APEX TASK IV
SOME ASPECTS OF THE EVOLVE TRAYS' CONFIGURATION

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Subjects Covered

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- **Evaluation of tray design using the first wall tubes as part of the Li containment in the trays (integrated design)**
- **Evaluation of tray design using a separate wall, independent of first wall tubes, to contain the Li in the trays (separated design)**
- **Trade study and recommendation**
- **Vapor fraction in the trays as a function of tray height**
- **Issues of newly proposed transpiration blanket**
- **Possible construction for transpiration panels**

Integrated First Wall and Trays

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In this design the FW tubes constitute the front and side surfaces of the trays to provide the Li barrier in the trays. Thus, the front edge of the tray bottom is welded across the 3 m length to the back of one of the FW tubes while the sides of the tray bottom are welded to the 70 cm sides of the FW tubes which lead to the front edge facing the plasma. The 70 cm sides of the FW tubes are not subjected to surface heating because they are hidden.

- **To help support the tray (OB tray is 3 m long), five reinforcing ribs are placed radially at 50 cm spaces, and are tack welded to the FW, tray bottom, the bottom of the tray above and back wall of the vapor manifold.**

- **None of these welds need to be leak tight with the possible exception of the last tray in any vertical column.**

Top View of EVOLVE Tray Showing Placement of Reinforcing Ribs

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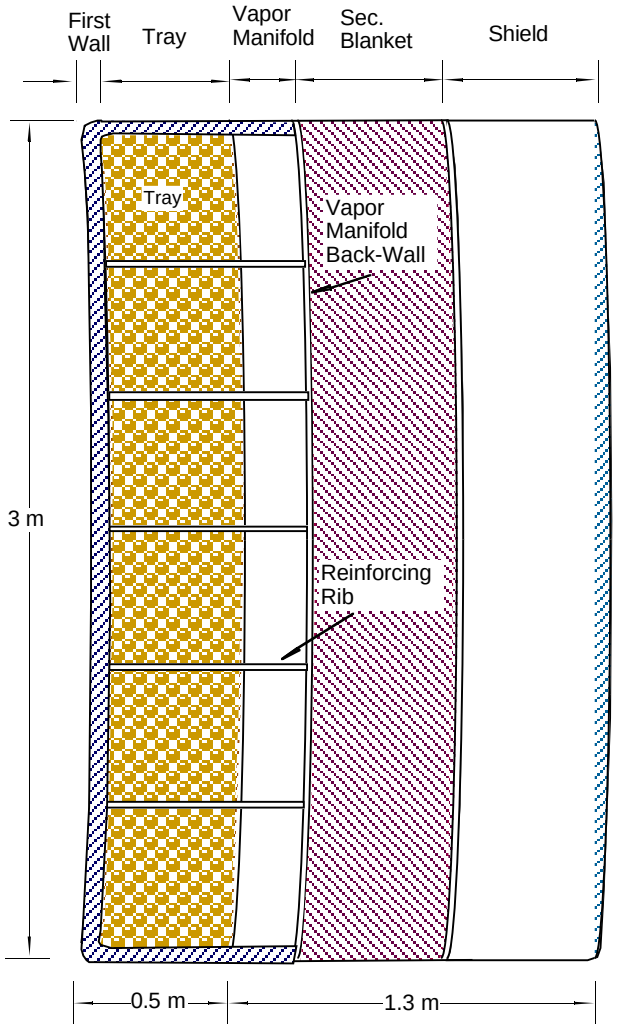

Reinforcing ribs shown attached to the FW tubes spaced every 50 cm

Side View of Several Trays Showing Attachment of Reinforcing Ribs

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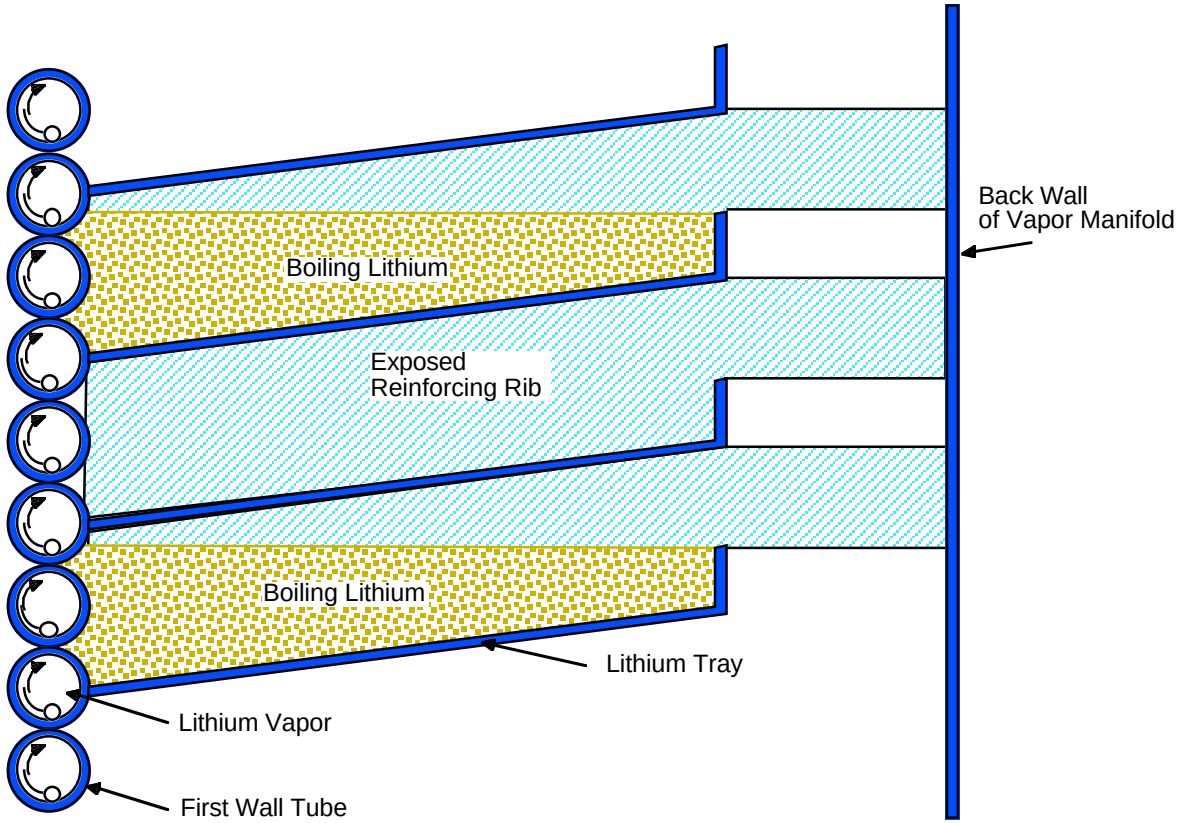

Middle tray is shown without Li, to expose a typical reinforcing rib. The rib is tack welded to the FW tubes, the bottom of the exposed tray, to the tray immediately above, and to the back of the vapor manifold.

Issues of EVOLVE Integrated FW/Tray Design

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- **Welding of the tray front to the FW tubes is not desirable**
  - **Heat affected zone of the weld is a vulnerable area for stress concentration and possible crack initiation.**
  - **Vigorous boiling in the trays will set up vibrations which may fatigue the weld zone and initiate failure in the W material which is brittle to begin with.**

What are the consequences of a tube failure?

- **Effect of a small crack in the backside of a FW tube:**
  - **Vapor pressure in the FW tube will be higher than in the tray zone, so no major problem would be expected.**
- **Effect of a large crack in the back-side of a FW tube:**
  - **A large quantity of Li entering a FW tube will disrupt the heat pipe operation and render it inoperative.**
  - **Any hot spot on the FW will lead to further failures possible breeching the vacuum barrier and quenching the plasma.**

Issues of EVOLVE Integrated FW/Tray Design (contd.)

- **Attachment of tray side-walls:**
  - **The trays have a sloping orientation from the back to the front (towards the FW). The side-wall tubes feeding the FW tubes are oriented horizontally. Welding a sloping surface to a horizontal bank of straight tubes will be very difficult.**

- **Construction of the FW itself, where tube surface to tube surface hermetic (vacuum barrier) welding is required is very challenging, if at all possible.**

- **The physical attachment of the trays to the FW will be a major problem due to space limitation of tight quarters.**

Is There a Solution?

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- **To avoid welding to the FW tubes on the front or side walls, provide a separate continuous top to bottom front and side wall to contain and support the trays independently from the FW.**
  - **Avoids welding to the FW and compromising its structural integrity.**
  - **Avoids welding the side walls to the FW radial feed tubes obviating the problem of the slanted tray.**
  - **The trays and their support walls are constructed separately from the FW and then assembled together.**

What are the Issues of the EVOLVE Separated FW/Tray design?

- **Construction of the FW is still an issue**
- **Cooling of the separate wall needs to be addressed**
- **Additional W material in the separate walls adds to the afterheat and to waste disposal**

Top View of EVOLVE Tray with a Separate Wall

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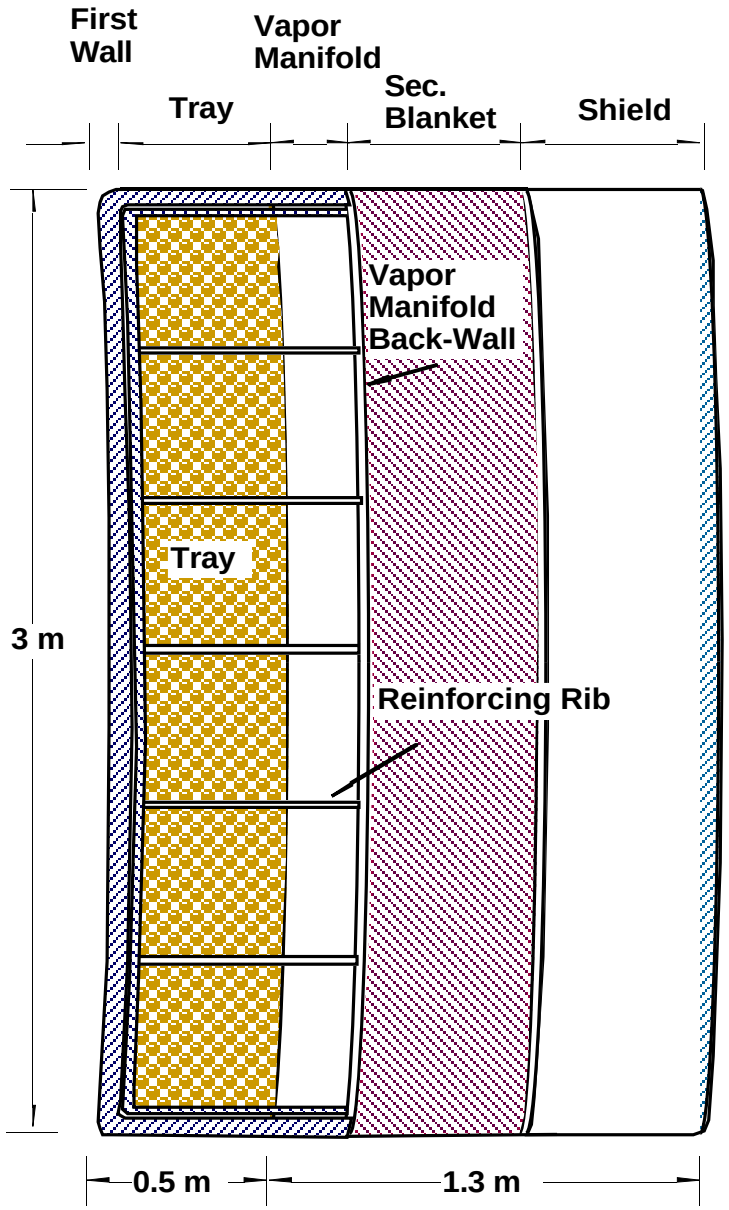

Side View of Several Trays with Separate Wall, Using No Attachment to First Wall Tubes

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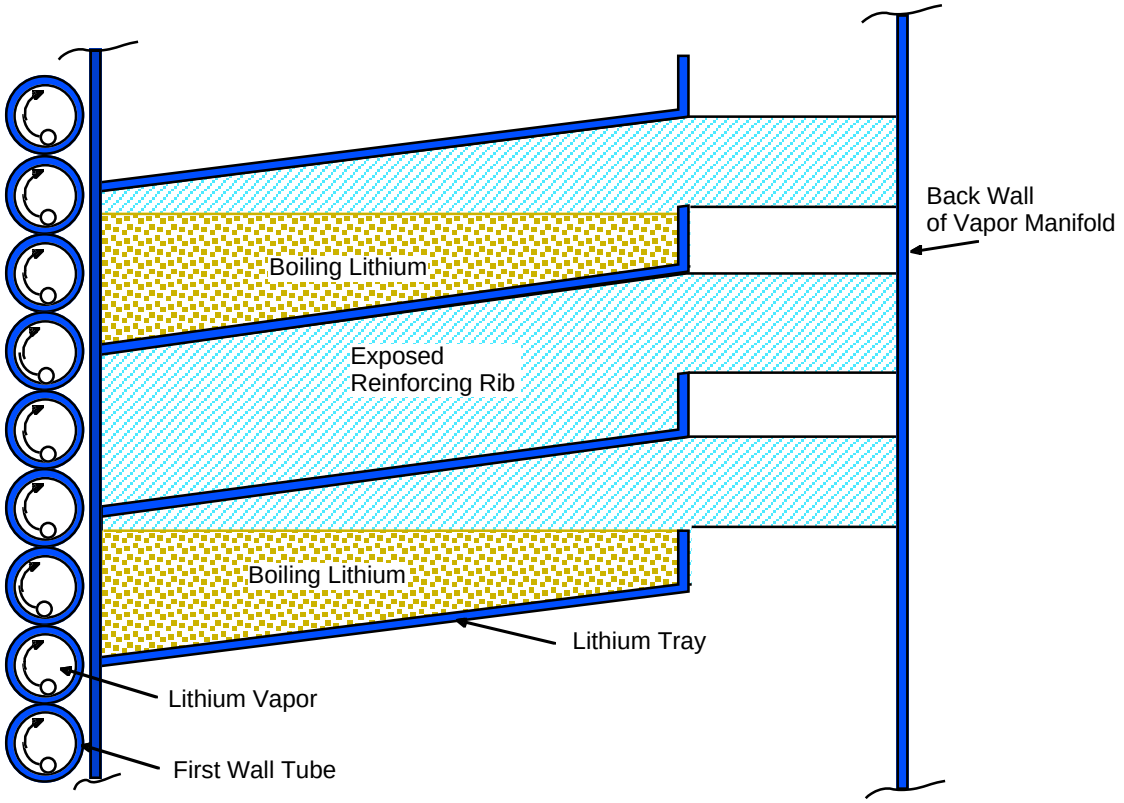

Middle tray is shown without Li, to expose a typical reinforcing rib. The rib is welded to the separate front wall, the bottom of the exposed tray, the tray above and the back wall of the vapor manifold.

Trade Study

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	Masses/Tray (3 m long, 16 cm high) (kg)	Volume Fraction per Tray (%)	Cooling	T_2 Breeding	Failure Mode
Integrated FW/tray design	W = 282 Li = 120 Total = 402	W = 5.0 Li = 80 Void = 15	All components adequately cooled	Adequate breeding	Heat affected zone in welds and impact of vibrations leading to cracks in FW
Separated FW/tray design Option 2	W = 366 Li = 120 Total = 486	W = 6.3 Li = 79.0 Void = 14.7	Need to investigate separate wall cooling. Might need to cool the back side of FW tubes same as front side.	Adequate Breeding	No impact from trays on FW.

One Possible Way to Construct a Transpiration Panel

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- **Start with a 1–1.5 mm thick W sheet perforated with a close packed pinhole array.**

- **Cover the transpiration side with a fine W wool attached to the perforated sheet with fine spot welds or intermittent plasma fusion spots between perforations.**

- **The W wool should provide opacity to prevent direct leakage or drippage from the panel surfaces.**

- **Attachment of panels will be by welding the perforated sheets together providing adequate structure to support itself and the Li liquid.**

Issues of the EVOLVE Transpiration Cooled Blanket Concept

- **Transpiration panels' design, construction, shaping and joining will be a major issue.**

- **A transpiration cooling panel must have:**
  - **Controlled seepage to provide a wetted surface on the evaporating side and bulk liquid on the other.**
  - **It should not leak excessively as to drip.**
  - **The panels must be capable of being joined panel to panel, in end to surface joints and butt joints.**
  - **The unit must be stiff and strong enough to support the weight of the fluid and be capable of resisting vibration forces.**
  - **The transpiration surfaces should provide adequate cooling to avoid boiling in the bulk Li containers.**

- **The general physical construction and assembly of this blanket almost entirely made of transpiration panels including attachments to the FW would be very difficult to achieve.**

Possible Transpiration Panel Design

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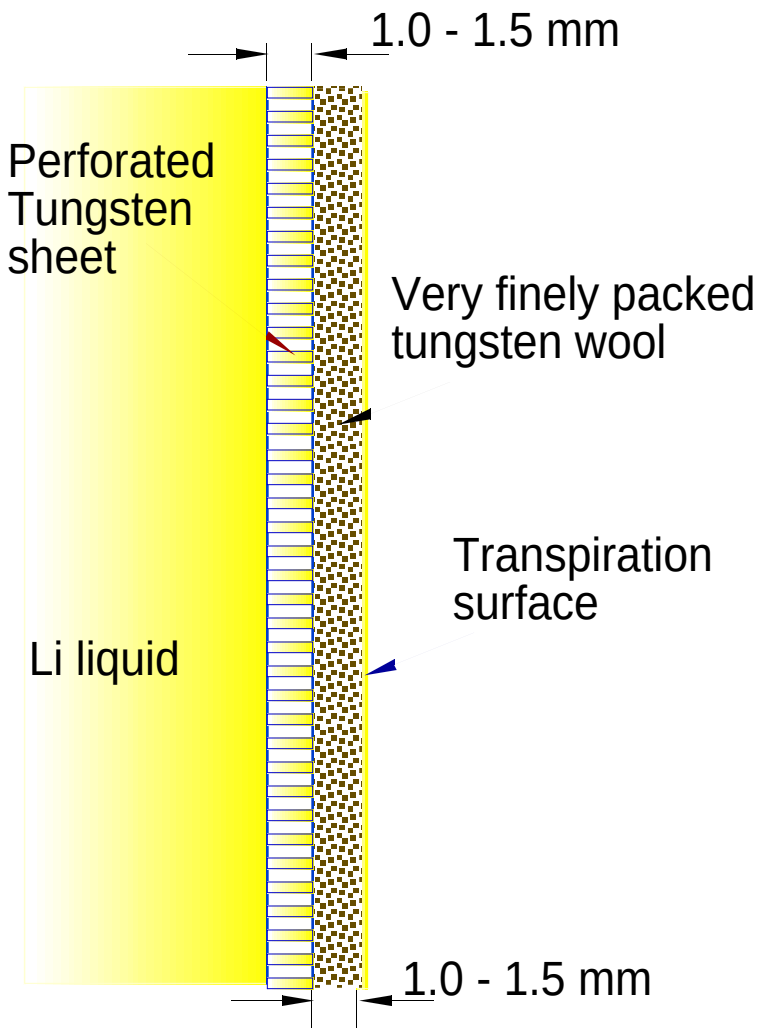

- Welding between perforated sheets
- Attachment of W-wool by :
  - Spot welding
  - Plasma welding
  - Spot brazing

Reducing the height of the tray does not decrease the void fraction

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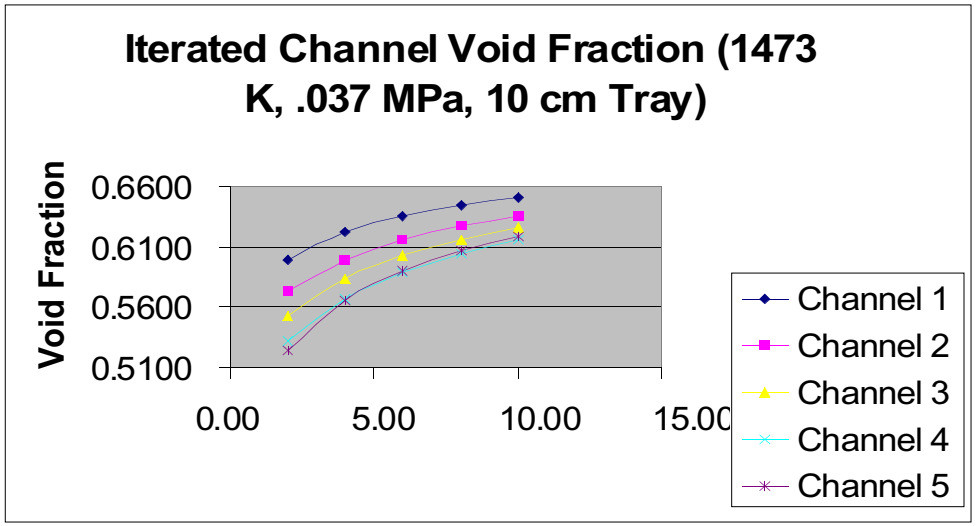

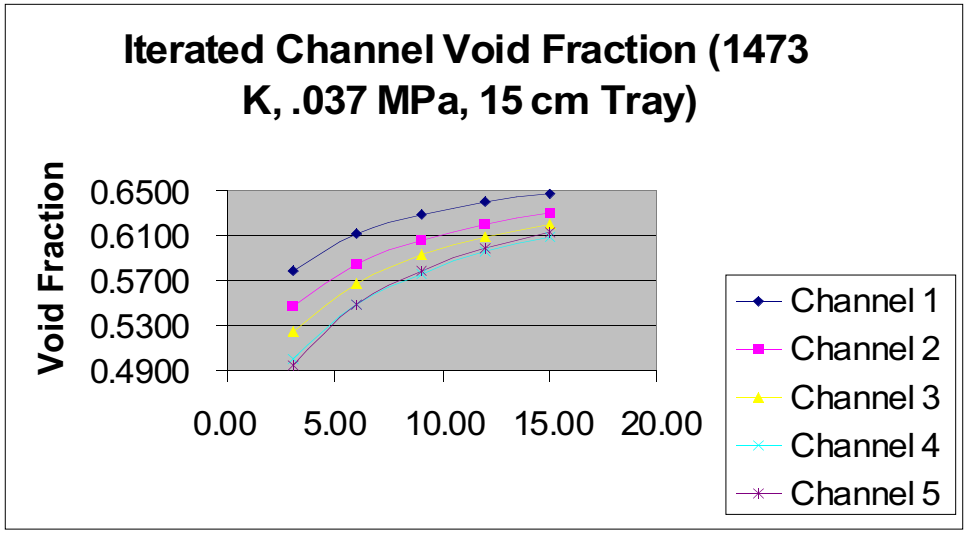

EVOLVE Tray Design Recommendation

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Transpiration blanket not considered.

- **The separated FW/tray design is favored over the integrated FW/tray design**
  - **No impact on the FW**
  - **Breeding not affected**
  - **Easier assembly**

Downside

- **30% more W structure in the trays (FW excluded) – more afterheat and radwaste**
- **Cooling of additional structures must be evaluated**