APEX TASK IV
SOME ASPECTS OF THE EVOLVE TRAYS' CONFIGURATION

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APEX Web Conference
March 24, 2000

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)**

- **Draining the trays during downtime**

- **Issue of decreasing vapor fraction in the trays**

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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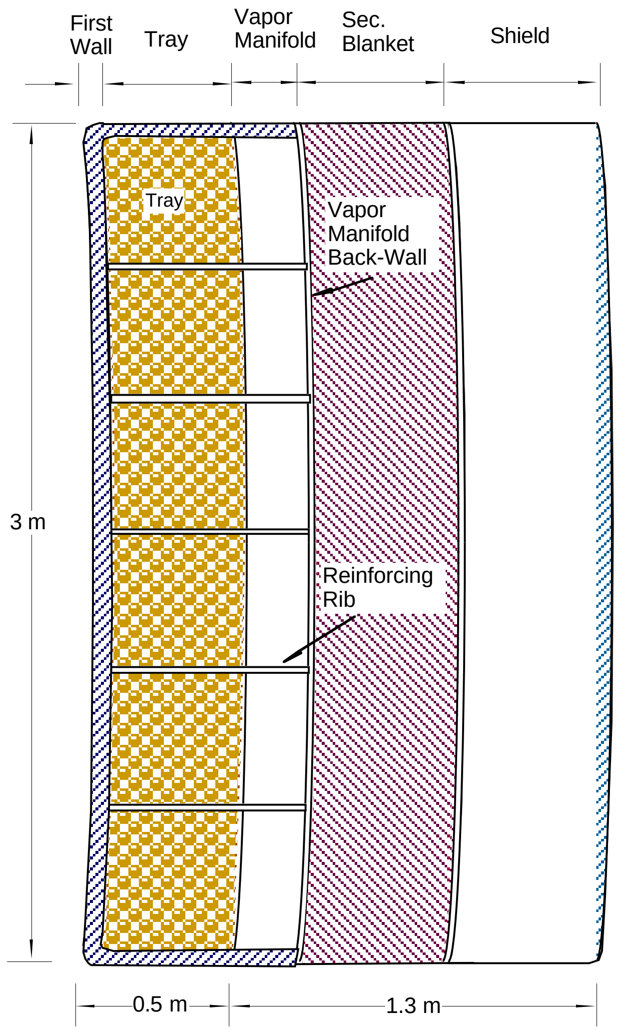

Reinforcing ribs shown attached to the FW tubes
spaced every 50 cm

Side View of Several Trays Showing Attachment of Reinforcing Ribs

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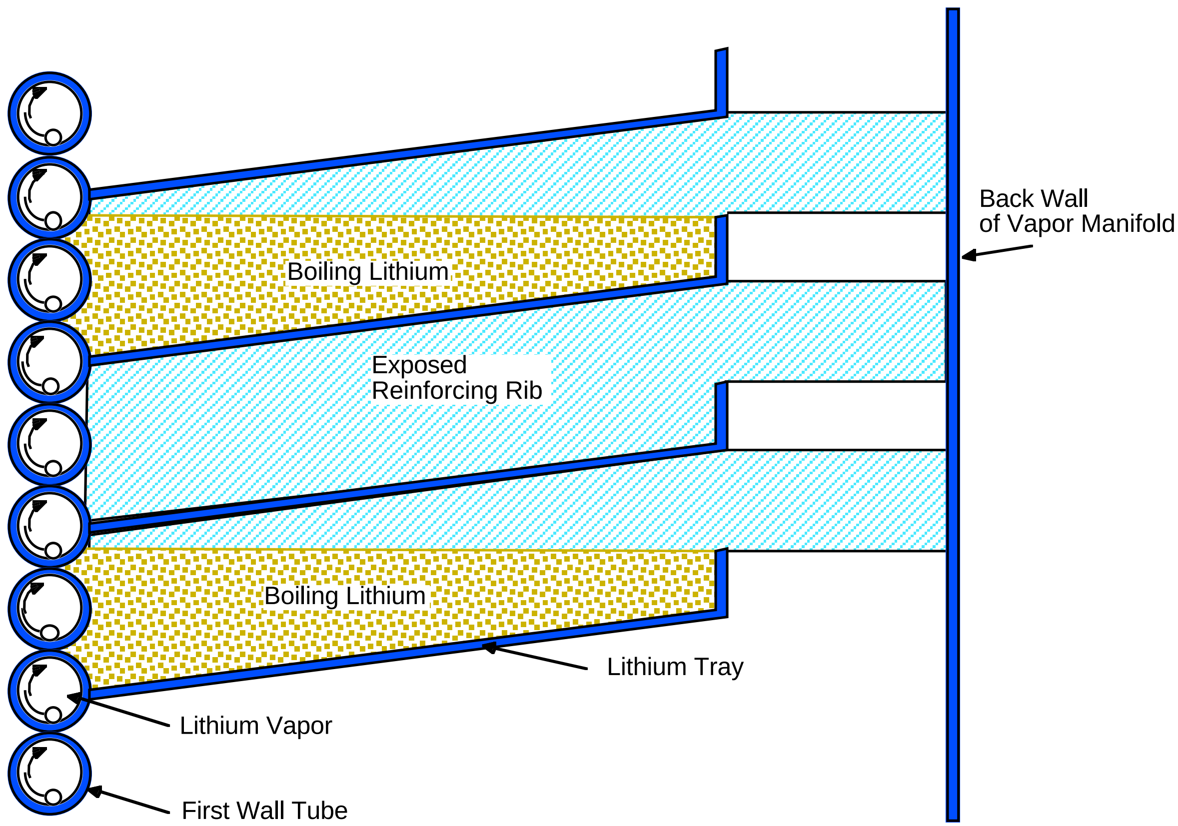

Middle tray is shown without Li, to expose a typical reinforcing rib. The rib is tack welded to the FW tubes, the bottom of the exposed tray, to the tray immediately above, and to the back of the vapor manifold.

Issues with the Integrated Design

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

What is the effect of a FW tube failure?

- **Effect of a small crack in the FW**
  - **Vapor pressure in the FW tube will be higher than in the tray area, so no major problem would be expected**

- **Effect of a large crack in the FW**
  - **A large quantity of Li entering a FW tube will disrupt the heat pipe operation and render the tube ineffective**
  - **Tube overheating may lead to further failures possibly breeching the vacuum barrier, which is the FW**

Is There a Solution?

Several possible improvements have been considered:

1) **Provide a separate front to the tray and attach to the FW by means of swivels incapable of applying a torque on the FW.**

2) **Provide a separate front to the trays on the side FW tubes out of the view of the plasma. Here the tube walls can be made thicker.**

Option 1- Still requires welding to the FW and vibrations will still be felt on the FW tubes, but not as much as in the original design.

Option 2- Avoids all welding to the FW, thus removing the primary concern. The separate front wall will be cooled by conduction and by vapor from the trays. Vibrations need to be evaluated as to frequency and impact on the FW side wall tubes, which can be made thicker.

Option 2 is preferable to Option 1.

Top View of EVOLVE Tray with a Separate Front Wall

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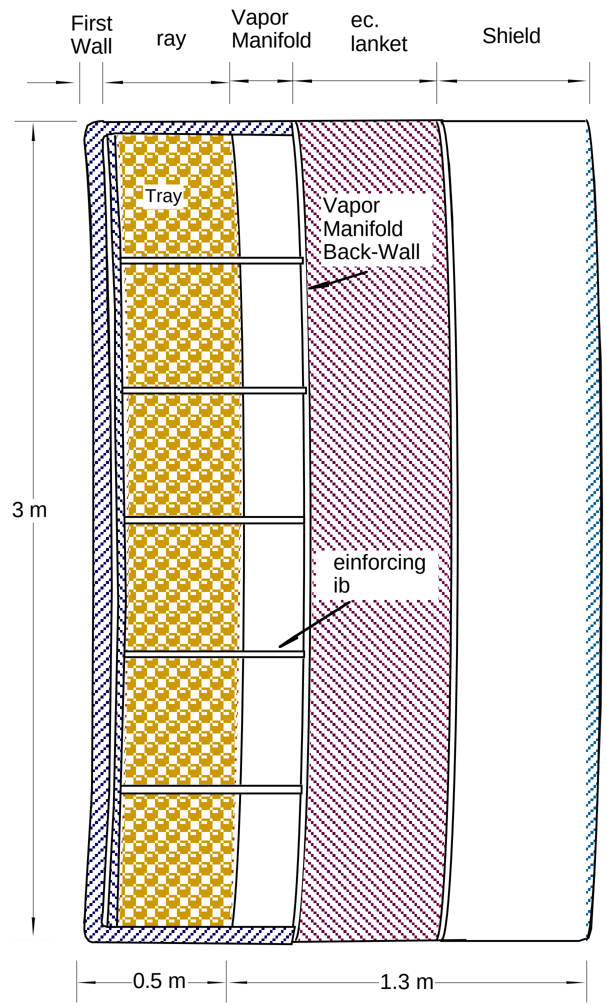

Reinforcing ribs shown attached to the front wall of the trays, spaced every 50 cm. The trays are welded to the first wall sides.

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

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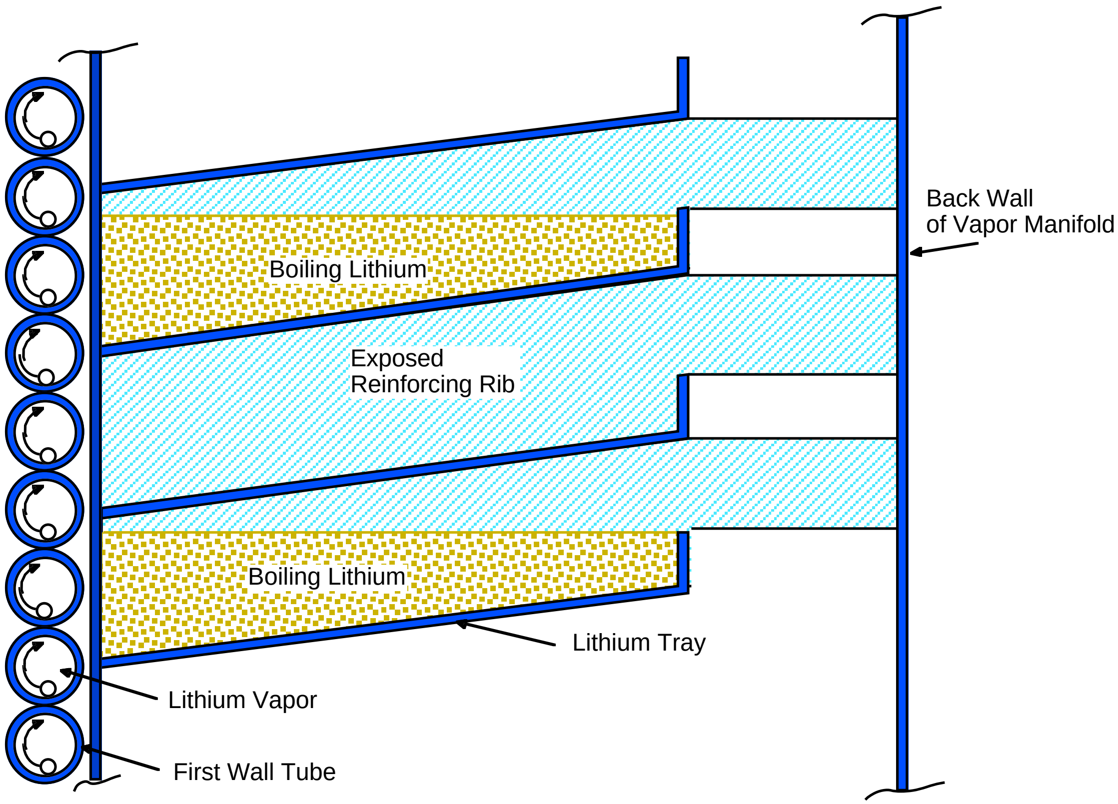

Middle tray is shown without Li, to expose a typical reinforcing rib. The rib is welded to the separate front wall, the bottom of the exposed tray, the tray above and the back wall of the vapor manifold.

Trade Study

	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 = 345 Li = 120 Total = 465**	**W = 6.1 Li = 79.1 Void = 14.8**	**Need to investigate separate wall cooling. Might need to cool the back side of FW tubes same as front side.**	**Need to investigate impact of separate wall on T_2 breeding.**	**Similar effect on side FW tubes. However, these tubes can be made thicker and they do not face the plasma.**

Draining the Trays

- **Controlled draining of the Li from the trays is desirable when the power plant is shut down.**

- **This can be accomplished by making small weep holes in the bottom of the trays at the deep (front) end. The Li will slowly drain from one tray to the next and finally have a return line to the storage tank from the last tray in the column.**

- **The rate of seepage can be controlled to aid in the absorption of afterheat from the W.**

Vapor Fraction in Li

- It has been suggested that the vapor fraction in the trays can be reduced by using trays that are shorter in height and stacked more closely.

- However, in an example which compared a 15 cm deep tray with a 10 cm tray, it was discovered that the vapor fraction did not change, and actually increased slightly.

- In the shorter tray the nuclear heating is lower. The experimentally determined coefficient C in the drift flux model is also dependent on the tray depth, decreasing with depth. The combination of these values in the drift flux model essentially leaves the vapor fraction unchanged.