Radiation

- Radiation across plasma channel simulated by simply radiating with corresponding cross node. Should underestimate radiation due to surface area mismatch.
- Inboard temperatures are reduced significantly, but both still exceed limits.

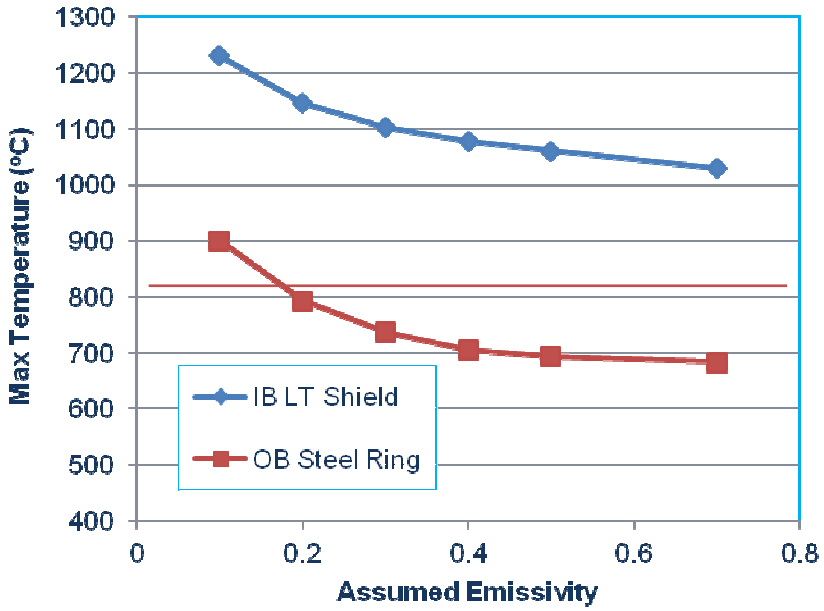




Effect of Assumed Surface Emissivity on Structural Temperatures

- Emissivity of the various structures are difficult to predict as they are dependent on surface finish, oxidation, etc.
- Inboard temperatures remain well above limits even with significantly higher emissivities.

Variation of Maximum Temperatures with Assumed Emissivity



Future Work and Conclusions

- Divertors need to be incorporated in the model.
- Other avenues for heat loss (plumbing, supports, vacuum ports) need to be assessed.
- Initial results indicate loss of water for longer than a few days is unacceptable with inboard VV and LT-shield temperatures exceeding 1000 ^{o}C.
- Can this model be used to assess methods for removing decay heat if this scenario is unacceptable?