UT-BATTELLE

High Power Hg Target Conceptual Design Review

Hg Jet Nozzle Analysis

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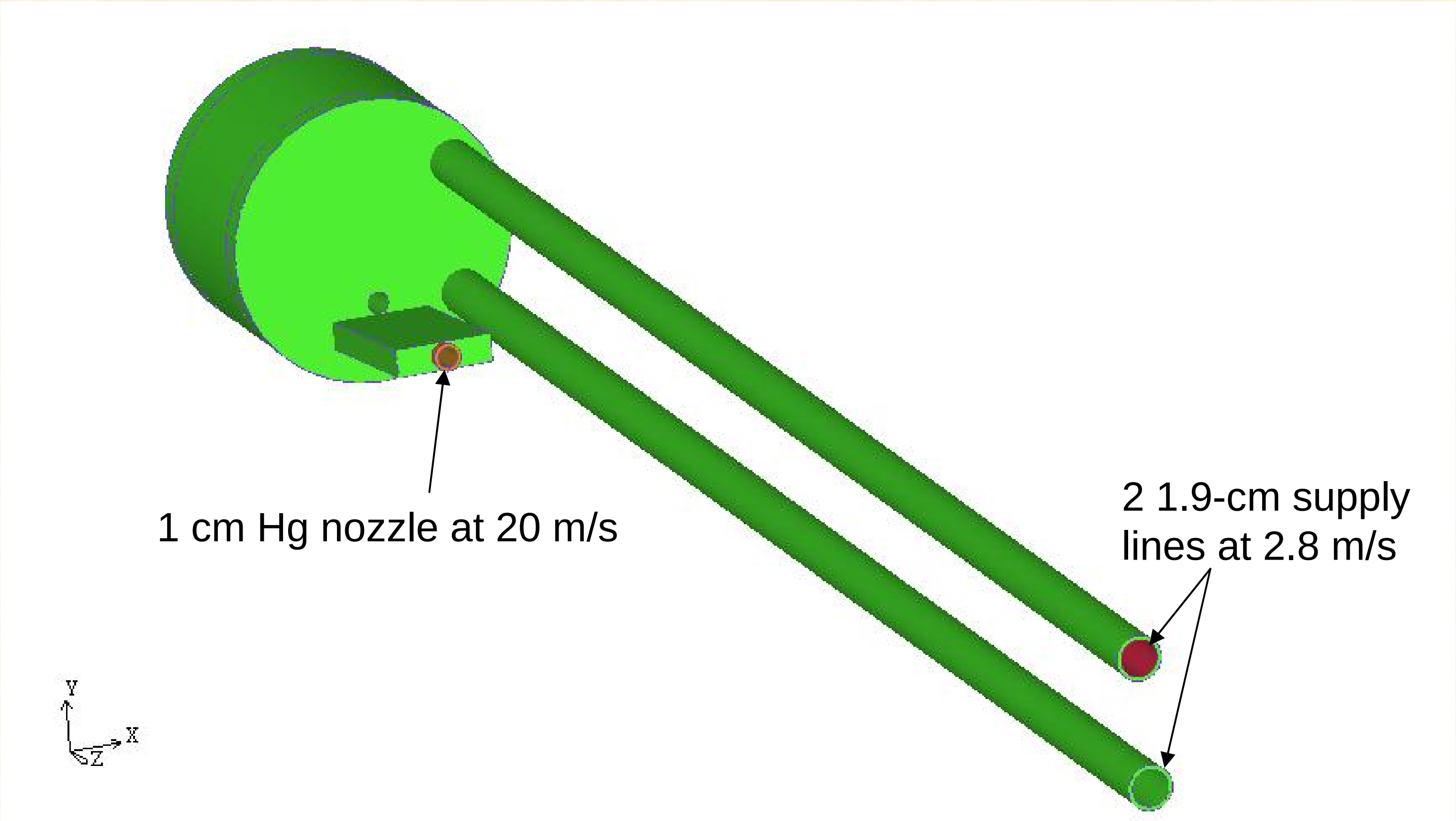
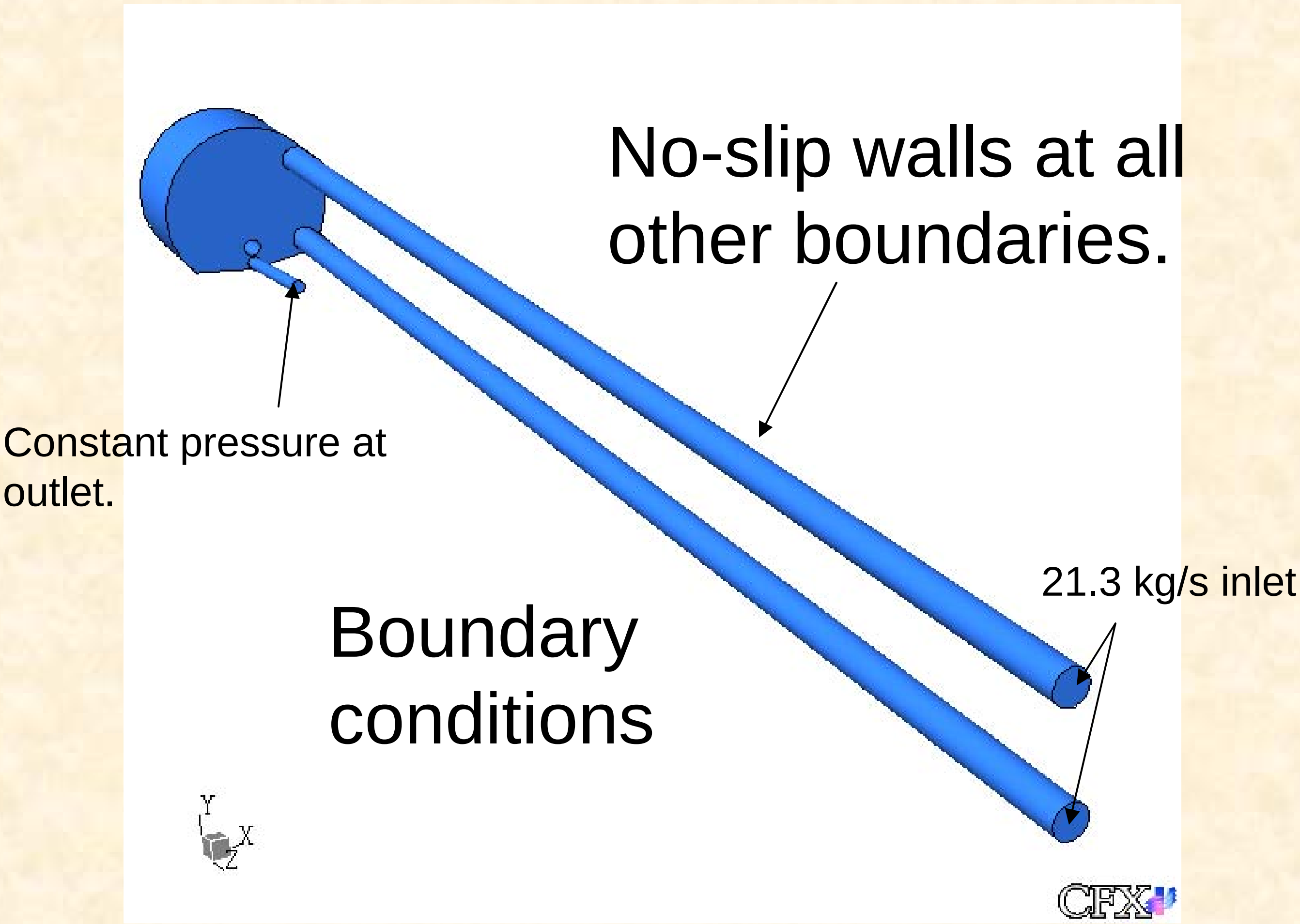
February 7-8, 2005

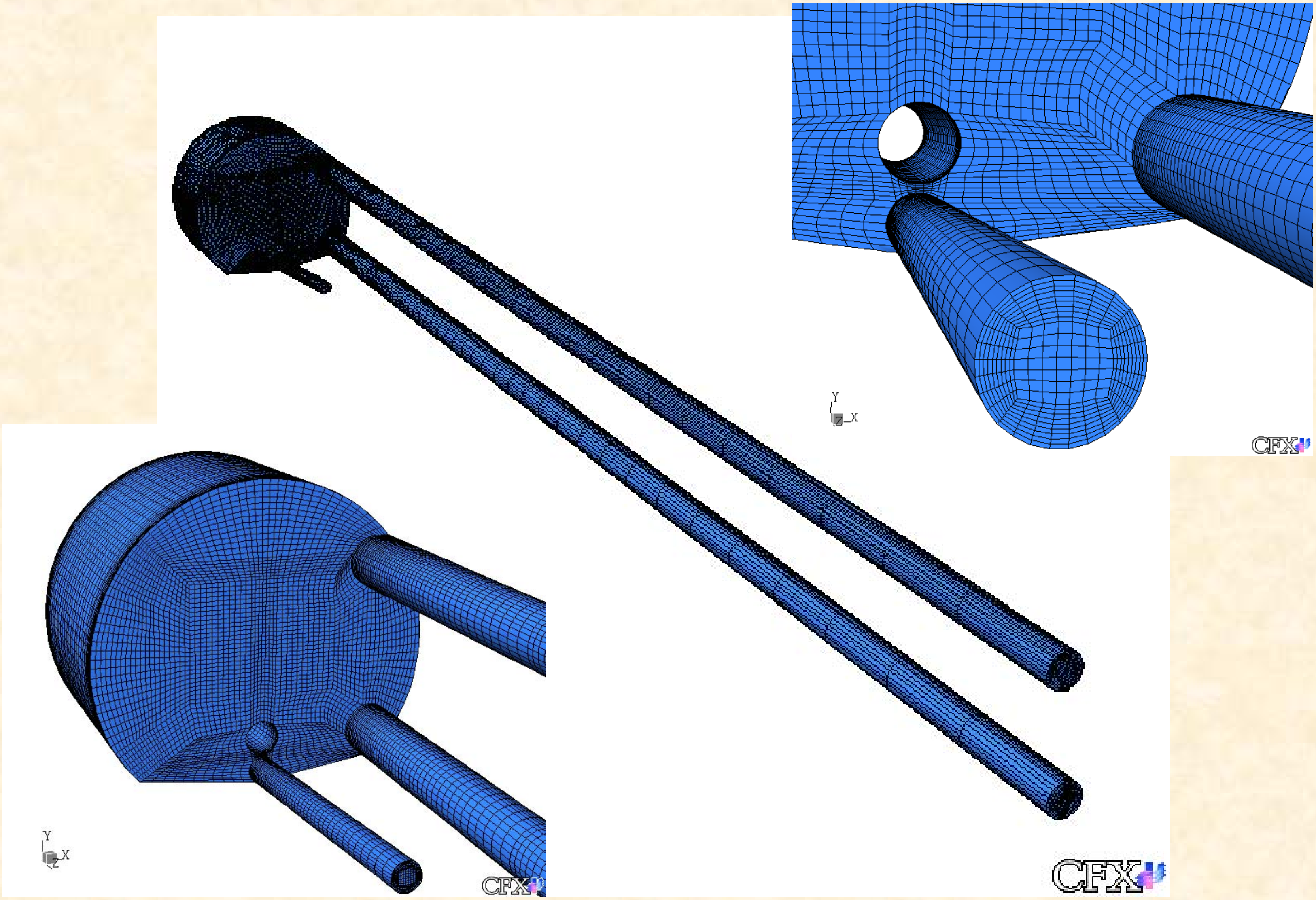
An Initial Computational Fluid Dynamic Analysis was completed.



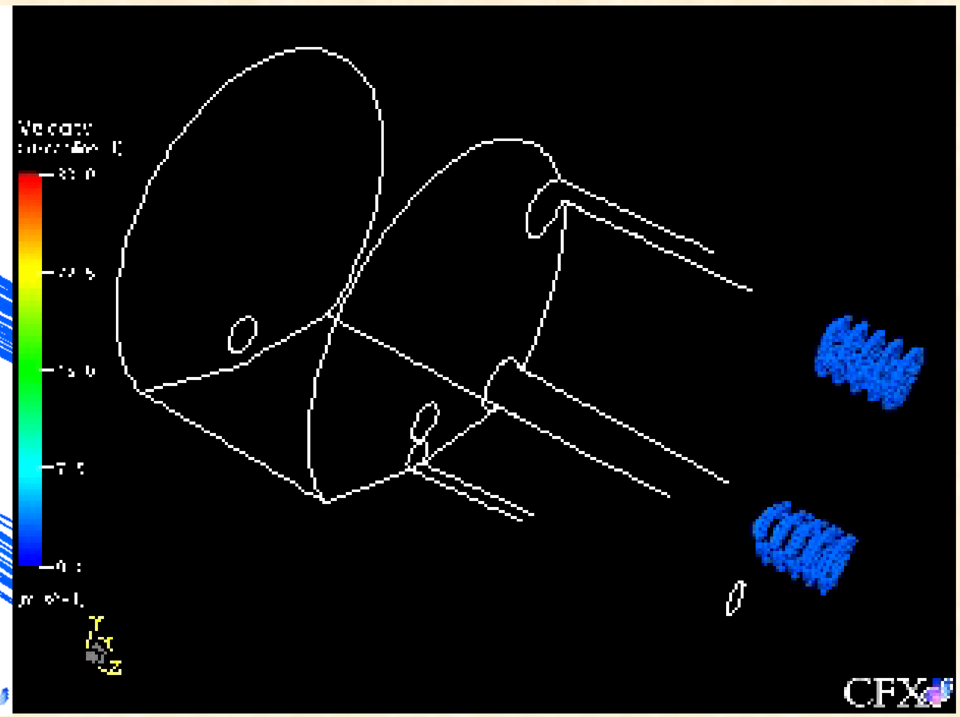
Only the mercury itself was modeled in the simulation.



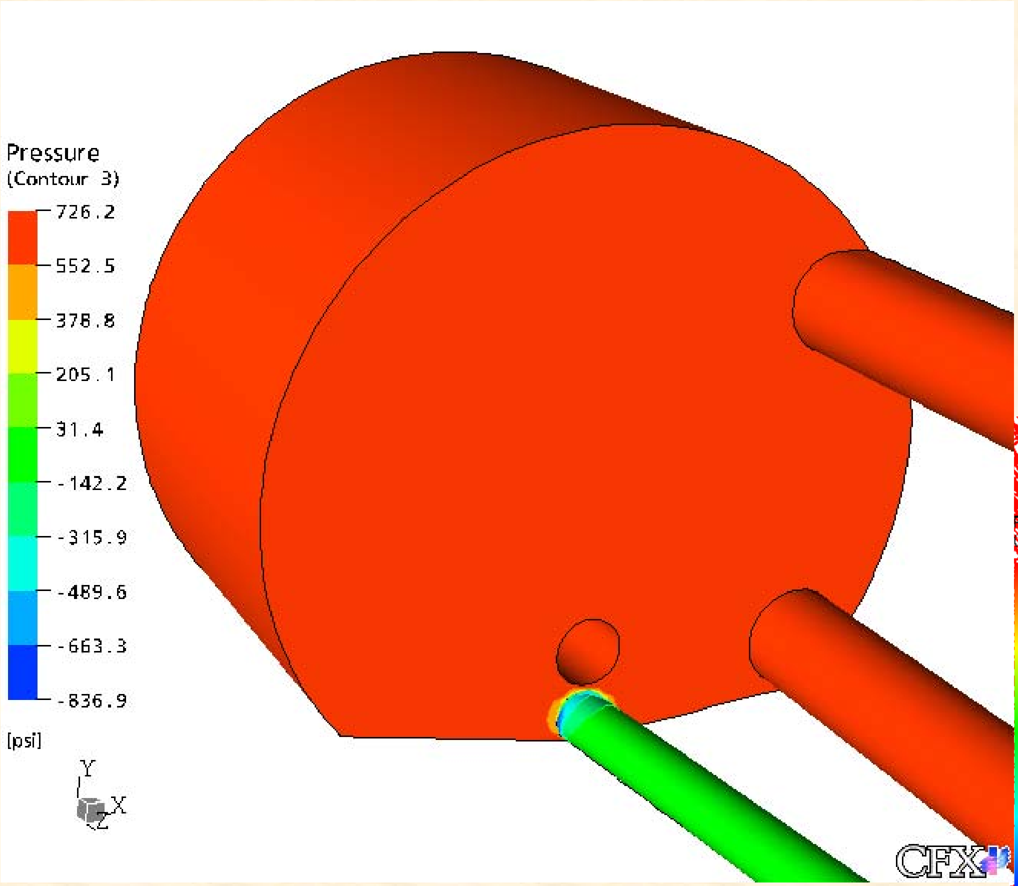
The computational mesh consisted of 230,545 hexahedral control volumes.



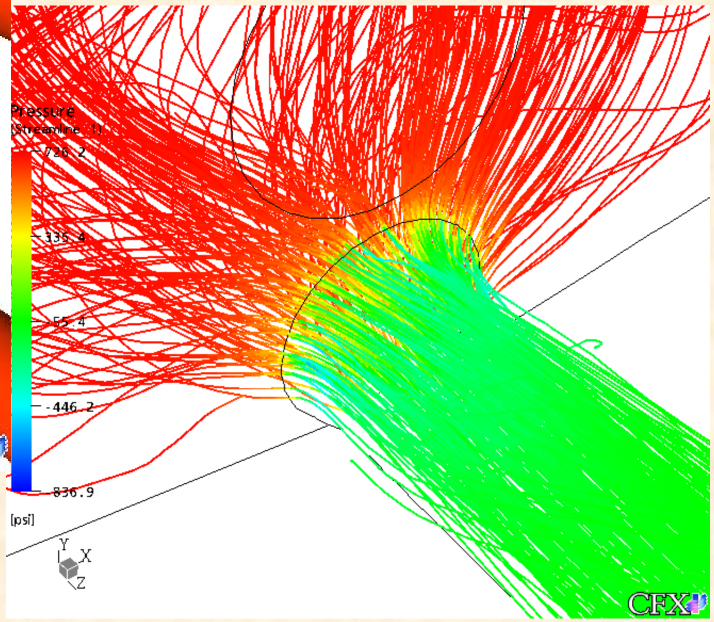
The computed flow shows smooth streamlines for the inlet lines and reservoir, but extreme conditions near the nozzle inlet.



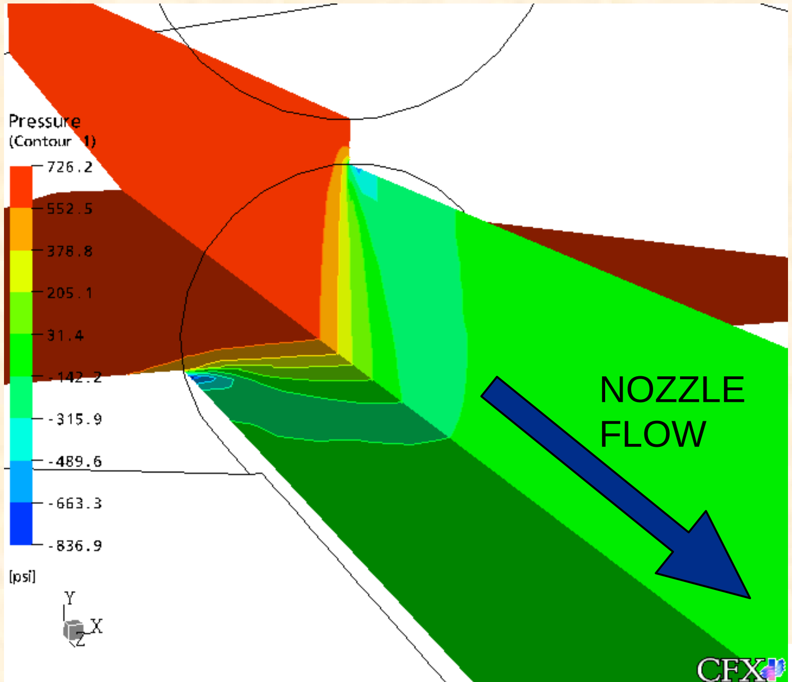
The computed pressures show cavitation will occur at the nozzle inlet.

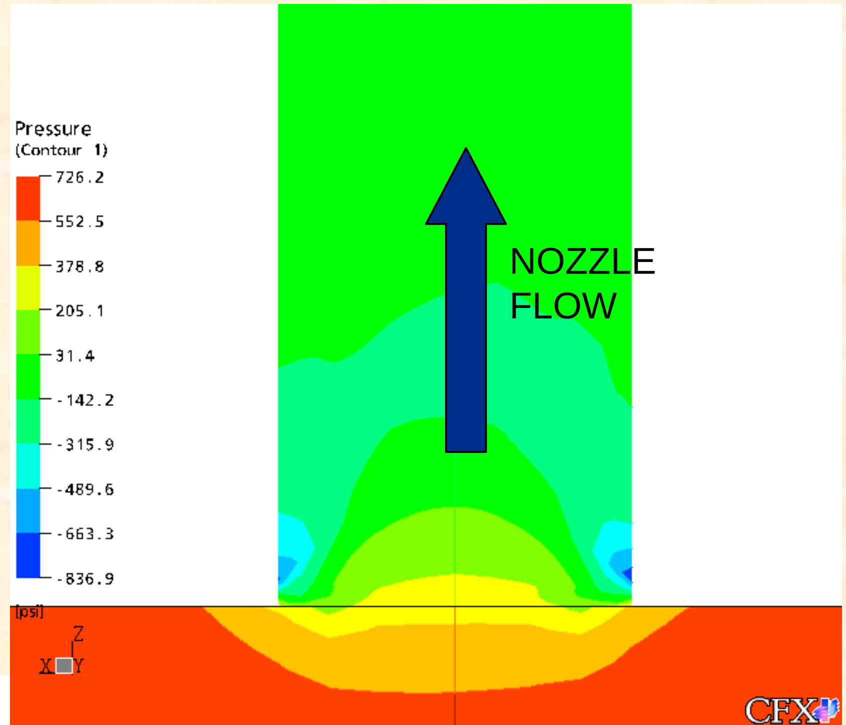


Computed pressure differential is 722 psi

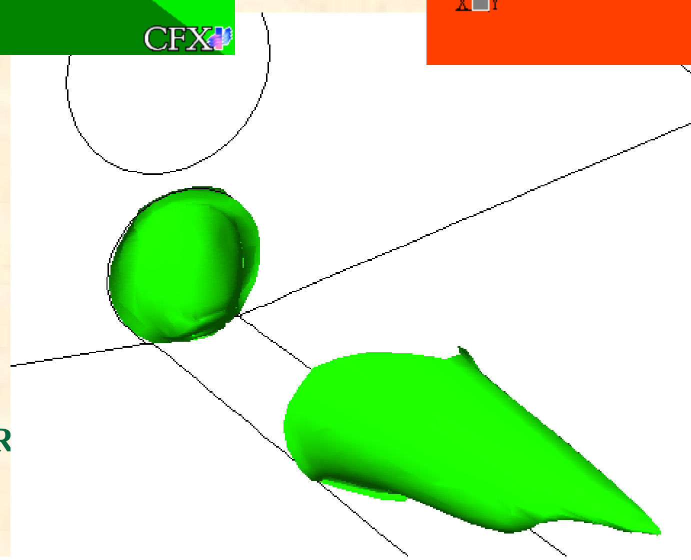


The computed pressures are particularly low where the flow accelerates around the corners.

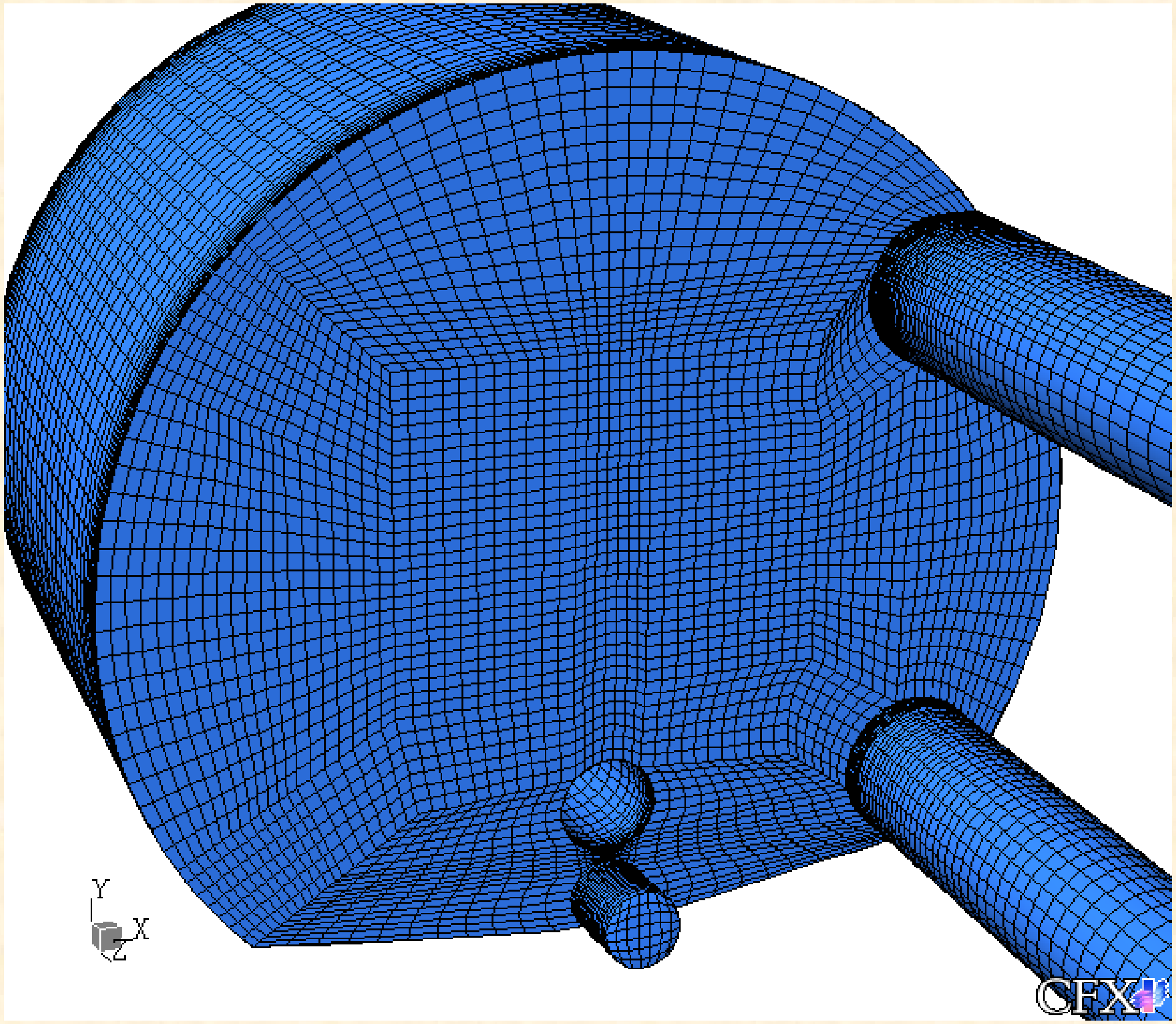




TOP VIEW

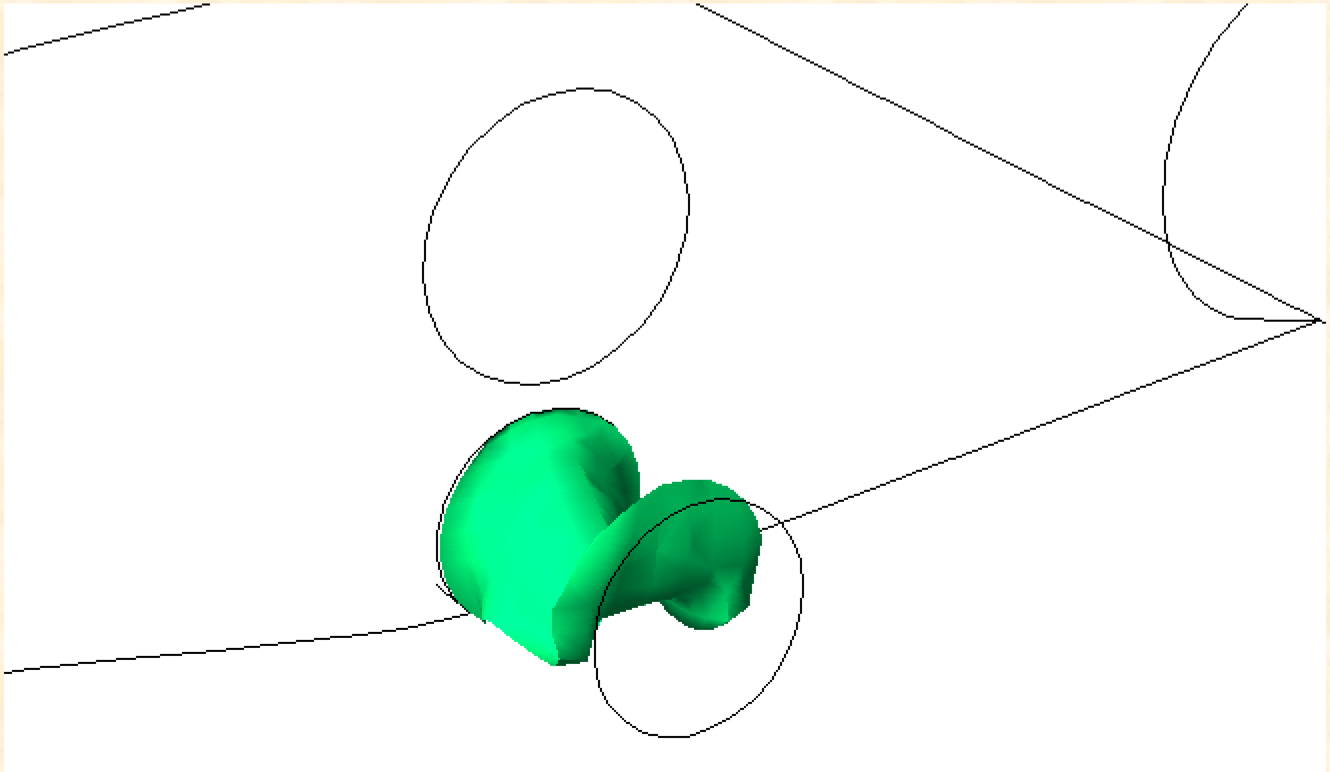


A shorter (1/2-inch) orifice was also analyzed



Computed stream-lines are similar and the total pressure drop is just under 800 psi.

Again, cavitation is predicted, although the conditions are less severe.



Cavitation is highly likely because of the low pressure at the nozzle exit, and the high velocity in the nozzle.

- **$P_{static} = P_{stagnation} - \frac{1}{2} \rho V^2$**
  - **ρ is density**
  - **V is velocity**
  - **If $P_{static} < P_{sat}$, then mercury will cavitate**

$$\left\{ \begin{array}{l} \text{for 20 m/s, } \tfrac{1}{2} \rho V^2 = 400 \text{ psi} \\ \text{for 30 m/s, } \tfrac{1}{2} \rho V^2 = 900 \text{ psi} \end{array} \right\}$$

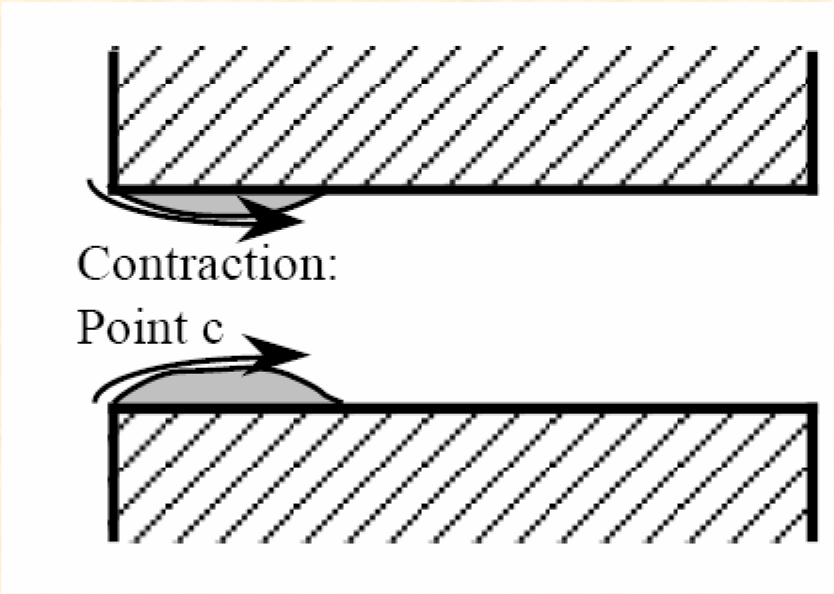
- **The CFD model is not conservative in predicting cavitation due to the transient aspect of the flow which is not simulated.**
- **In the SNS Target Test Facility mitered bends, CFD results showed much less severe conditions than computed here.**

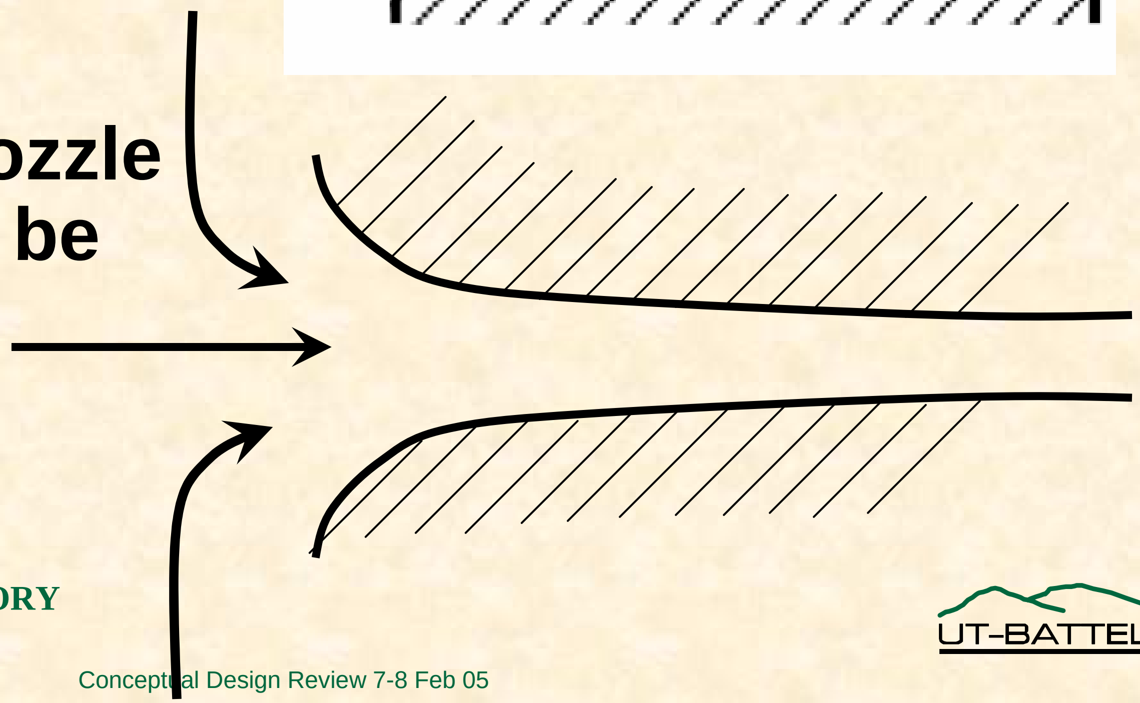
Cavitation in the nozzle is undesirable.

- **Short nozzle lifetime**
- **Choked flow**
- **Erratic jet flow pattern**
- **Noise**

Design changes can reduce or eliminate cavitation.

- Redesign the nozzle
  - Rounded corners
  - Contoured inlet
- Increase the chamber pressure
- Ultimately the nozzle design needs to be tested.





Recommended Future Work

- **Analyses on improved nozzle designs**
- **Literature searches on intake nozzle designs**