Fermilab

SSC DETECTOR SOLENOID DESIGN NOTE #117

TITLE: High Vacuum Pumping of a Helium or Nitrogen Leak in the SDC Solenoid Vacuum Vessel (Cylindrical Chimney)

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ABSTRACT: This Design Note contains the high vacuum pumping calculations for the SDC solenoid vacuum vessel. The calculation uses the cylindrical chimney dimensions given in Design Note 115.

SUMMARY: The calculations indicate the following throughputs for conductance values at 300 K and 80 K:

1.0 6" turbomolecular pump with 1,100 l/s helium pumping speed:

	Throughput (Atm cc/sec)	
	Helium	Nitrogen
1.1 At 2.2 x (10**-5) torr (CDF magnet trip point):		
At 300 K:	3.5 x (10**-3)	1.5 x (10**-3)
At 80 K:	2.0 x (10**-3)	0.8 x (10**-3)
1.2 At 5.5 x (10**-7) torr:		
At 300 K:	9.0 x (10**-5)	3.7 x (10**-5)
At 80 K:	4.9 x (10**-5)	1.9 x (10**-5)

2.0 4" turbomolecular pump with 390 l/s helium pumping speed:

	Throughput (Atm cc/sec)	
	Helium	Nitrogen
2.1 At 2.2 x (10**-5) torr (CDF magnet trip point):		
At 300 K:	2.7 x (10**-3)	1.2 x (10**-3)
At 80 K:	1.6 x (10**-3)	0.7 x (10**-3)

2.2 At 5.5 x (10**-7) torr:

At 300 K:	6.8 x (10**-5)	3.0 x (10**-5)
At 80 K:	4.0 x (10**-5)	1.7 x (10**-5)

CONCLUSION: High vacuum throughput is sufficient for reasonable helium or nitrogen leak rates.

For comparison, the CDF helium leak rate at ambient temperature was 1 x (10**-9) Atm cc/s. The leak rate with liquid helium was determined to be about 1.5 x (10**-7) Atm cc/s.

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SUBJECT	NAME	
HIGH VACUUM PUMPING OF A He OR N_2 LEAK IN THE SDC SOLENOID VACUUM VESSEL (CYLINDRICAL CHIMNEY)	A. M. STEFANIK	
	DATE 10/2/90	REVISION DATE

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SUBJECT: CHIMNEY CONDUCTANCE FOR HELIUM

NAME: AMS

DATE: 9/27/90 | REVISION DATE:

1.0 DETERMINE FLOW REGIME:

$$Kn = \lambda / D \qquad \lambda = \left(\frac{\mu}{p}\right)\left(\frac{\pi R_u T}{2 g_c M}\right)^{1/2}$$

AT 300 K:

ACCORDING TO RICH SCHMITT, THE MAGNET AT CDF TRIPS OFF AT A VACUUM GAUGE READING OF 4×10^{-6} torr. ACTUAL PRESSURE IN A HELIUM ENVIRONMENT IS OBTAINED BY DIVIDING THE GAUGE READING BY 0.182. THIS CORRECTED PRESSURE WILL BE USED TO DETERMINE THE FLOW REGIME.

$$p = 4 \times 10^{-6}\,\text{torr}/0.182 = 2.2 \times 10^{-5}\ \text{Torr} \quad \text{(CDF TRIP POINT)}$$

$$= 2.2 \times 10^{-5}\ \text{TORR} \times \frac{14.696\ \text{psia}}{760\ \text{TORR}} = 4.25 \times 10^{-7}\ \text{psia}$$

$$T = 540^\circ R \qquad \mu = 0.0481\ \text{Lbm/ft-hr}$$

$$M = 4\ \text{Lbm/Lbmole}$$

$$R = 1545\ \frac{\text{ft-Lbf}}{\text{Lbmole-}^\circ R}$$

$$g_c = 32.174\ \frac{\text{Lbm-ft}}{\text{Lbf-sec}^2}$$

$$\lambda = \frac{0.0481\ \frac{\text{Lbm}}{\text{ft-hr}} \times \frac{\text{hr}}{3600\,\text{sec}}}{(4.25 \times 10^{-7})\ \frac{\text{Lbf}}{\text{in}^2} \times \frac{144\ \text{in}^2}{\text{ft}^2}} \left[\frac{\pi\left(1545\ \frac{\text{ft-Lbf}}{\text{Lbmole-}^\circ R}\right)(540\ ^\circ R)}{2\left(32.174\ \frac{\text{Lbm ft}}{\text{Lbf-sec}^2}\right)\left(4\ \frac{\text{Lbm}}{\text{Lbmole}}\right)}\right]^{1/2}$$

$$\lambda = 22\ \text{Ft} = 671.5\ \text{cm}$$

$$Kn_{D_H} = \frac{(22 \times 12)\,\text{in}}{3.77\ \text{in}} = 70 > 0.3$$

$$Kn_{OD} = \frac{(22 \times 12)}{12.39} = 21 > 0.3$$

$\Rightarrow$ FREE MOLECULAR FLOW

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AT 80 K:

$T = 144\ ^{o}R$

$\mu = 0.02$ Lbm/ft-hr

$P = 4.25 \times 10^{-7}$ psia

$$\lambda = \frac{\frac{0.02}{3600}}{(4.25\times10^{-7})(144)} \left[\frac{\pi\ (1545)(144)}{2\ (32.174)(4)} \right]^{1/2}$$

$= 4.7$ Ft $= 144$ cm.

$$\left.\begin{aligned} Kn_{DH} &= \frac{(4.7\times12)}{3.77} = 15 > 0.3 \\ Kn_{OD} &= \frac{(4.7\times12)}{12.39} = 4.6 > 0.3 \end{aligned}\right\} \Rightarrow \text{FREE MOLECULAR FLOW}$$

AT 4.2 K: ← FOR COMPARISON ONLY. THE LEAK IS AT 80 K MINIMUM IN THE CHIMNEY AND IN THE VACUUM VESSEL.

$T = 7.56\ ^\circ R$

$\mu = 0.003\ Lbm/ft\cdot hr$

$P = 4.25 \times 10^{-7}\ psia$

$$\lambda = \frac{\frac{0.003}{3600}}{4.25\times10^{-7}(144)}\left[\frac{\pi\,(1545)(7.56)}{2(32.174)(4)}\right]^{1/2} = 0.16\ ft = 5\,cm$$

$$Kn_{DH} = \frac{0.16\,(12)}{3.77} = 0.5 > 0.3 \Rightarrow \text{FREE MOLECULAR FLOW}$$

$$Kn_{OD} = \frac{0.16\,(12)}{12.39} = 0.15 < 0.3 \Rightarrow \text{MIXED FLOW}$$

CONCLUSION: FLOW REGIME IS FREE MOLECULAR REGARDLESS OF TEMP.

2.0 CALCULATE CHIMNEY CONDUCTANCE ... (REFER TO § 5.0 FOR LINE LENGTHS & FITTINGS)

2.1 ENTRANCE TO CHIMNEY ...

$$C = \left[\frac{\pi g_c R_u T}{32 M}\right]^{1/2}\left(\frac{4A}{\pi}\right) = \left[\frac{\pi\left(32.174\ \frac{Lbm\text{-}ft}{Lbf\text{-}sec^2}\right)\left(1545\ \frac{ft\text{-}Lbf}{Lbmole\text{-}^\circ R}\right)(540^\circ R)}{32\left(4\ Lbm/Lbmole\right)}\right] * \frac{4}{\pi}\left[62.17\ in^2 * \frac{ft^2}{144\ in^2}\right]$$

(REFR: BARRON - 1985 ED. PG 434)

$$C = 446.2\ \frac{ft^3}{sec} = \underline{12{,}636\ \ell/s}$$

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2.2 34' OF ANNULAR FLOW AREA ...

THIS IS BASED ON KNUDSEN'S GENERAL FORMULA

$$C = \frac{16}{3}\alpha\sqrt{\frac{RT}{2\pi M}}\,\frac{A^2}{BL}\left[\frac{cc}{s}\right]$$

REFR: VACUUM ENGR. BOSTON TECHNICAL PUBLISHERS 1967 PG. 17

$$= \frac{16}{3}\alpha\sqrt{\frac{(8.314\times10^7)\,T}{2\pi M}}\,\frac{A^2}{BL}\left[\frac{cc}{s}\right]$$

$$= 48629.94\,\alpha\sqrt{\frac{T}{2\pi M}}\,\frac{A^2}{BL}\left[\frac{cc}{s}\right]$$

$$= 48.63\,\alpha\sqrt{\frac{T}{2\pi M}}\,\frac{A^2}{BL}\left[\frac{l}{s}\right]$$

FOR THIS CASE -

$D_1 = 31.5$ cm $\quad D_2 = 22$ cm $\quad L = 1{,}036$ cm

$$A = \frac{\pi}{4}(D_1^2 - D_2^2) = \frac{\pi}{4}(31.5^2 - 22^2) = 399\ \text{cm}^2$$

$$B = \pi(D_1 + D_2) = \pi(31.5 + 22) = 168\ \text{cm}$$

$$Q = 48.63(1.25)\sqrt{\frac{300}{2\pi\,4}}\,\frac{399^2}{168(1{,}036)} = \underline{192\ l/s}$$

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2.3 LOSS AT TEE FOR CHIMNEY BAYONET BOX:

2.3.1 TEE RUN AND 2' OF ANNULAR FLOW AREA -

TEE RUN - $L_e = L_{AXIAL} + 1.33D$

$$= \left(\frac{20}{12}\right) ft + 1.33\left(\frac{12.39}{12}\right) ft = 3.04\ ft$$

$$\Sigma L = 2' + 3' = 5\ ft$$

REFR: VACUUM EQUIPMENT AND TECHNIQUES
1949 GUTHRIE & WAKERLING
PG. 41

RATIO THE CONDUCTANCE CALCULATED IN 2.2 -

$$C = 192\ \frac{\ell}{s}\left(\frac{34'}{5'}\right) = 1{,}305\ \ell/s$$

2.3.2 RESTRICTION LOSS

$$C = 3.64\left(\frac{T}{M}\right)^{1/2} A\ [\ell/s]$$ (USE SMALL APERTURE EQN)

REFR: VACUUM SCIENCE & ENGR, PG 49
VAN ATTA & CHESTER MURRAY
1965

$$A = 42.67\ in^2 = 275\ cm^2$$

$$C = 3.64\left(\frac{300}{4}\right)^{1/2}(275) = 8{,}668\ \ell/s$$

USE A SAFETY FACTOR OF 2 BECAUSE OF THIS UNSYMETRIC RESTRICTION

$$\frac{1}{C_{TEE}} = \frac{1}{1{,}305} + \frac{1}{8{,}668/2} \Rightarrow \underline{C_{TEE} = 1{,}003\ \ell/s}$$

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2.4 TEE BRANCH (AT TURBOMOLECULAR PUMP TEE)

2.4.1 LENGTH

$L_e = L_{AXIAL} + 1.33\,D$

$= \frac{20}{12}\,ft + 1.33\left(\frac{12.39}{12}\,ft\right) = 3.04\,ft = 93\ cm$

$$C = \frac{\pi}{3}\sqrt{\frac{kT}{2\pi m}}\,\frac{D^3}{L}\ \left[cc/s\right]$$

$$C = \frac{\pi}{3}\sqrt{\frac{1.381\times10^{-16}\,\frac{g\text{-}cm^2}{sec^2\text{-}K}\,(300\,K)}{2\pi\ 6.64\times10^{-24}\,g}}\ \frac{\left(12.39\,in\times 2.54\,\frac{cm}{in}\right)^3}{93\,cm}$$

$= 1.106\times10^7\ cc/s = 11{,}060\ l/s$

2.4.2 APERTURE – 6"φ SCH 10S BRANCH LINE

$C = 3.64\left(\frac{T}{M}\right)^{1/2} A\ \left[l/s\right]$ (USE SMALL APERTURE EQN)

$A \equiv$ PIPE CROSS SECTIONAL AREA $= 31.74\ in^2 = 204\ cm^2$

$C = 3.64\left(\frac{300}{4}\right)^{1/2}(204) = 6{,}430\ l/s$

$\frac{1}{C_{TEE\ BRANCH}} = \frac{1}{11{,}060} + \frac{1}{6{,}430} \Rightarrow C_{TEE\ BRANCH} = \underline{4{,}066\ l/s}$

(FOR 4"φ SCH 10S BRANCH, $\frac{1}{C} = \frac{1}{11{,}060} + \frac{1}{2{,}898} \Rightarrow C = 2{,}296\ l/s$)

2.5 SUDDEN EXPANSION WHERE LN_2 SHIELD ENDS

$C = \infty$

2.6 SPACERS FOR LN_2 SHIELD

$$C = 3.64 \left(\frac{T}{M}\right)^{1/2} \frac{A\,A_0}{A_0 - A} \quad [\ell/s]$$

$A_0 \equiv$ FULL FLOW AREA $= 62.17\ in^2 = 399\ cm^2$

$A \equiv$ RESTRICTED FLOW AREA $= 54.64\ in^2 = 352\ cm^2$

$$C_{\text{PER SPACER}} = 3.64 \left(\frac{300}{4}\right)^{1/2} 352\left(\frac{399}{399-352}\right) = 94{,}200\ \ell/s$$

$$\frac{1}{C_{\text{SPACERS}}} = \frac{4}{94{,}200} \Rightarrow C_{\text{SPACERS}} = \underline{23{,}550\ \ell/s}$$

2.7 ONE LONG RADIUS 90° ELBOW FROM THE TURBOMOLECULAR PUMP TEE TO THE PUMP INLET CONNECTION –

$L_e = L_{AXIAL} + 1.33\,D$

ELBOW SIZE 6"φ SCH 10S ID = 6.357 in = 16.1 cm
$A_c = 31.74\ in^2 = 204\ cm^2$

$$L_{AXIAL} = \frac{2\pi r}{4} = \frac{2\pi}{4}(9\ in) = 14.2\ in$$

$$L_e = 14.2 + 1.33(6.357") = 22.7" = 58\ cm \quad \left[\begin{matrix}38\ cm \\ (4"\phi)\end{matrix}\right]$$

$$C = \frac{\pi}{3}\sqrt{\frac{KT}{2\pi M}}\ \frac{D^3}{L}$$

$$= \frac{\pi}{3}\sqrt{\frac{1.381\times10^{-16}\ \frac{g\text{-}cm^2}{sec^2\text{-}K}\,(300\,K)}{2\pi\,(6.64\times10^{-24}\,g)}}\ \frac{(16.1^3)\ cm^3}{58\ cm}$$

(FOR 1 – 4"φ SCH 10S ELBOW, C = 1,100 ℓ/s)

$$= 2.37\times10^6\ cc/s = \underline{2{,}374\ \ell/s}$$

2.8 HIGH VACUUM GATE VALVE AT PUMP INLET

$$C = 3{,}400\ \ell/s\sqrt{\frac{29}{4}} = 9{,}154\ \ell/s$$

(FOR 4"φ VALVE, C = 2,960 ℓ/s)

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3.0 CONDUCTANCE SUMMARY AT 300 K:
FOR 6" ϕ BRANCH LINE TO PUMP –

SUBSECTION NO.	DESCRIPTION	C_i CONDUCTANCE AT 300 K (ℓ/s)
2.1	ENTRANCE TO CHIMNEY	12,636
2.2	34' OF ANNULAR FLOW AREA	192
2.3	TEE FOR CHIMNEY BAYONET BOX	1,003
2.4	TURBOMOLECULAR PUMP TEE BRANCH	4,066
2.5	SUDDEN EXPANSION WHERE LN_2 SHIELD ENDS	∞
2.6	LN_2 SHIELD SPACERS	23,550
2.7	ONE 6"ϕ LONG RADIUS ELBOW	2,374
2.8	6" ϕ HIGH VACUUM GATE VALVE AT PUMP INLET	9,154

$$\frac{1}{C_s} = \sum \frac{1}{C_i}$$

$$= \frac{1}{12,636} + \frac{1}{192} + \frac{1}{1,003} + \frac{1}{4,066} + \frac{1}{\infty} + \frac{1}{23,550} + \frac{1}{2,374} + \frac{1}{9,154}$$

$C_{s_{6''}} = 140.8$ ℓ/s FOR 6" ϕ BRANCH LINE TO PUMP

FOR 4" ϕ BRANCH LINE TO PUMP –

$$\frac{1}{C_s} = \frac{1}{12,636} + \frac{1}{192} + \frac{1}{1,003} + \frac{1}{2,296} + \frac{1}{\infty} + \frac{1}{23,550} + \frac{1}{1,100} + \frac{1}{2,960}$$

$C_{s_{4''}} = 124.9$ ℓ/s FOR 4"ϕ BRANCH LINE TO PUMP

4.0 CONDUCTANCE SUMMARY AT 80 K:

FOR 6"φ BRANCH LINE TO PUMP –

$$C_{80K} = C_{300K}\sqrt{\frac{80}{300}} = 140.8\,\frac{\ell}{s}\sqrt{\frac{80}{300}}$$

$$= 72.7\ \ell/s$$

FOR 4"φ BRANCH LINE TO PUMP –

$$C_{80K} = 124.9\ \ell/s\sqrt{\frac{80}{300}} = 64.5\ \ell/s$$

SUBJECT: SYSTEM PUMPING SPEED AND THROUGHPUT

NAME: AMS

DATE: 10/2/90 | REVISION DATE:

$$\frac{1}{S_s} = \frac{1}{S_p} + \frac{1}{C_s}$$

1.0 FOR 6" ASA LEYBOLD TURBOMOLECULAR PUMP, $S_p = 1{,}100$ ℓ/s FOR HELIUM FOR $P \leq 4 \times 10^{-4}$ mbar $= 3 \times 10^{-4}$ torr.

CDF TRIP POINT IS 2.2×10^{-5} Torr (CORRECTED VALUE, PG 2)
NORMAL PRESSURE WOULD BE LESS THAN 5.5×10^{-7} torr (LOW END OF GAUGE, CORRECTED FOR HELIUM.)

AT 300 K:

$$\frac{1}{S_s} = \frac{1}{1{,}100} + \frac{1}{140.8}$$

$$S_s = 124.8 \ \ell/s$$

THROUGHPUT AT 2.2×10^{-5} torr –

$$Q = SP$$

$$Q_{2.2 \times 10^{-5}} = 124.8 \frac{\ell}{s} * 2.2 \times 10^{-5} \text{ torr}$$
$$= 0.0027 \ \frac{\text{torr-}\ell}{s}$$

$$0.0027 \ \frac{\text{torr-}\ell}{s} * \frac{\text{Atm}}{760 \text{ torr}} * 1000 \frac{\text{cc}}{\ell} = 3.5 \times 10^{-3} \frac{\text{Atm cc}}{s}$$

THROUGHPUT AT 5.5×10^{-7} torr –

$$Q_{5.5 \times 10^{-7}} = 124.8 \ (5.5 \times 10^{-7}) = 6.86 \times 10^{-5} \text{ torr-}\ell/s$$
$$= 9 \times 10^{-5} \text{ Atm cc/s}$$

CALCULATE HELIUM MASS FLOW RATE AT 2.2×10^{-5} torr:

$$\dot{m} = 3.5 \times 10^{-3} \frac{\text{ATM cc}}{s} * \frac{g}{6{,}153.7 \text{ ATM cc}} = 5.7 \times 10^{-7} \ g/s$$

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AT 80 K :

$$\frac{1}{S_S} = \frac{1}{1{,}100} + \frac{1}{72.7}$$

$$S_S = 68.2 \ \ell/s$$

THROUGHPUT AT 2.2×10^{-5} torr –

$$Q_{2.2\times10^{-5}} = 68.2 \ \ell/s * 2.2\times10^{-5} \text{ torr} = 0.0015 \ \frac{\text{torr-}\ell}{s}$$

$$0.0015 \ \frac{\cancel{\text{torr-}\ell}}{s} * \frac{\text{Atm}}{760 \ \cancel{\text{torr}}} * \frac{1000 \text{ cc}}{\cancel{\ell}} = 2\times10^{-3} \ \frac{\text{Atm cc}}{s}$$

THROUGHPUT AT 5.5×10^{-7} torr –

$$Q_{5.5\times10^{-7}} = 68.2\,(5.5\times10^{-7}) = 3.751\times10^{-5} \text{ torr-}\ell/s$$

$$= 4.9\times10^{-5} \text{ ATM cc}/s$$

2.0 COMPARE THROUGHPUTS

AT 2.2×10^{-5} torr –

$$\frac{Q_{300K}}{Q_{80K}} = \frac{3.5\times10^{-3} \ \frac{\text{Atm cc}}{s}}{2\times10^{-3} \ \frac{\text{Atm cc}}{s}} = 1.75$$

Q_{80K} IS 43% LESS THAN Q_{300K}.

AT 5.5×10^{-7} torr –

$$\frac{Q_{300K}}{Q_{80K}} = \frac{9\times10^{-5}}{4.9\times10^{-5}} = 1.84$$

Q_{80K} IS 46% LESS THAN Q_{300K}.

3.0 FOR 4" ASA LEYBOLD TURBOMOLECULAR PUMP, $S_p = 390$ ℓ/s
FOR HELIUM FOR $P \leq 6 \times 10^{-4}$ mbar $= 4.5 \times 10^{-4}$ torr.

AT 300 K:

$$\frac{1}{S_s} = \frac{1}{S_p} + \frac{1}{C_s} = \frac{1}{390} + \frac{1}{124.9}$$

$$S_s = 94.6 \text{ ℓ/s}$$

AT 80 K:

$$\frac{1}{S_s} = \frac{1}{390} + \frac{1}{64.5}$$

$$S_s = 55.3 \text{ ℓ/s}$$

4.0 COMPARE THROUGHPUTS

AT 300 K:

$$\frac{S_{390}}{S_{1100}} = \frac{94.6}{124.8} = 0.76$$

S_{390} IS 24 % LESS THAN S_{1100} AT 300 K.

AT 80 K:

$$\frac{S_{390}}{S_{1100}} = \frac{55.3}{68.2} = 0.81$$

S_{390} IS 19 % LESS THAN S_{1100} AT 80 K.

5.0 COMPARE PUMP SPEEDS

$$\frac{S_{390}}{S_{1100}} = \frac{390}{1100} = 0.35$$

S_{390} IS 65 % LESS THAN S_{1100}.

6.0 CALCULATE THE THROUGHPUT FOR NITROGEN

6.1 SYSTEM CONDUCTANCE VALUES

FOR 6" ϕ BRANCH LINE TO PUMP —

AT 300 K:

$$C_{N_2} = C_{He}\sqrt{\frac{M_{He}}{M_{N_2}}} = 140.8\ \ell/s\sqrt{\frac{4}{28}} = 53.2\ \ell/s$$

AT 80 K:

$$C_{N_2} = 72.7\sqrt{\frac{4}{28}} = 27.5\ \ell/s$$

FOR 4" ϕ BRANCH LINE TO PUMP —

AT 300 K:

$$C_{N_2} = 124.9\sqrt{\frac{4}{28}} = 47.2\ \ell/s$$

AT 80 K:

$$C_{N_2} = 64.5\sqrt{\frac{4}{28}} = 24.4\ \ell/s$$

6.2 CALCULATE THE THROUGHPUT AT 80 K

FOR 6" PUMP — $S_p = 1{,}150\ \ell/s$

$$\frac{1}{S_s} = \frac{1}{1{,}150} + \frac{1}{27.5} \Rightarrow S_s = 26.8\ \ell/s$$

THROUGHPUT AT 2.2×10^{-5} torr —

$$Q_{2.2\times10^{-5}} = 26.8\ \ell/s \times 2.2\times10^{-5}\ \text{torr} = 5.9\times10^{-4}\ \text{torr-}\ell/s$$

$$5.9\times10^{-4}\ \text{torr-}\ell/s\left(\frac{1000}{760}\right) = 7.8\times10^{-4}\ \text{Atm cc/s}$$

THROUGHPUT AT 5.5×10^{-7} torr —

$$Q_{5.5\times10^{-7}} = 26.8\,(5.5\times10^{-7})(1000/760) = 1.9\times10^{-5}\ \text{Atm cc/s}$$

FOR 4" PUMP – $S_p = 400$ l/s

$$\frac{1}{S_s} = \frac{1}{400} + \frac{1}{24.4} \Rightarrow S_s = 23 \text{ l/s}$$

THROUGHPUT AT 2.2×10^{-5} torr –

$$Q_{2.2\times10^{-5}} = 23\,(2.2\times10^{-5})(1000/760) = 6.7\times10^{-4}\ \frac{\text{Atm cc}}{\text{s}}$$

THROUGHPUT AT 5.5×10^{-7} torr

$$Q_{5.5\times10^{-7}} = 23\,(5.5\times10^{-7})(1000/760) = 1.7\times10^{-5}\ \frac{\text{Atm cc}}{\text{s}}$$

6.3 CALCULATE THE THROUGHPUT AT 300 K

FOR 6" PUMP –

$$\frac{1}{S_s} = \frac{1}{1{,}150} + \frac{1}{53.2} \Rightarrow S_s = 50.8 \text{ l/s}$$

THROUGHPUT AT 2.2×10^{-5} torr –

$$Q_{2.2\times10^{-5}} = 50.8\ \text{l/s} * 2.2\times10^{-5}\ \text{torr} * (1000/760)$$
$$= 1.5\times10^{-3}\ \text{Atm cc/s}$$

THROUGHPUT AT 5.5×10^{-7} torr –

$$Q_{5.5\times10^{-7}} = 50.8\,(5.5\times10^{-7})(1000/760) = 3.7\times10^{-5}$$

FOR 4" PUMP

$$\frac{1}{S_s} = \frac{1}{400} + \frac{1}{47.2} = 42.2 \text{ l/s}$$

THROUGHPUT AT 2.2×10^{-5} torr –

$$Q_{2.2\times10^{-5}} = 42.2\,(2.2\times10^{-5})(1000/760) = 1.2\times10^{-3}\ \text{Atm cc/s}$$

THROUGHPUT AT 5.5×10^{-7} torr –

$$Q_{5.5\times10^{-7}} = 42.2\,(5.5\times10^{-7})(1000/760) = 3\times10^{-5}\ \text{Atm cc/s}$$

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SUBJECT: LAYOUT (FROM §4.4 - DESIGN NOTE 115)

NAME: AMS

DATE: 9/18/90

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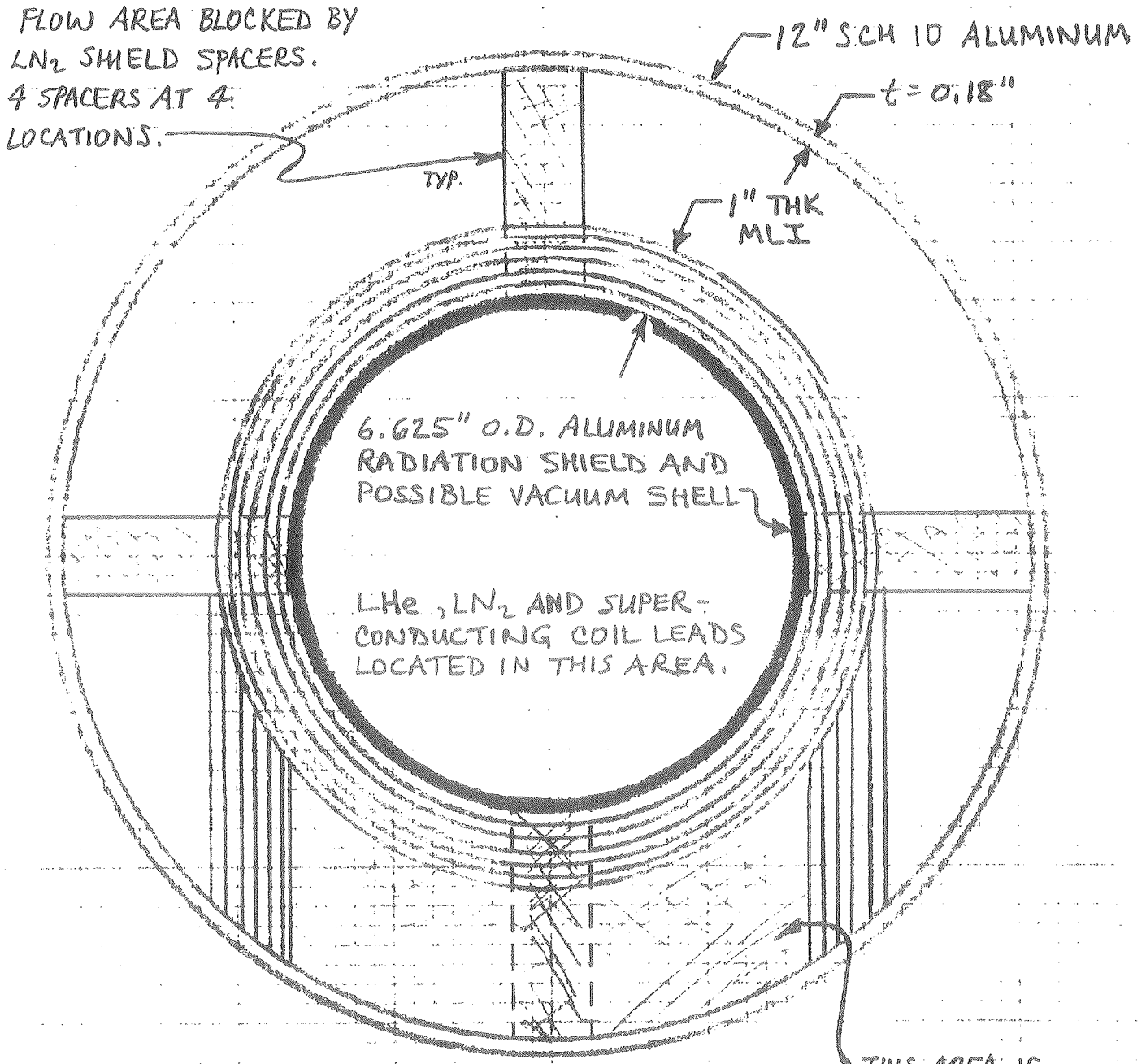
CROSS SECTION



NOTE: THE MLI SHALL BE SECURED SO THE VENTING GAS WILL NOT RIP IT OFF THE LN_2 SHIELD. FOR EXAMPLE, WRAP THE MLI WITH A FABRIC, I.E. NYLON, COVER SHEET AND SECURE THE FABRIC WITH NYLON OR STEEL (CHICKEN WIRE TYPE) MESH, OR ENCLOSE THE MLI WITH A THIN ALUMINUM JACKET.

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ENGINEERING NOTE

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6.3	SDC		17

SUBJECT

NAME: AMS

DATE: 9/18/90

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PLAN

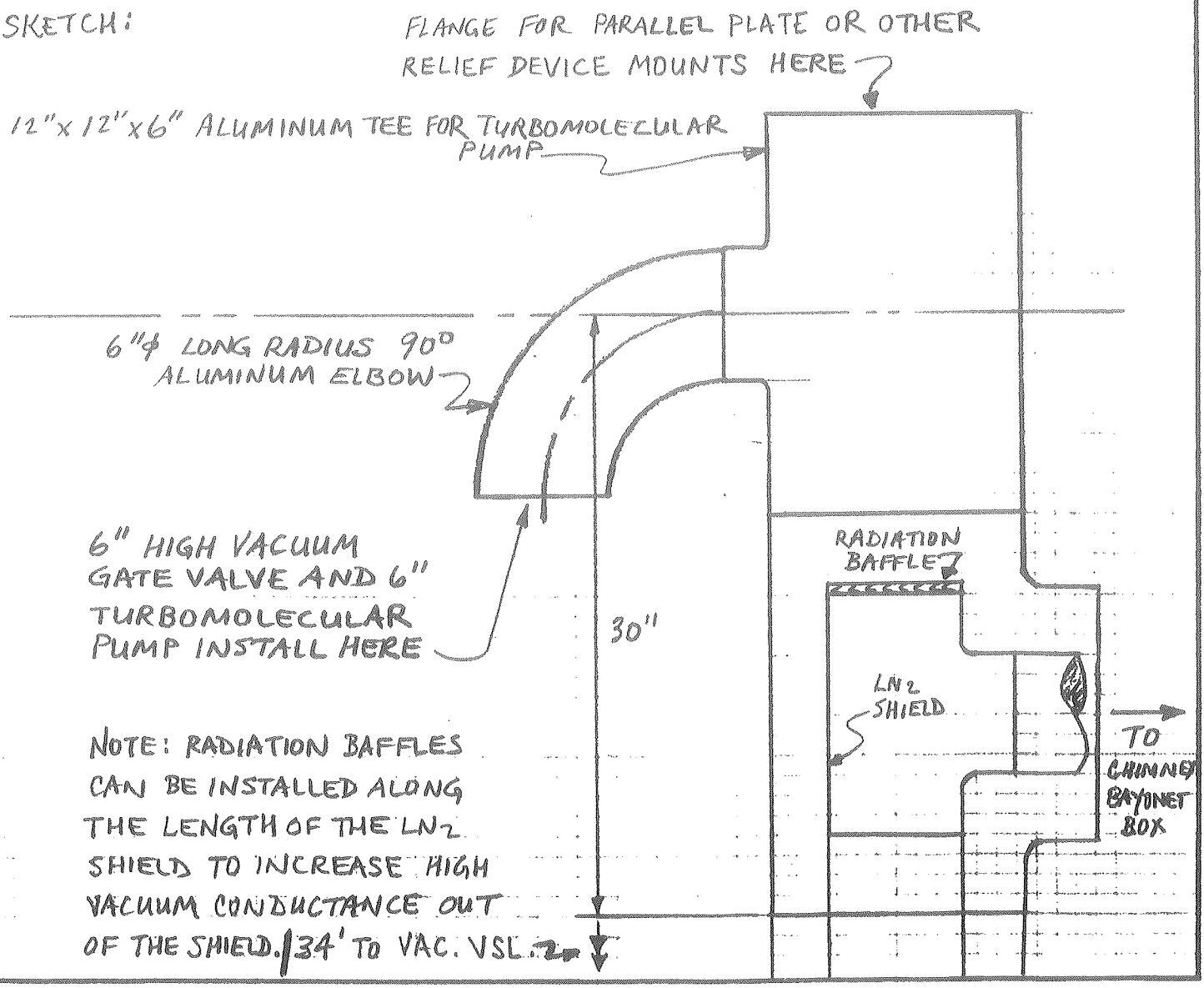
CHIMNEY LENGTH THROUGH THE DETECTOR $= 11{,}315 - \frac{2{,}200}{2} = 10{,}215\ mm$

$= 33.5\ ft$

ASSUME THE CHIMNEY EXTENDS 6" PAST THE DETECTOR BEFORE THE TEE IS ATTACHED.

$\therefore$ STRAIGHT PIPE LENGTH $= 33.5' + 0.5'$
$= 34'$

SKETCH:



NOTE: RADIATION BAFFLES CAN BE INSTALLED ALONG THE LENGTH OF THE LN_2 SHIELD TO INCREASE HIGH VACUUM CONDUCTANCE OUT OF THE SHIELD.

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