High Voltage Check

D. Shuman, 9/23/10

Paschen curve for Xenon, from:

DEVELOPMENT AND CHAMBER TESTING OF A MINIATURE RADIO-FREQUENCY ION THRUSTER FOR MICROSPACECRAFT

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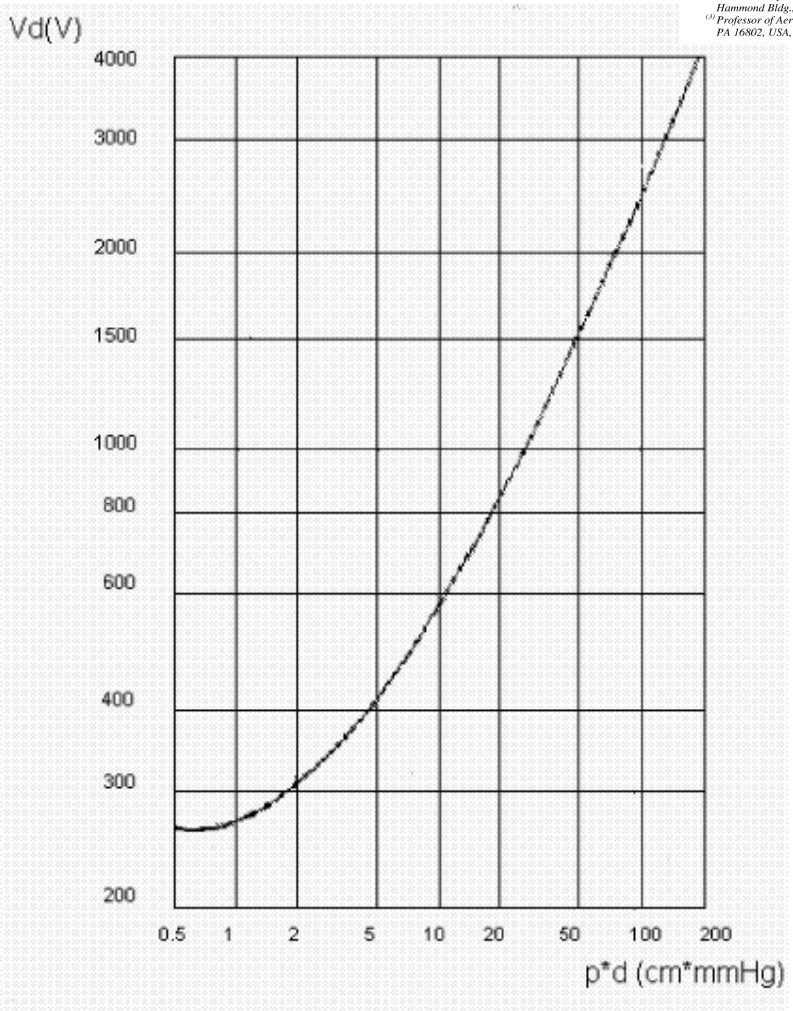


Fig. 5. Paschen curve for xenon (after Ref. [9])

9. Kruithof A.A., "Townsend's ionization coefficients for neon, argon, krypton and xenon," *Physica VII*, June 1940, pp. 519–540.

note log-log scale; pick two points near top section where line is reasonably straight:

$V_0 := 1500 \quad pd_0 := 49$ $\qquad$ $V_1 := 4000 \quad pd_1 := 180$

slope of top section is:

$$m_p := \frac{\ln(V_1) - \ln(V_0)}{\ln(pd_1) - \ln(pd_0)}$$

voltage function is then:

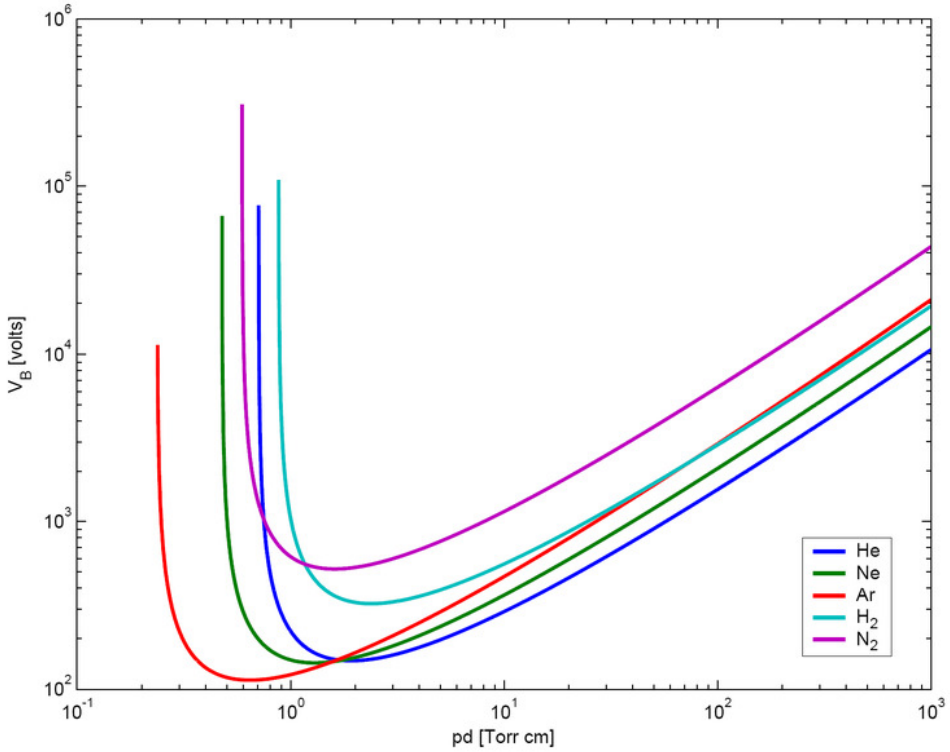
$$V_x := V_0 \cdot \left(\frac{pd_x}{pd_0}\right)^{m_p}$$

we know desired voltage, solve for pd:

$V_x := 20000$

$$pd_x := \left(\frac{V_x}{V_0}\right)^{m_p - 1} \cdot pd_0 \cdot torr \cdot cm \qquad pd_x = 1522\,torr \cdot cm$$

compare with argon at 20 kV : from: http://en.wikipedia.org/wiki/Paschen'slaw



$pd_{x\_Ar} := 1000 \cdot torr \cdot cm$ @20kV

ratio, Xe to argon breakdown strength

$$R_{bd} := \frac{pd_{x\_Ar}}{pd_x} \qquad R_{bd} = 0.657$$

pressure ratio: $R_{pr} := \frac{16.5bar}{1bar}$ $R_{pr} = 16.5$ $240psi = 1.655 \times 10^6\,Pa$

Combined ratio, we scale voltage down for lower pressure, but up for stronger gas:

$$R_{tot} := R_{pr} \cdot R_{bd} \qquad R_{tot} = 10.839$$

Final voltages:

$$V_{cath} := \frac{-20kV}{R_{tot}} \qquad V_{cath} = -1845\,V$$

$$V_{EL\_anode} := \frac{20kV}{R_{tot}} \qquad V_{EL\_anode} = 1845\,V$$

$$V_{EL\_cathode} := \frac{11kV}{R_{tot}} \qquad V_{EL\_cathode} = 1015\,V$$