SNS Linac Technical Memo

Vacuum Loads throughout the D-Plate Beam Line Outgassing Rate

Jim O'Hara

4/4/2001

WBS 14.5.2.8 (Diagnostics – D-Plate)

Vacuum Loads on the D-Plate Beam Line
Summary : In order to do the initial design of the D-plate vaccuum system a calculation was done to estimate the out-gassing load from the begining to the end of the D-Plate beam line. Also note that as the designs of these devices become more mature, the responsible person should update these values and pass the information on to the vacuum system designers, especially if the new values exceed these presented here.

The assumption is based on the D-plate layout as it existed back in November of 2000. The calculation starts at the end wall of the drift tube tank and continues down through to the D-plate beamstop. Included in these loads is the assumption that the H- beam particles re-combine back into H2 molecules that must be accounted for by the vacuum system.

material is SS, the out gassing rate is:

$$SS := 1 \cdot 10^{-10} \cdot \frac{torr \cdot L}{s \cdot cm^2}$$

Wire Scanner in Drift tube tank

$$OGR_{ws} := 1.772 \cdot 10^{-7} \cdot torr \cdot \frac{L}{s}$$

Faraday cup in Drift tube tank

$$OGR_{fc} := 5.581 \cdot 10^{-7} \cdot torr \cdot \frac{L}{s}$$

Total gas load from end of drift tube tank:

$$tank := OGR_{ws} + OGR_{fc}$$

$tank = 7.353 \times 10^{-7} \frac{torr \cdot L}{s}$

Toroid on endwall of DTL tank.

$OGR_{toroid} := 4.1011 10^{-7} \cdot torr \cdot \frac{L}{s}$

Beam Position Monitor DTL

$OGR_{DTL_bpm} := 1.246 10^{-8} \cdot torr \cdot \frac{L}{s}$

Welded bellows - 1 (1.5" OD by 1" ID, style A ends, 2 plates per seg, 2 seg)

$A_{cuff} := \pi \cdot 1.027 \cdot in \cdot .430 \cdot in$

$A_{seg} := \frac{\pi \cdot (1.5 in - 1.0 in)^2}{4} \cdot 2 \cdot 2$

$SA_{b_1} := A_{seg} + 2 \cdot A_{cuff}$

$SA_{b_1} = 22.968\ cm^2$

$OGR_{b_1} := SA_{b_1} SS$

$OGR_{b_1} = 2.297 \times 10^{-9} \frac{torr \cdot L}{s}$

Isolation Valve

$LR_{valve} := 2 \cdot 10^{-10} \cdot \frac{atm \cdot cm^3}{s}$

$A_{valve} := \pi \cdot 2.0 \cdot in \cdot 2.25 \cdot in$

$OGR_{valve} := A_{valve} \cdot SS + LR_{valve}$

$OGR_{valve} = 9.273 \times 10^{-9} \frac{torr \cdot L}{s}$

beam tube 2" ID by 221 mm long

$A := \pi \cdot 2.0 \cdot in \cdot 221 \cdot mm$

$A = 352.7 cm^2$

$OGR_{2_221} := A \cdot SS$

$OGR_{2_221} = 3.527 \times 10^{-8} torr \cdot \frac{L}{s}$

Welded bellows - 2 (2.625" OD by 1875" ID, style A ends, 2 plates per seg, 1 seg)

$A_{cuff} := \pi \cdot 1.87 in \cdot .50 \cdot in$

$SA_{b_2} := A_{seg} + 2 \cdot A_{cuff}$

$A_{seg} := \frac{\pi \cdot (2.625 \cdot in - 1.875 in)^2}{4} \cdot 2$

$SA_{b_2} = 42.969\ cm^2$

$OGR_{b_2} := SA_{b_2} \cdot SS$

$OGR_{b_2} = 4.297 \times 10^{-9} \frac{torr \cdot L}{s}$

Box - 1 (10.5" x 23" x 6.38") Contains 2 slits, phosphor screen, and wire scanner

$Length := 6.38 \cdot in$

$Width := 23 \cdot in$

$Height := 10.5 in$

$SA_{box} := 2 \cdot (Length \cdot Width + Length \cdot Height + Width \cdot Height)$

$SA_{box} = 5.874 \times 10^3\ cm^2$

$OGR_{box} := SA_{box} \cdot SS$

$OGR_{box} = 5.874 \times 10^{-7} \frac{torr \cdot L}{s}$

$OGR_{ws} = 1.772 \times 10^{-7}\ torr \cdot \frac{L}{s}$

$OGR_{slit} := 7.617 \times 10^{-7} \cdot torr \cdot \frac{L}{s}$

$OGR_{Phos} := 6.489 \times 10^{-6} \cdot torr \cdot \frac{L}{s}$

Beam tube 3.87 ID by 160 mm long

$A := \pi \cdot 3.87 \cdot in \cdot 160 \cdot mm$

$A = 494.1 cm^2$

$OGR_{3_8_160} := A \cdot SS$

$OGR_{3_8_160} = 4.941 \times 10^{-8}\ torr \cdot \frac{L}{s}$

BPM - 2, 3.87 ID

$A := 69.69 \cdot in^2$

$A = 449.612 cm^2$

$LR_{feedthru} := 1 \cdot 10^{-11} \cdot \frac{atm \cdot cm^3}{s}$

$OGR_{BPM2} := A \cdot SS + 4 \cdot LR_{feedthru}$

$OGR_{BPM2} = 4.499 \times 10^{-8}\ torr \cdot \frac{L}{s}$

Beam tube 3.87 ID by 140 mm long

$A := \pi \cdot 3.87 \cdot in \cdot 140 \cdot mm$

$A = 432.337 cm^2$

$OGR_{3_8_140} := A \cdot SS$

$OGR_{3_8_140} = 4.323 \times 10^{-8}\ torr \cdot \frac{L}{s}$

BPM - 3, 3.87 ID

$A := 69.69 \cdot in^2$

$A = 449.612 cm^2$

$OGR_{BPM2} := A \cdot SS + 4 \cdot LR_{feedthru}$

$OGR_{BPM2} = 4.499 \times 10^{-8}\ torr \cdot \frac{L}{s}$

Beam tube 3.87" ID by 50 mm long

$A := \pi \cdot 3.87 \cdot in \cdot 50 \cdot mm$

$A = 154.406 cm^2$

$OGR_{3_8_50} := A \cdot SS$

$OGR_{3_8_50} = 1.544 \times 10^{-8}\ torr \cdot \frac{L}{s}$

Box - 2 Contains collectors and wire scanner

$OGR_{box} := SA_{box} SS$

$OGR_{box} = 5.874 \times 10^{-7} \frac{torr \cdot L}{s}$

$OGR_{ws} := 1.264 \cdot 10^{-5} \cdot torr \cdot \frac{L}{s}$

$OGR_{coll} := 1.239 \cdot 10^{-5} \cdot torr \cdot \frac{L}{s}$

Beam tube 7.87" ID by 470 mm long

$A := \pi \cdot 7.87 \cdot in \cdot 470 \cdot mm$

$A = 2.952 \times 10^{3}\ cm^{2}$

$OGR_{7_8_470} := A \cdot SS$

$OGR_{7_8_470} = 2.952 \times 10^{-7}\ torr \cdot \frac{L}{s}$

Box - 3, contains farday cup, and x and y harps

$OGR_{box} := SA_{box} \cdot SS$

$OGR_{box} = 5.874 \times 10^{-7}\ \frac{torr \cdot L}{s}$

assuming the harp is similar
to the wire scanner.

$OGR_{fc} := 5.581 \cdot 10^{-7} \cdot torr \cdot \frac{L}{s}$

$OGR_{harp} := 5.581 \cdot 10^{-7} \cdot torr \cdot \frac{L}{s}$

Beam tube 7.87" ID by 275 mm

$A := \pi \cdot 7.87 \cdot in \cdot 275 \cdot mm$

$A = 1.727 \times 10^{3}\ cm^{2}$

$OGR_{7_8_470} := A \cdot SS$

$OGR_{7_8_470} = 1.727 \times 10^{-7}\ torr \cdot \frac{L}{s}$

Welded Bellows -3 (9.5" OD by 18.5" ID, style E ends, 2
plates per seg, 3 seg)

$A_{cuff} := \pi \cdot 7.834 \cdot in \cdot .50 \cdot in$

$SA_{b_3} := A_{seg} + 2 \cdot A_{cuff}$

$A_{seg} := \frac{\pi \cdot (9.5 \cdot in - 8.5 \cdot in)^{2}}{4} \cdot 2 \cdot 3$

$SA_{b_3} = 164.482 cm^{2}$

$OGR_{b_3} := SA_{b_3} \cdot SS$

$OGR_{b_3} = 1.645 \times 10^{-8}\ \frac{torr \cdot L}{s}$

Beam Stop Assembly, Nickel surface

$r := 100 \cdot mm$

$side := \sqrt{(100 \cdot mm)^2 + (362 \cdot mm)^2}$

$SA := \pi \cdot r \cdot side$

$SA = 1.18 \times 10^3\ cm^2$

$Ni := 2.33 \cdot 10^{-10} \cdot \frac{torr \cdot L}{s \cdot cm^2}$

$OGR_{beamstop} := SA \cdot Ni$

$OGR_{beamstop} = 2.749 \times 10^{-7}\ torr \cdot \frac{L}{s}$

Based on Martin Shculze's calculation for LEDA, the main assumption is that all of the H- particles recombine into H2 molecules after striking the beam stop.
redefine variable A back to amp

$A := amp$

$current := 2.16\ 10^{-3} \cdot A$

$particles := 1$

$molecules := 1$

$e := 1.602177333\ 10^{-19} \cdot C$

$H_{part} := \frac{current}{e}$

$H_{part} = 1.348 \times 10^{16}\ \frac{particles}{s}$

$H2_{part} := \frac{H_{part}}{2}$

$H2_{part} = 6.741 \times 10^{15}\ \frac{molecules}{s}$

$mole := 6.023 \cdot 10^{23} \cdot molecules$

$R_{bar} := 8.31434\ \frac{J}{mole \cdot K}$

$p := 1 \cdot atm$

$n := 1 \cdot mole$

$T := 298.15 \cdot K$

From the ideal gas law

$$V := \frac{n \cdot R_{bar} \cdot T}{p}$$

$$V = 24.465\ L$$

$$p := \frac{n \cdot R_{bar} \cdot T}{V}$$

$$p = 1.013 \times 10^{5}\ Pa$$

$$rate := H2_{part} \cdot R_{bar} \cdot T$$

$$rate = 2.081 \times 10^{-4}\ \frac{torr \cdot L}{s}$$