Vacuum Analysis and Improvement for the Jefferson Lab Photo-Electron Guns

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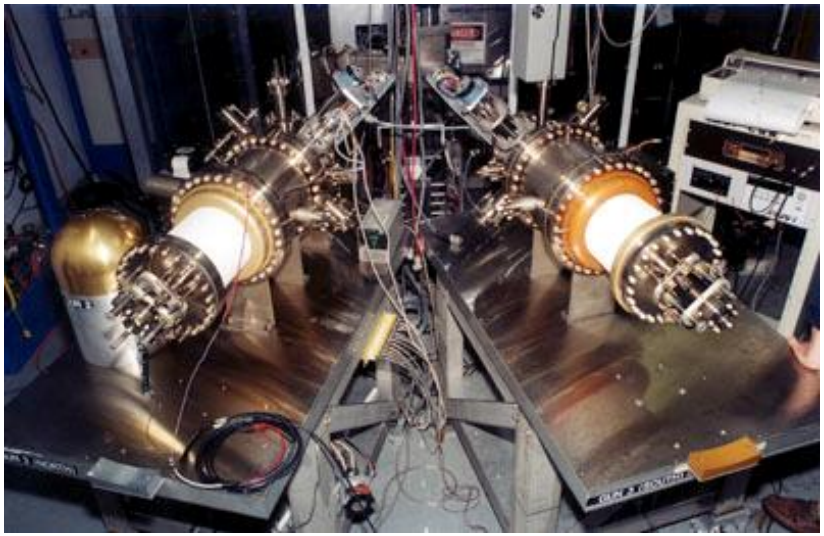
Jefferson Lab

- 6 GeV Nuclear Physics Laboratory
- 3 Experimental Halls
- 200 uA, 80% polarized electron beam
- UHV Photoelectron guns

Thomas Jefferson National Accelerator Facility

Photoelectron Guns



304 Stainless Steel Chambers

Pressure ~1e 1 Torr (Extractor Gauges)

100 kV Ceramic

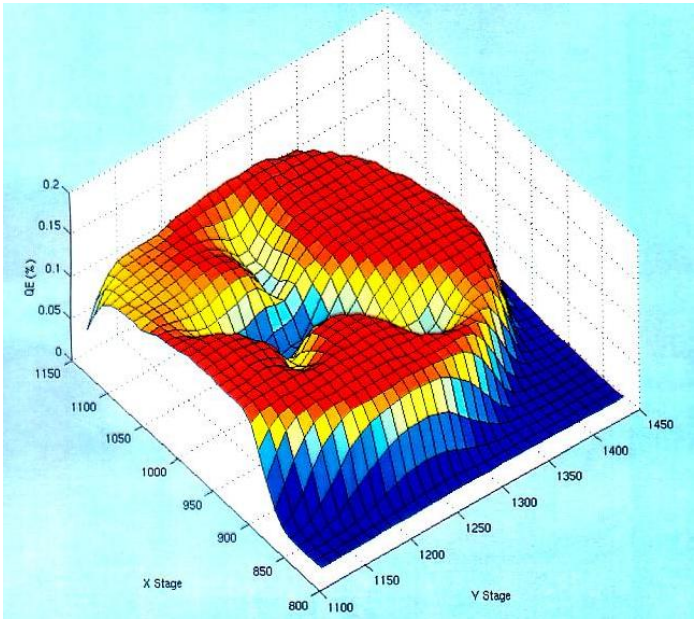
Open to beamline during operation

Differential Pumping cans with NEGS

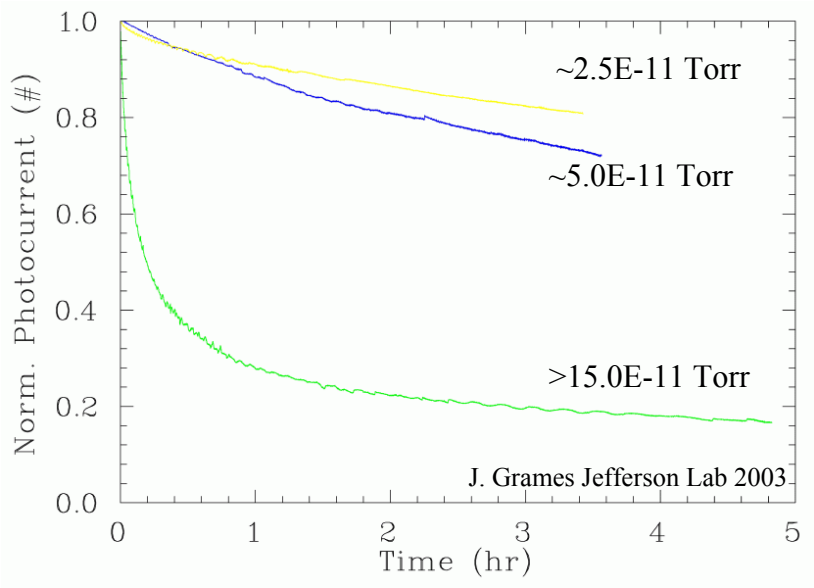
GaAs Photocathode

Process with Cs and NF_3 in chambers

Photocathode Lifetime



Quantum Efficiency across cathode after running beam

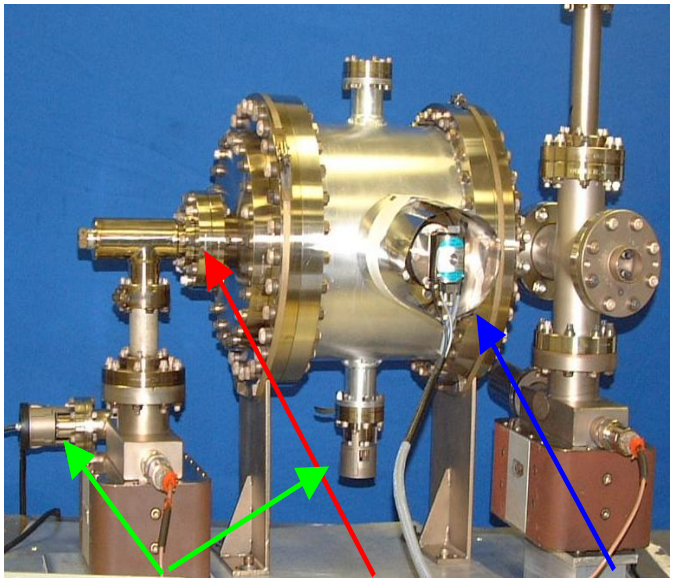


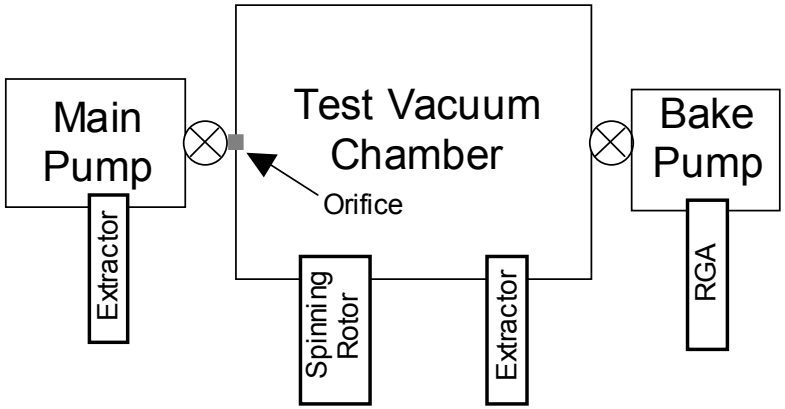
Cathode lifetime vs. Chamber Pressure

Outline

- Jefferson Lab and the Photoelectron Guns
- Outgassing Measurements
- Pump Speed Measurements
- Coatings

Experimental Setup





Measurement Methods

Orifice Method

- Bake Chamber (250 ºC, 30 hours)
- Equilibrate ~12 hours across orifice
- Measure pressures with extractor gauges
- Flow Rate through orifice = C·ΔP
  with C the conductance of the orifice
- Calculate Outgassing Rate:

$$Q = \frac{C \cdot \Delta P}{A}$$

Accumulation Method

- Bake Chamber (250 ºC, 30 hours)
- Eliminate Pumping
- Track Pressure Rise with
  Spinning Rotor Gauge
- Calculate Outgassing Rate:

$$Q = \frac{\Delta P}{\Delta t} \cdot \frac{V}{A}$$

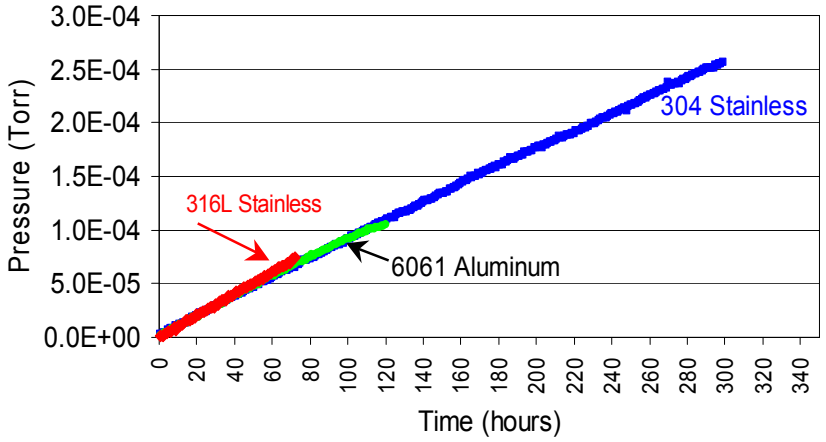
Recommended practices for measuring and reporting outgassing data, P.A.Redhead, JVSTA **20**, 1667 (2002)

Outgassing Data

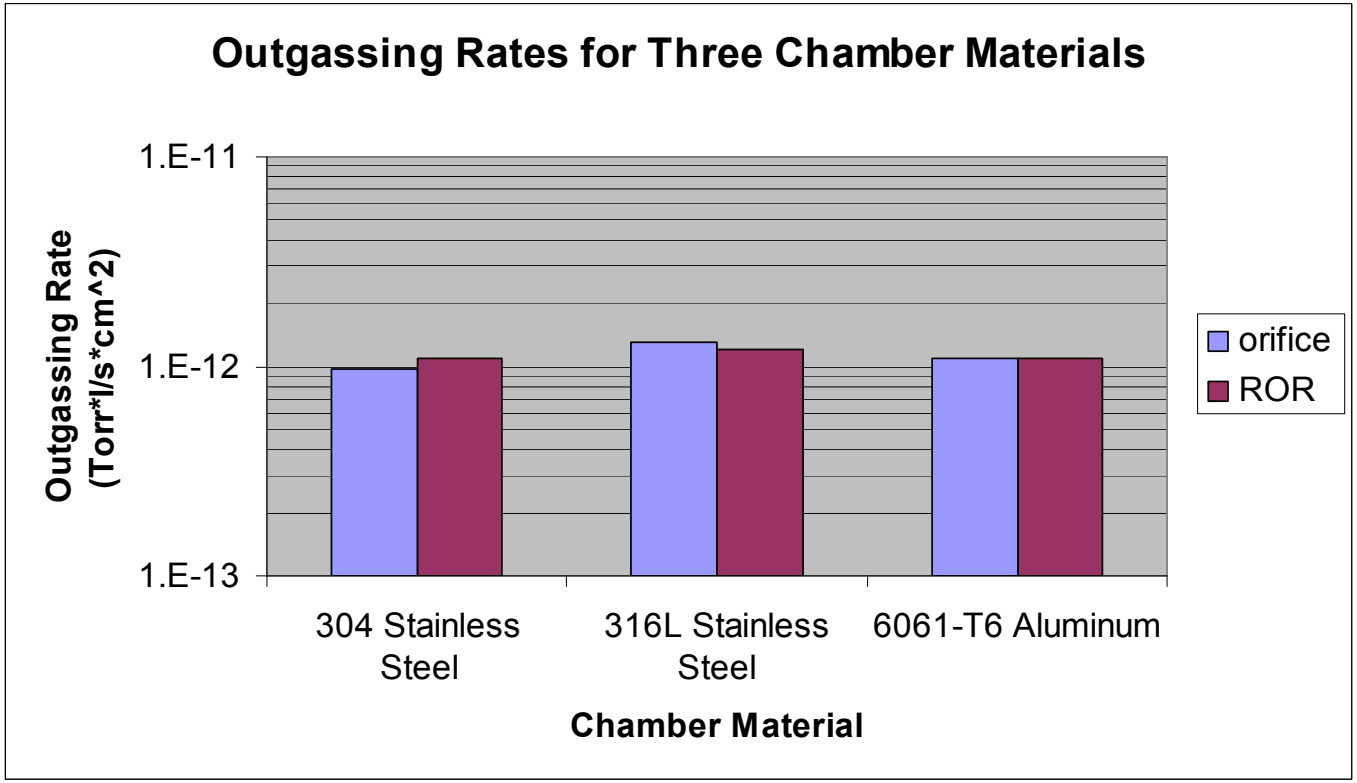
Orifice Measurement Data for Three Vacuum Chamber Materials

	Chamber Pressure	Pump Pressure
304 Stainless Steel	1.85×10^{-9}	1.67×10^{-10}
316L Stainless Steel	2.46×10^{-9}	2.16×10^{-10}
6061-T6 Aluminum	1.96×10^{-9}	1.26×10^{-10}

Rate of Rise with Spinning Rotor Gauge for Three Vacuum Chamber Materials



Outgassing Results



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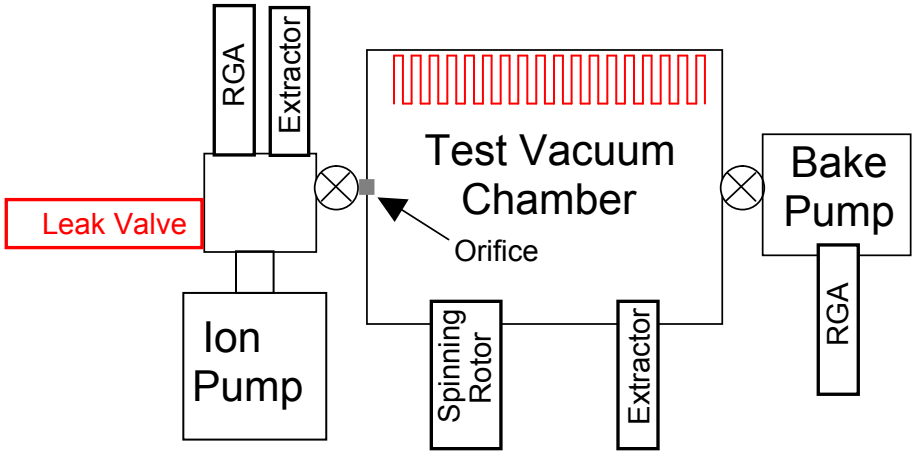
Pump Speed Measurement Motivation

Activation protocol check…

Pump Speed Setup Modifications



- SAES WP-950 getter cartridges
- ST-707 getter material
- Leak valve loaded with UHP Hydrogen

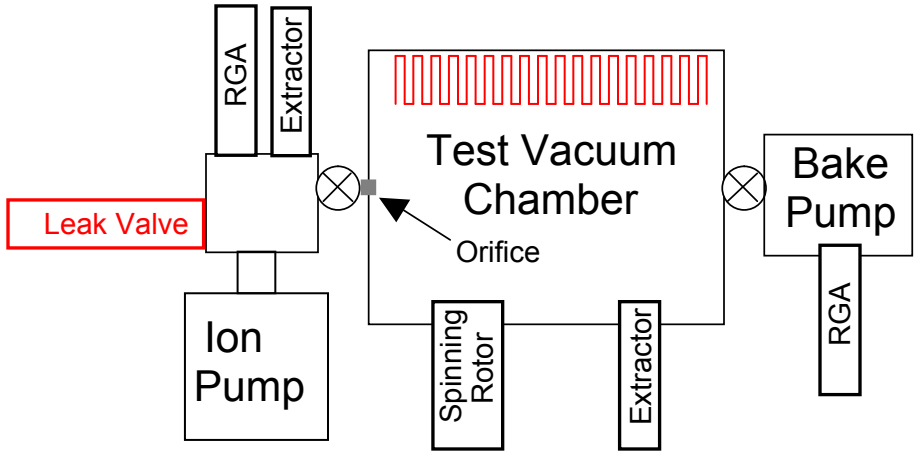
Recommended practices for measuring pumping speeds, M.H.Hablanian, JVSTA **5**, 2552 (1987).

Rated Pump Speeds

3×10^{-6} Torr, 23 ºC

Hydrogen:	430 L/s
Oxygen:	280 L/s
CO:	170 L/s
Nitrogen:	65 L/s

Pump Speed Measurement



Modified Flowmeter:

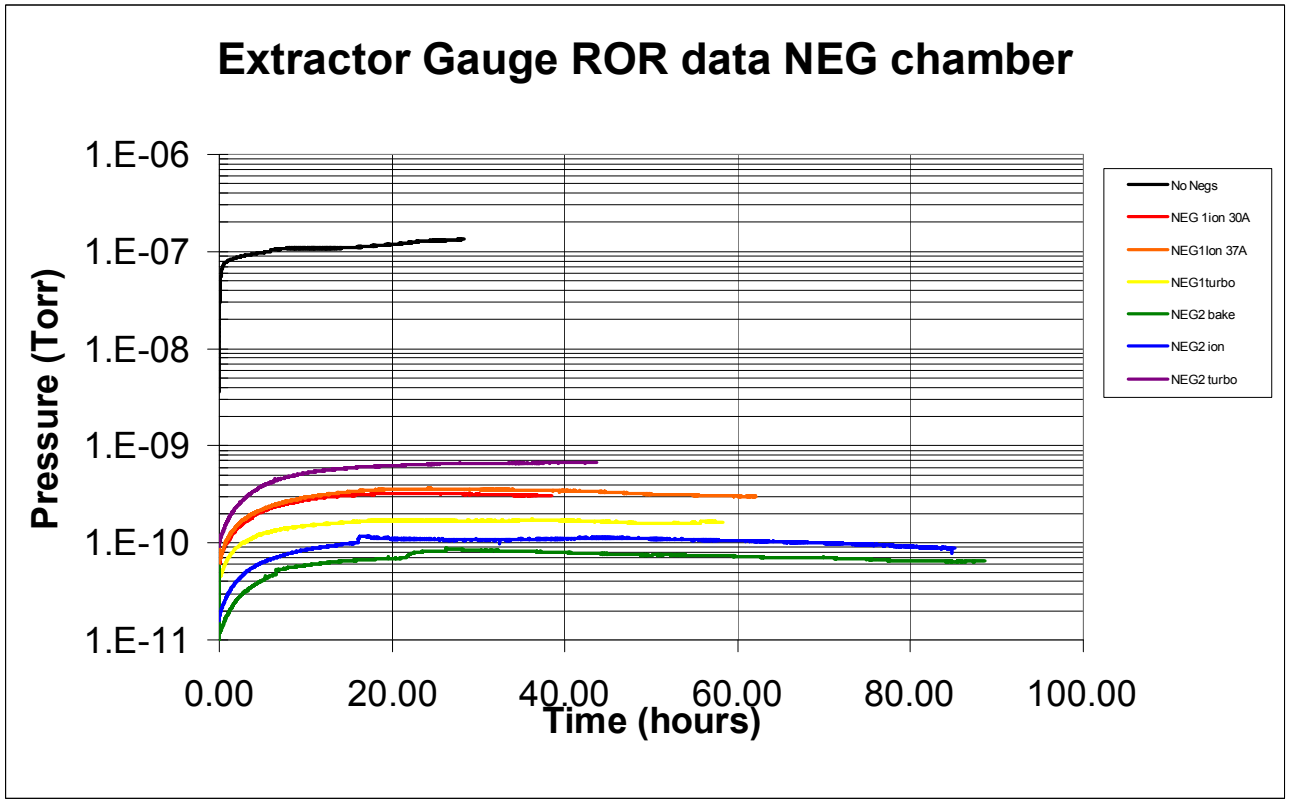
$$S = \frac{Q}{p - p_0}$$

Orifice Method:

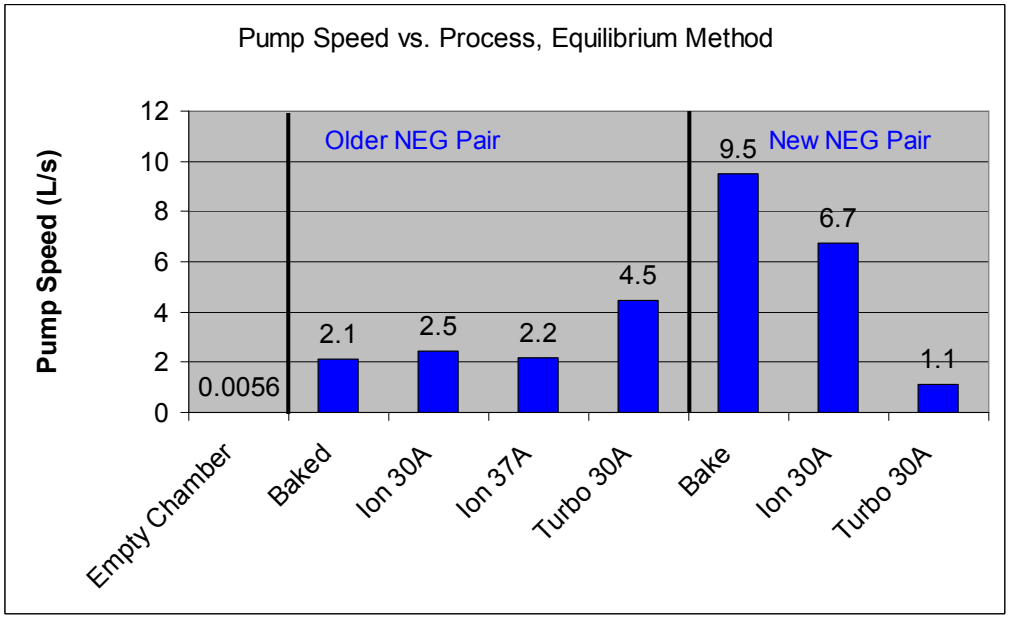
$$S = C\left(\frac{p_1 - p_{01}}{p_2 - p_{02}} - 1\right)$$

M.H.Hablanian Recommend Procedure for measuring pump speeds, JVSTA, 1987

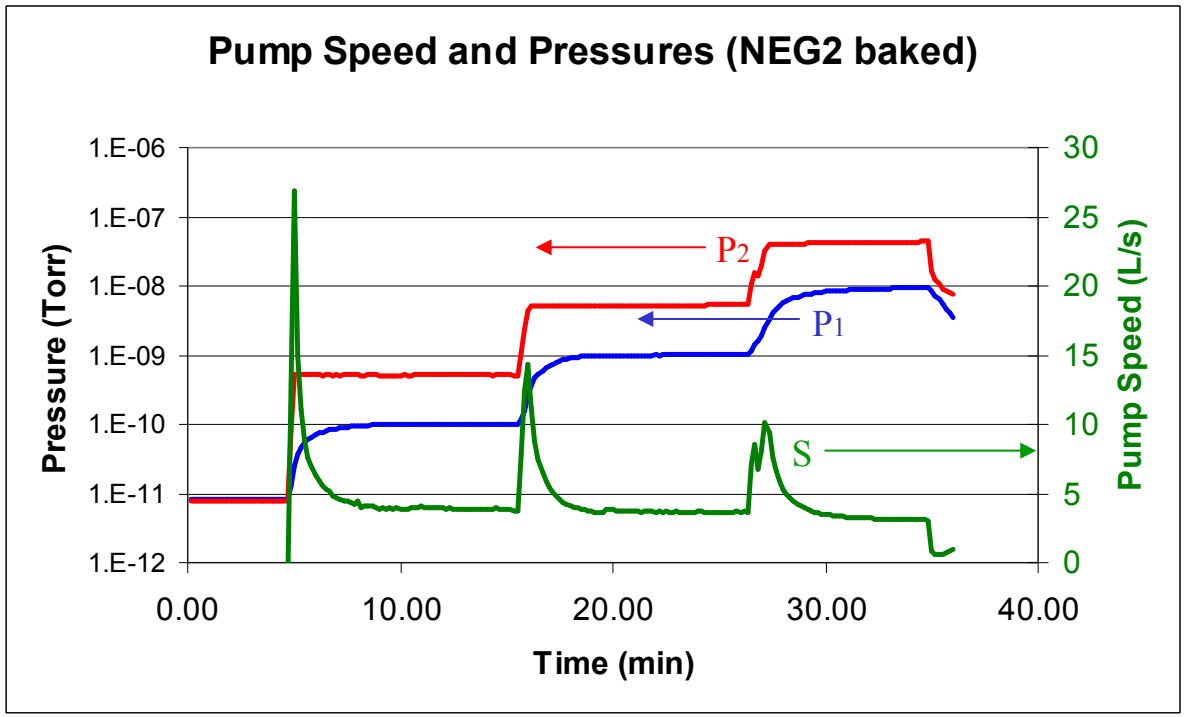
Pump Speed Results - Equilibrium



Pump Speed Results



Bleed-In Measurement



Bleed-In Pump Speed Results

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NEG coated tube results

Ti/Zr/V coating
600V, Argon discharge
Orifice measurement for outgassing rate

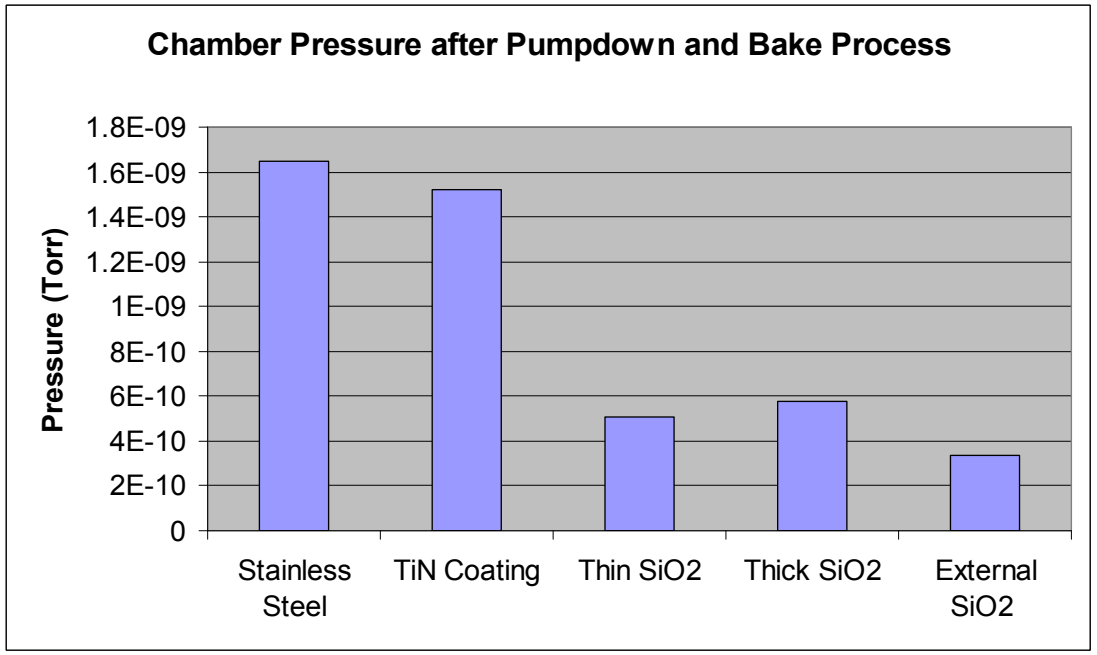
Uncoated Tube: ~2x10 $^{-2}$ Torr L/s·cm^2
Coated Tube: -9x10 $^{-3}$ Torr L/s·cm^2

Conclusion: The coating does pump, orifice to ion pump makes pump speed calculation extremely complex.

SiO_2 and TiN coatings

Process:

- Turbo pump stand
- Pump Down for 24 hours
- Bake at ~180ºC 24 hours
- Pump for 48 more hours
- Record pressure



Methods for Reducing Hydrogen Outgassing
C.Dong, P. Mehrotra and G.R.Myneni
Hydrogen in Materials and Vacuum Systems
AIP Conf.Proc.671:300-306,2003

Future work

Maybe SiO2 ROR data?

Coat inside of chamber with NEG, outside with SiO2, TiN?

Conclusions

- Outgassing rate is limited not by the material at this level, but rather by the technique that we are using for our bakeouts

- NEGs do reduce ultimate pressure, but measured pump speeds are lower than expected and activation protocol is not yet optimized

- To achieve XHV in our gun chambers, more work towards technique, materials, and coatings is still needed