# Dry Wall Evacuation Calculations

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# Can we clear a dry wall chamber?

**We want to sufficiently clear a dry wall IFE chamber while supporting shot rates up to 10 Hz and pressures as low as 1 mTorr using Xenon as a background gas.**

- Concerns:
  - Can we evacuate the chamber between shots (*i.e.*, pump out Xe and debris to 100 times below equilibrium pressure)?
    - ✓ **No.** Even assuming zero leak rate and ignoring gas in outlet ducts, it takes 2.4 sec to pump from P to 0.01P (*for any starting pressure* of Xe.)
  - Can we achieve a low enough background pressure for beam and target propagation under equilibrium flow conditions?
  - Can we control the gas composition adequately?

# Calculation procedure for single-species pumping

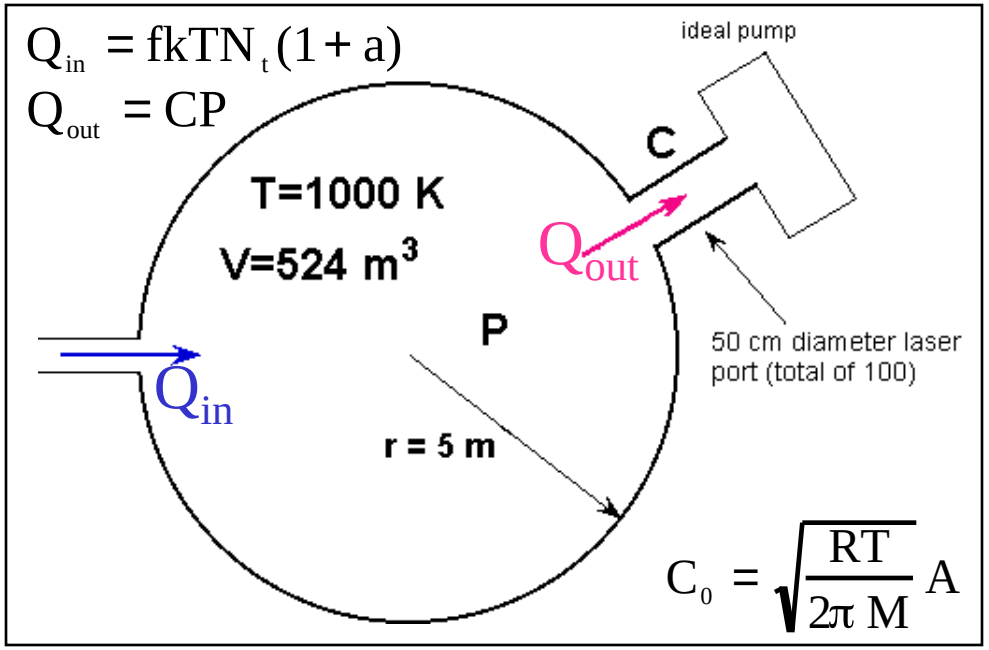
**We can inject Xe simultaneously with targets at a constant ratio, a:**

$$N_{Xe} = aN_t$$

Calculate Equilibrium Pressure, P (average over the chamber) for $Q_{in}=Q_{out}$:

$$P = \frac{f}{C} kTN_t(1+a)$$

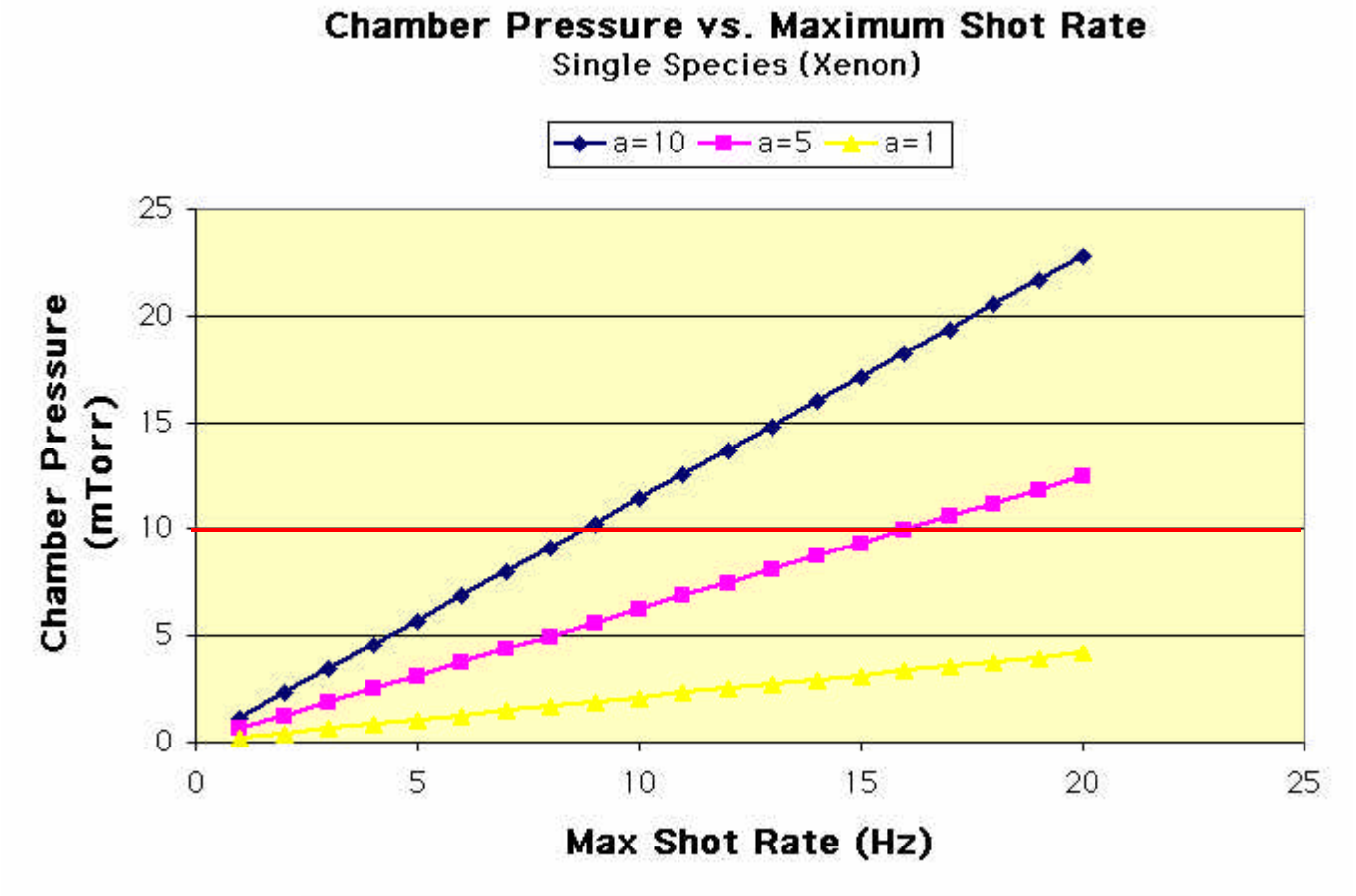
**f=shot rate, C=xenon conductance**




**Assumptions:**

- ✓Single species to be pumped is xenon ($C = 1 \times 10^6$ liter/sec = 0.4 x $C_{ideal}$ )
- ✓Ideal pump located 1m from the chamber wall
- ✓Molecular flow in ducts (Kn > 0.01 for pressures below 25 mTorr).
- ✓Pumping speed limited by duct conductance.
- ✓Ignore out-gassing of chamber wall and ignore leakage.
- ✓Ignore gas in the beam ducts (only chamber is pumped).

# Result for single-species pumping approximation




The number of molecules, $N_t$, of D & T in 5 targets produces about 1 mTorr of pressure for the given V and T.

**Observations:**

To get <10 mTorr @10 Hz, Need:

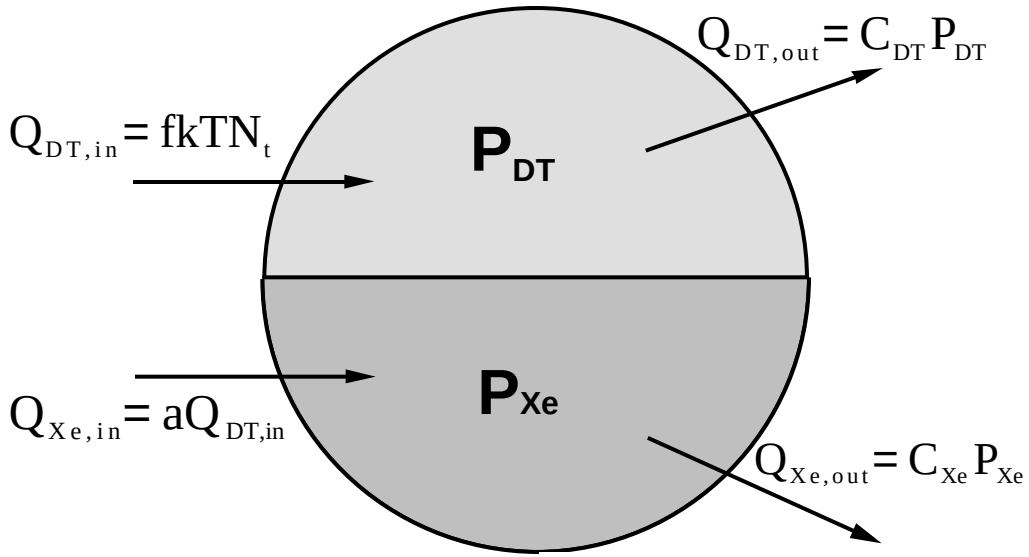
- larger aperture area (A)
- smaller Xe input rate

# Calculation procedure for multiple-species

$$P_{DT} = \frac{fkTN_t}{C_{DT}}$$

$$P_{Xe} = \frac{afkTN_t}{C_{Xe}}$$

$$\frac{P_{DT}}{P_{Xe}} = \frac{N_{DT}}{N_{Xe}} = \frac{1}{a}\frac{C_{Xe}}{C_{DT}}$$

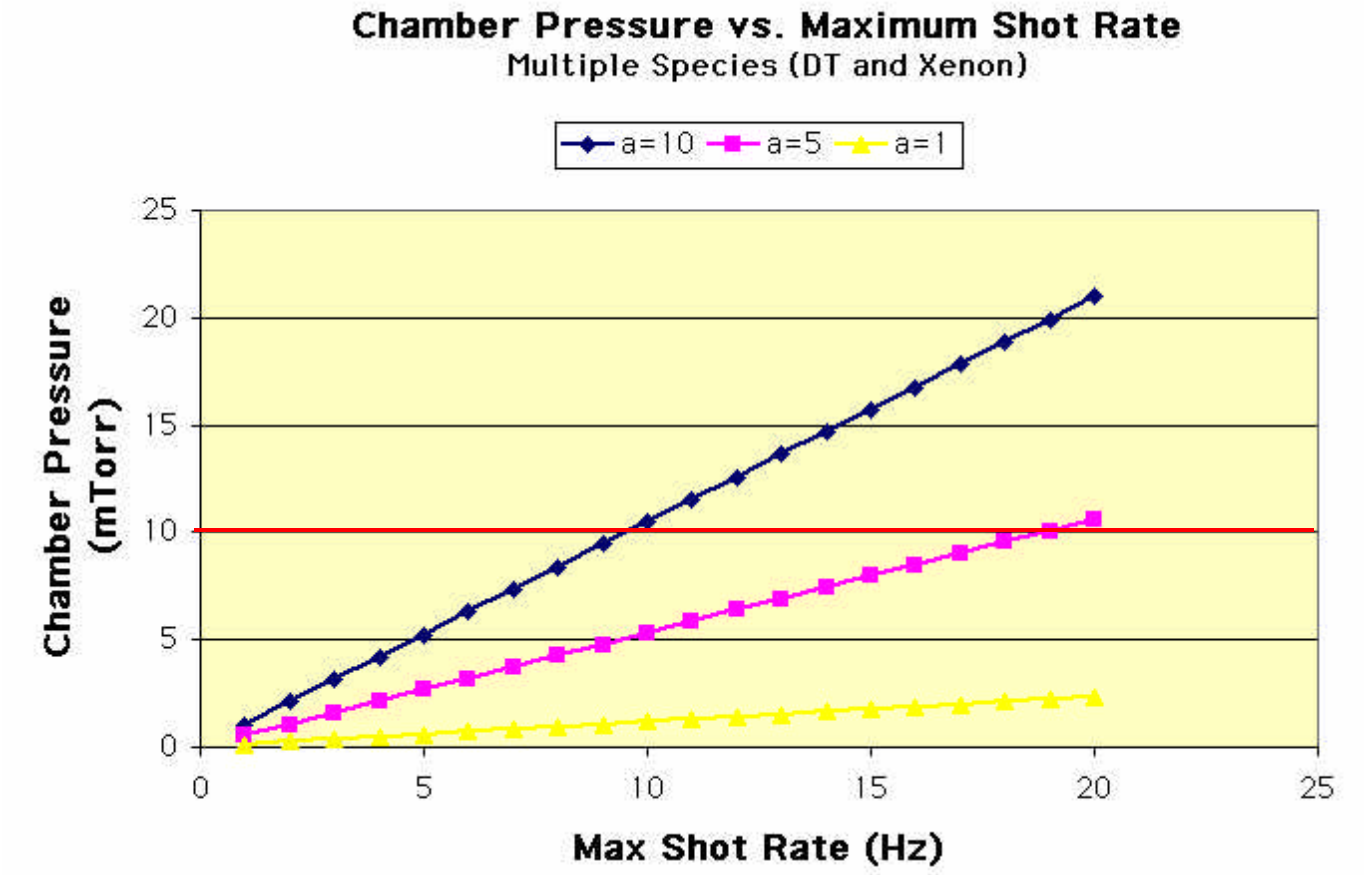



$$P = P_{DT} + P_{Xe} = fkTN_t\left[\frac{1}{C_{DT}} + \frac{a}{C_{Xe}}\right]$$

# Result for multiple-species

**Observation:**
Get a lower chamber pressure because D and T pump faster than Xe (smaller value of M).

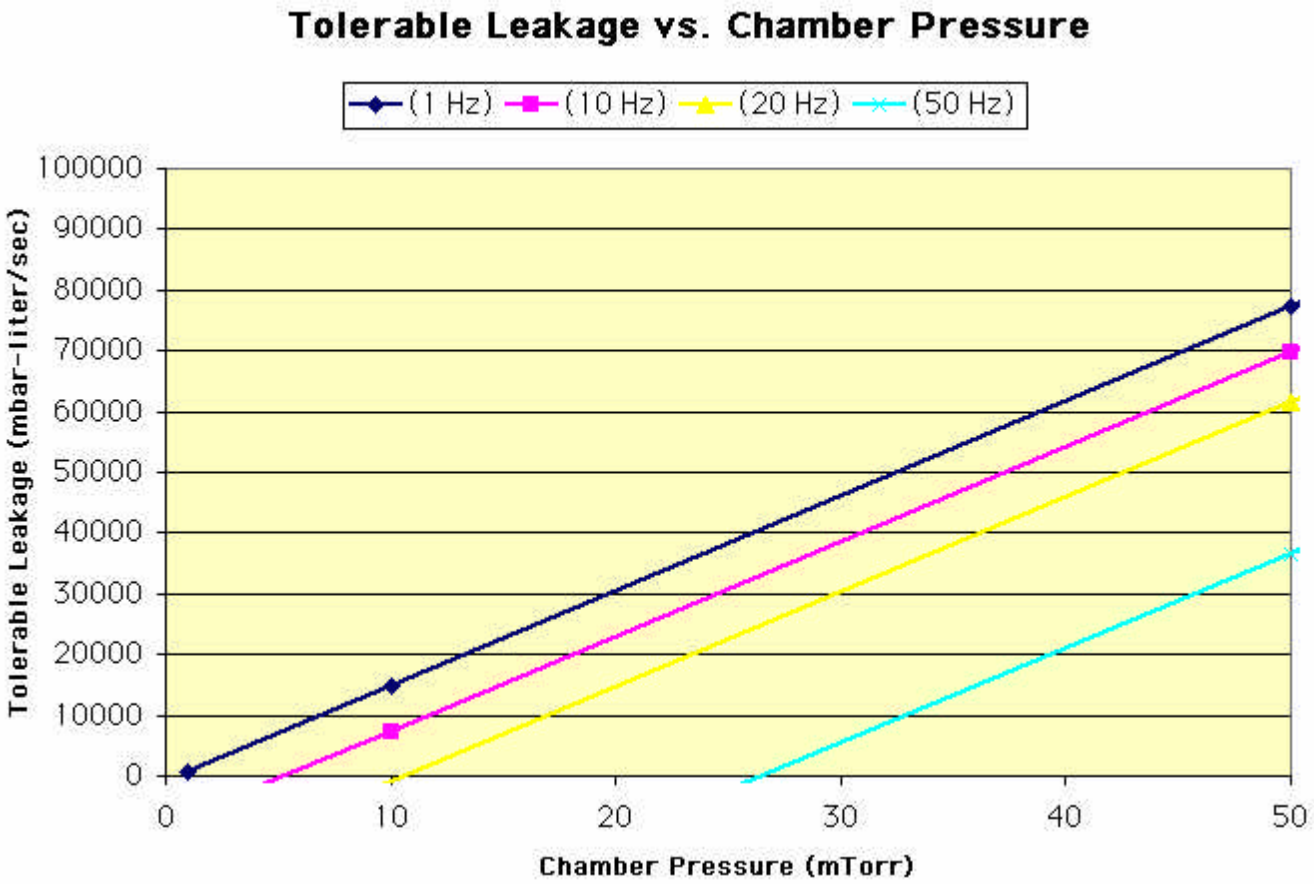
$$C_0 = \sqrt{\frac{RT}{2\pi M}}\,A$$




$$\frac{P_{DT}}{P_{Xe}} = \frac{N_{DT}}{N_{Xe}} = \frac{1}{a}\frac{C_{Xe}}{C_{DT}} = \frac{1}{6\,a}$$ **for M=0.004 kg/mol**

For example, while injecting equal numbers of targets and xenon (a=1), the ratio of target material to xenon at equilibrium in the chamber is 1 to 6

# Effect of Leakage (a = 5)



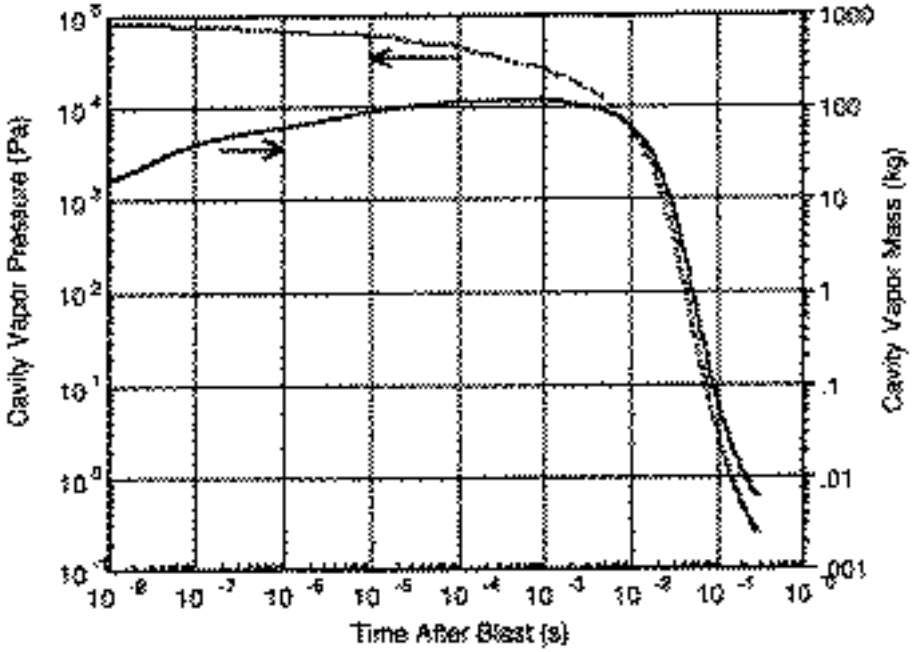

**10 Hz throughput is about 8,300 mbar-liter/sec of targets + xenon for a = 5.**

**Observations:**

- Possible to maintain chamber pressure below ~10 mTorr
- At ~40 mTorr and above, shot rate is NOT limited by pumping
- We are **looking for leak rates for NIF, Omega, Nike for comparison**

# Future Work

- Could use Tsunami (or similar chamber modeling code) to model fluid flow more accurately.
- Could return to this after we have our own fluid code running.
- Need to start looking into wetted wall clearing/evacuation.




From IFE Reactor Design Studies, Prometheus-L, March 1992