Management of Severe Accident Phenomena in the ESBWR Design

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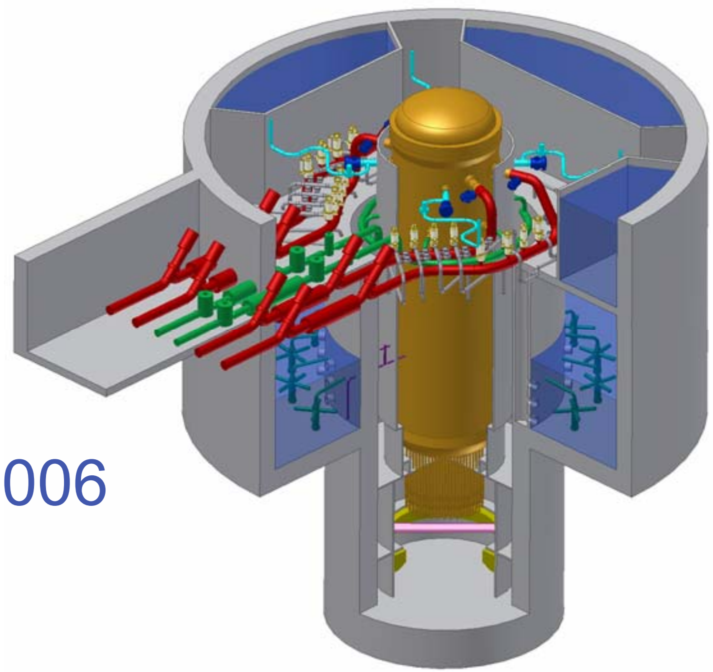

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Treatment of Severe Accidents

Severe Accidents in ESBWR are Remote and Speculative

> Core Damage Frequency □ 10^{-8} per year

> Could be treated as Residual Risk

GE Designs for Defense-In-Depth

> Assessed full complement of severe accident threats

> Determined and Enhanced ESBWR capabilities

Result:
ESBWR Containment Failure is Physically Unreasonable

Severe Accident Threats and Failure Modes Resolved in ESBWR Design

Direct Containment Heating (DCH)

> No energetic failure of upper drywell
> No liner failure in upper drywell
> Fission products contained during potential local failures of lower drywell liner

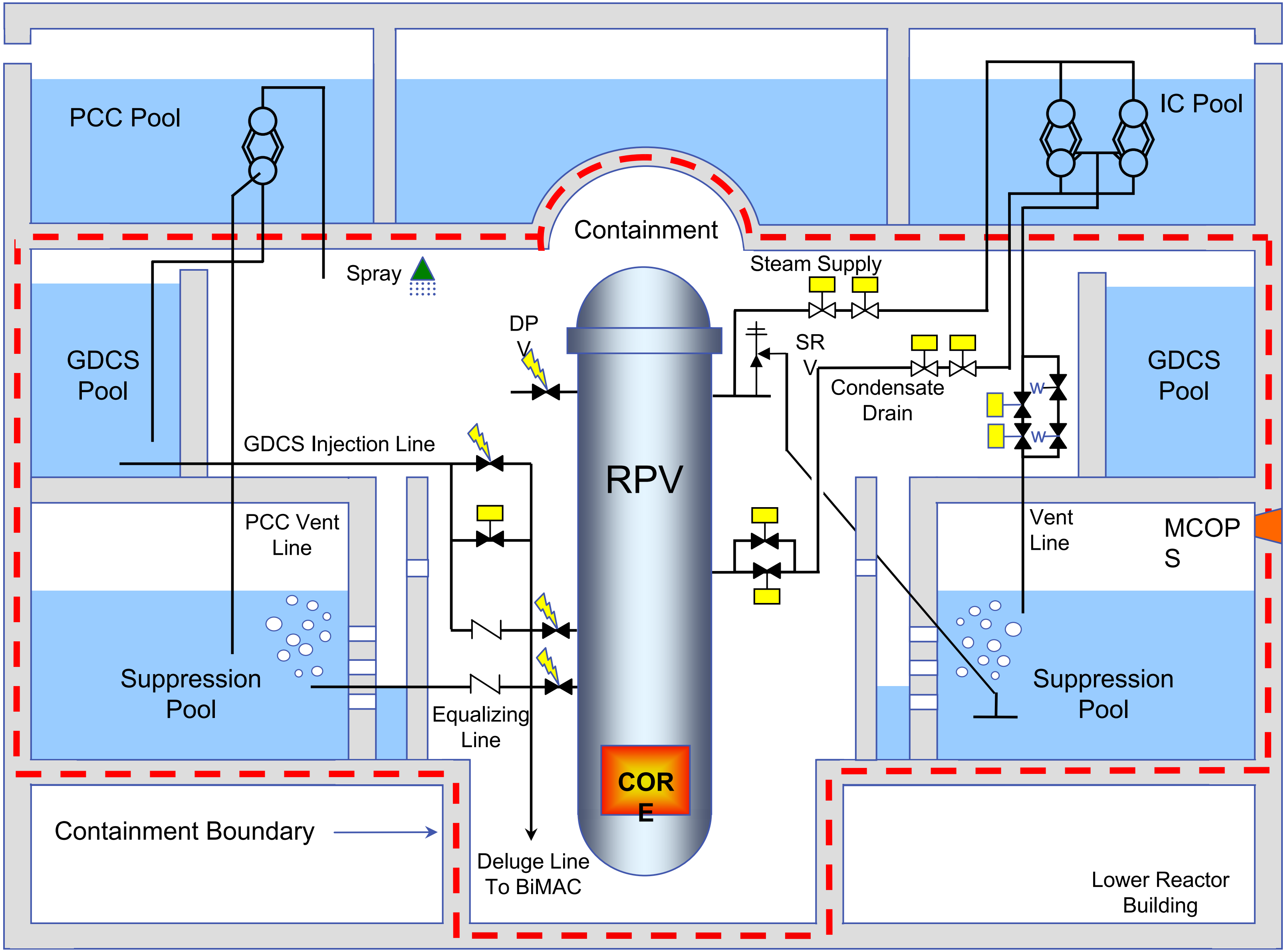
Ex-Vessel Explosions (EVE)

> Pedestal or BiMAC failure can occur only with deep subcooled pools of water in lower drywell
> ESBWR design resists formation of deep pools (~1% of CDF)

Basemat Melt Penetration (BMP)

> BiMAC thermal failure due to burnout, dryout, or penetration is physically unreasonable

ESBWR Containment Highlights



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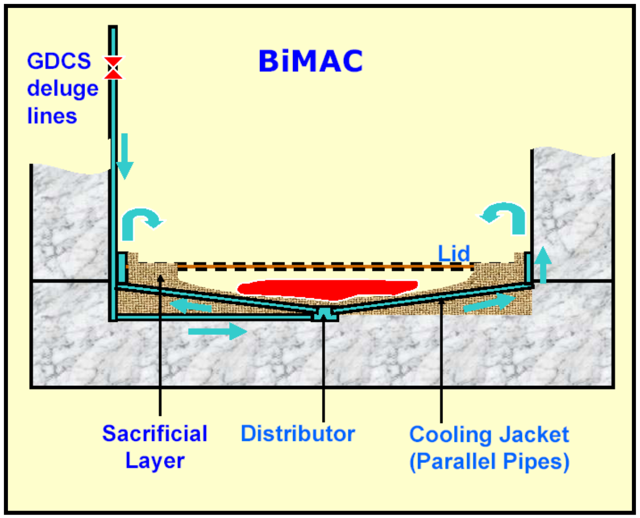
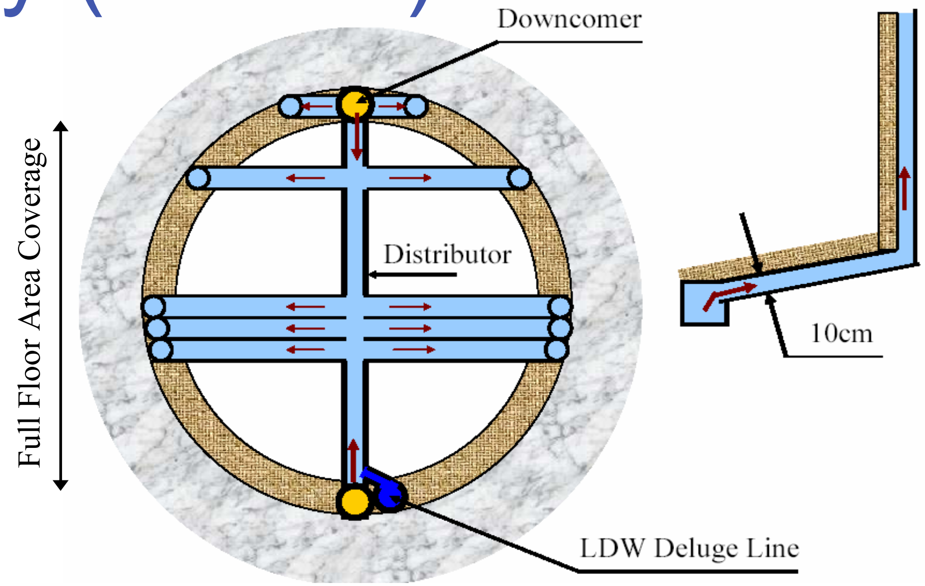
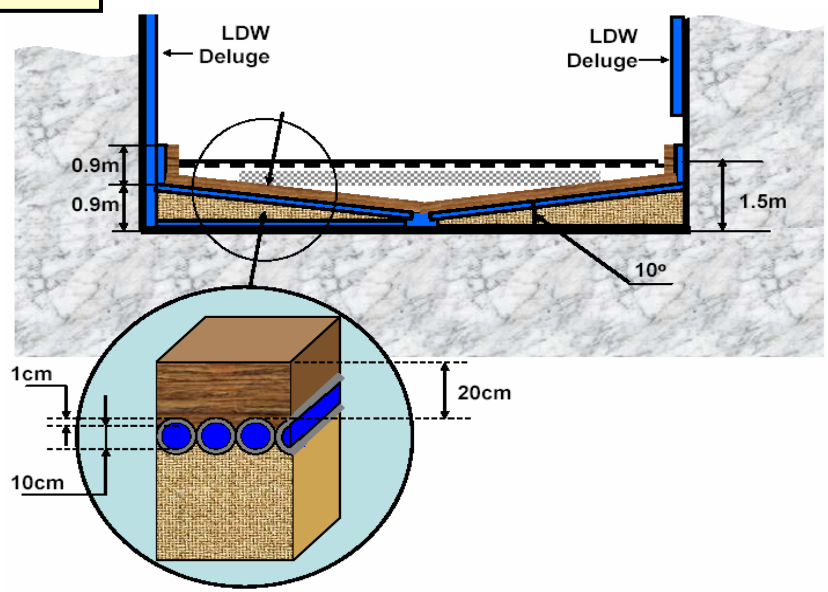
GE Introduces the Basemat internal Melt Arrest and Coolability (BiMAC) Device







Basemat Melt Penetration (BMP)

Assessment of BiMAC Thermal Failure due to Burnout or Dryout

Key Bounding Ingredients:

> Average thermal loads from full-core pools at bounding decay power levels

> Bounding local peaking of loads from verified CFD calculations

> Lower bounds of CHF from ULPU pool boiling experiments

> No flow-stability, or boil-off issues, found using a two-phase flow model that was verified using inclined-channel data from the SULTAN experiments

> Full floor area coverage—the melt has no other place to go but inside the BiMAC.

> Confirmatory full scale BiMAC tests during COL stage

BiMAC Thermal Failure is Physically Unreasonable

Average Thermal Loads and Peaking Factors

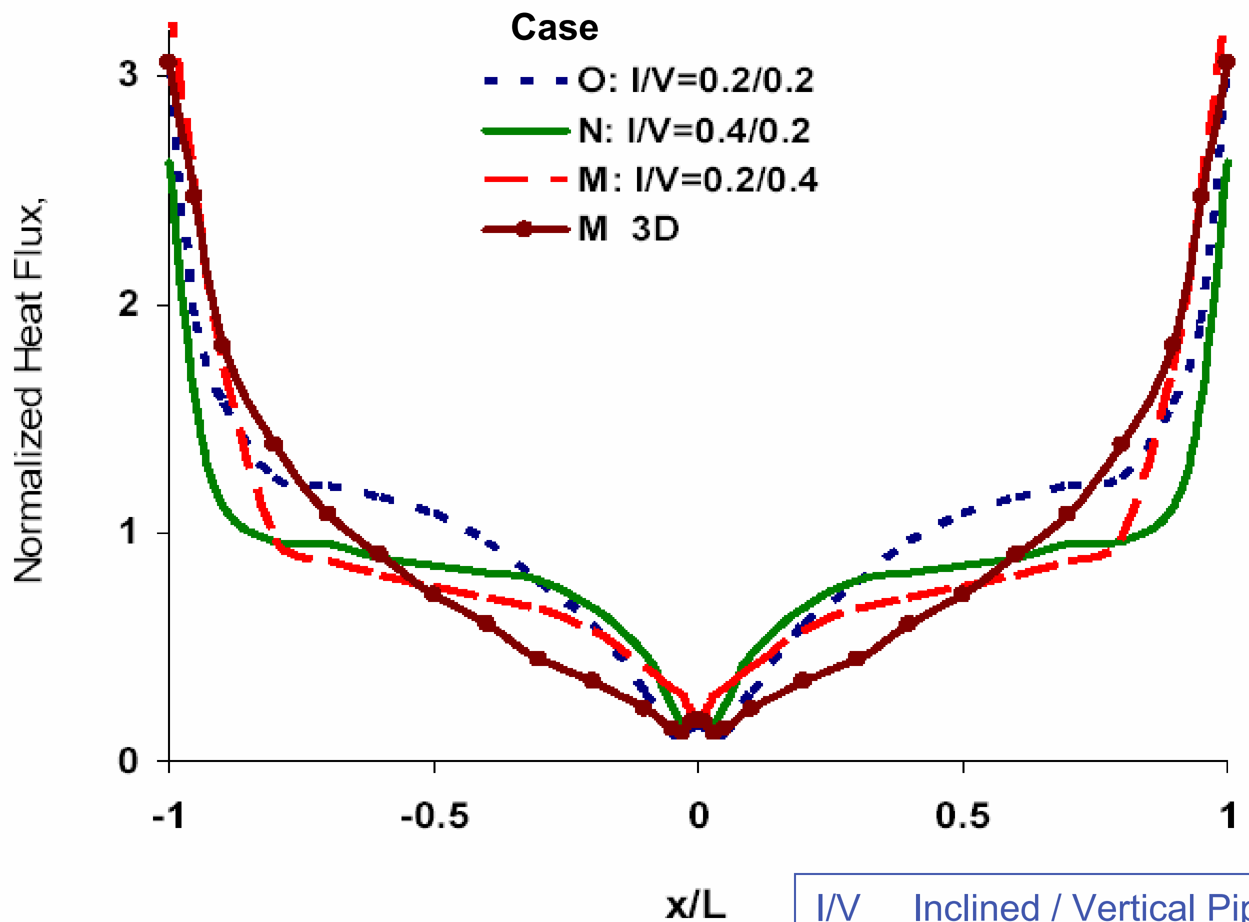
BiMAC Thermal Capacity a Function of Melt Pool Height and Resulting Average Heat Fluxes

- 100% core decay power at ~6 hr into the accident
- Bounding scenarios
  - ≤ 100 kW/m2 downward heat flux
  - ≤ 350 kW/m2 sideward heat flux

Power Split and Peaking Factors from Direct Numerical Simulations

- Downward peaking: 3.0
- Sideward Peaking: 1.4

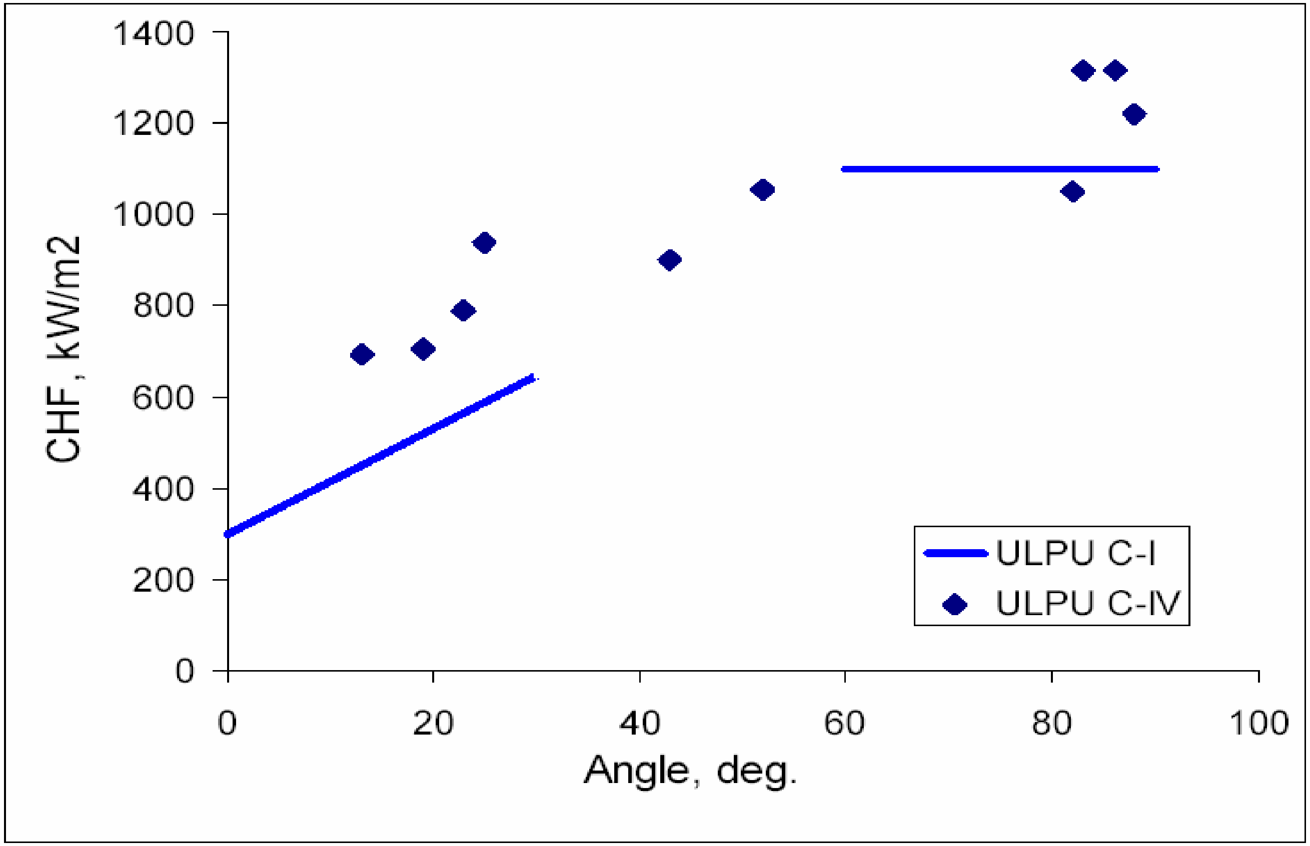
The Peaking at the Edge of Near-Edge Channels is the most Limiting



I/V	Inclined / Vertical Pipe Length Ratio
3D	Simulation

Coolability Limits for BiMAC

Applicability based on similarity of geometries and flow/heating regimes



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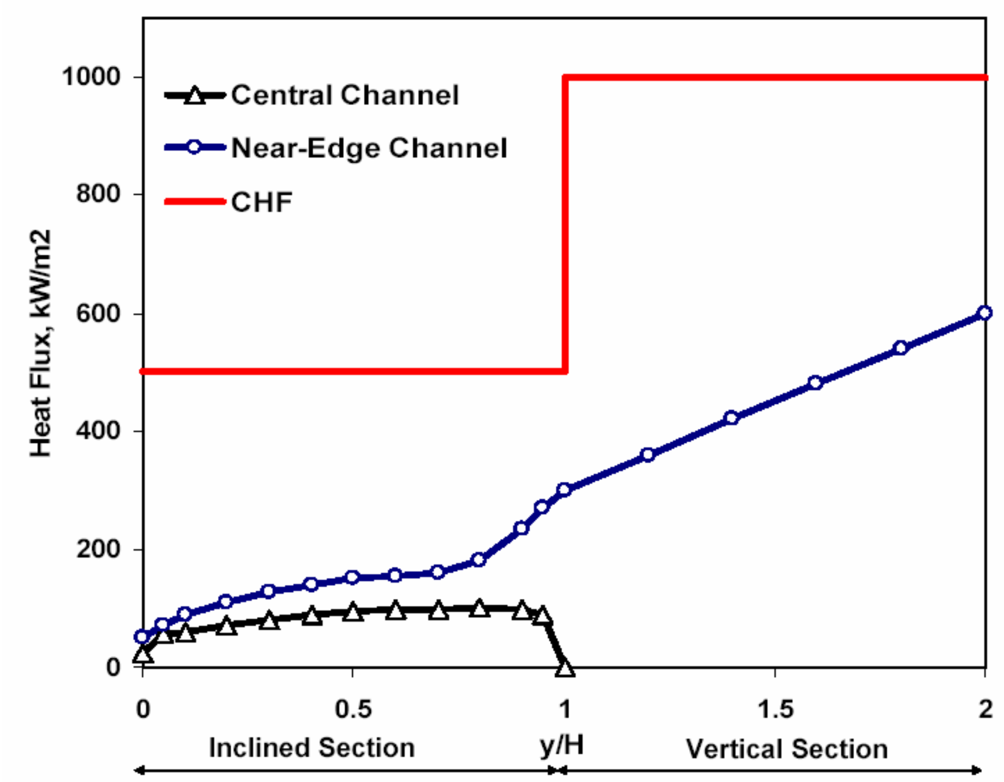
Thermal Loads vs Coolability Limits in BiMAC Channels



- ❖ Based on ULPU data
- ❖ Margins to be verified by new experiments at full scale

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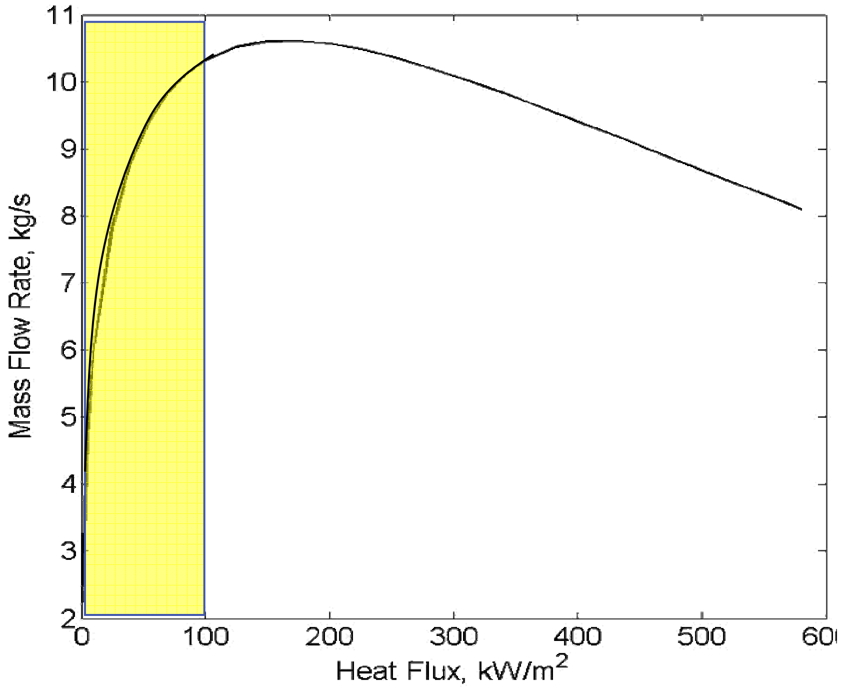
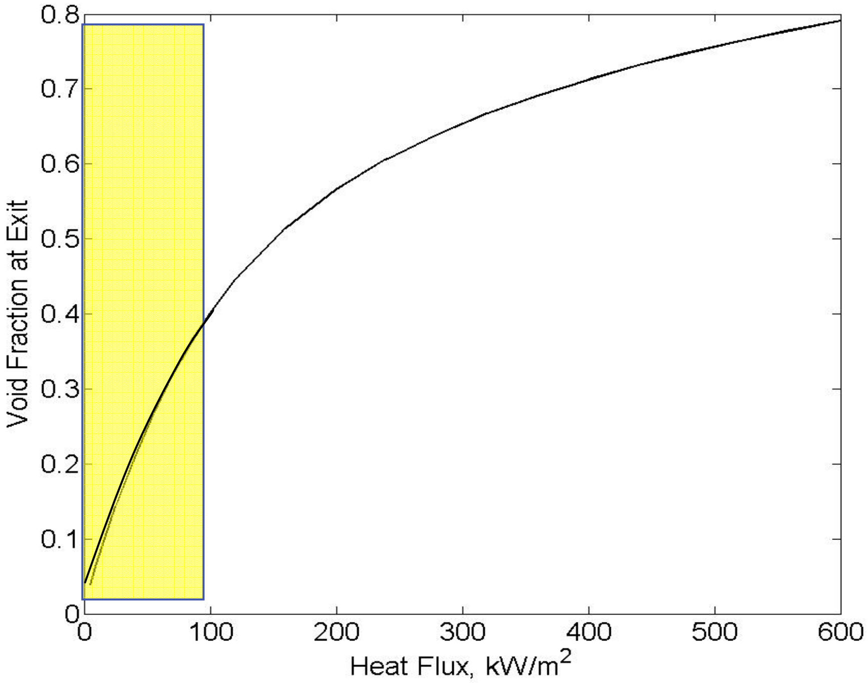
BiMAC Operating Range

Natural Convection in BiMAC



Thermal Margins for BiMAC



No Flow Instability

No Danger of Dryout

- Operating range to be optimized through new experiments at full scale

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- Determined and Enhanced ESBWR capabilities
- Verified by a full ROAAM treatment

NEDO-33201 Section 21 Contains Complete Details of these Analyses