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PBAR #433

VACUUM CONSIDERATIONS PERTAINING TO BELLOWS CHANGES ON DEBUNCHER TANKS

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ENGINEERING NOTE

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P Source	Vacuum		1 of 11

SUBJECT: Vacuum considerations pertaining to bellows changes on Debuncher Tanks

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DATE: 11-13-85 | REVISION DATE:

It has been proposed that the Stochastic Cooling Tanks in the Debuncher be modified so that their position can be changed remotely by installing motor driven stands. The present bellows that connect the tanks to the beam pipe vacuum chamber does not have enough radial movement to allow the movement required of the tanks. Inorder for this proposal to be enacted, the existing bellows will have to be replaced.

The present bellows is a formed bellows 5½" I.D. x 2" long, it will be replaced by a welded bellows 4" I.D. x 4" long. Due to the smaller size of the replacement bellows, its effect on the performance of the Debuncher Vacuum System must be examined.

The areas of concern are: pump down time, pressure attained by turbos, and pressure in the high vacuum range.

Pump-down time

Pump down time is a function of roughing pump size and system volume, providing connecting piping is of appropriate size. None of these parameters are being changed, therefore reducing the size of the bellows, will have no effect on the pump-down time of the sections involved. Pump-down time at present is a few hours to 10^{-5} torr, at which pressure the ion pumps can be started.

System pressure attained by turbos

Ultimate pressure in the system as attained by the turbo pumps is of concern, because it directly affects the starting procedure for the ion pumps. During pump-down at about 10^{-3} torr the gas flow changes from viscous to molecular flow and the pressure is determined by the out-gassing rate and

pumping speed. At the ion pumps, located on the stochastic cooling tanks, the pressure is determined by the effective speed of the turbo pump. The reciprocal of the effective speed (S_c) is equal to the sum of the reciprocals of the pump speed (S_p) and the conductances of the connecting tubes.

$$\left(\frac{1}{S_c} = \frac{1}{S_p} + \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{etc}\right)$$

The pressure in the tanks where the ion pumps are located is determined by the conductance of the connecting tubes and chambers. The changing of the bellows to a smaller diameter will result in a reduction in conductance of the connecting tubes (typically 800 l/s to 600 l/s), however this will have an insignificant effect on the pressure. The special devices with small conductance values, such as Micro-wave cut-offs (43 l/s), Schottky pick-ups (32 l/s) and quad star chambers (180 l/s) will determine the pressure in the tanks as achieved by the turbos.
(Calculations pg 8 → 11)

High Vacuum Performance

The high vacuum (10^{-8} torr) is produced in these sections by ion pumps, which in most cases are located on the stochastic tanks. These pumps also pump the chambers between tanks. The smaller bellows will slightly reduce the pumping speed available between tanks and slightly raise the pressure; for example in the quad chambers. In order to calculate the change in pressure it will be estimated that each 400 l/s ion pump located on a tank has an effective speed of 200 l/s at the ends of the tanks available for pumping adjoining

chambers.

Present configuration (large bellows)

$$\frac{1}{Se} = \frac{1}{Sp} + \frac{1}{C}$$

$$Se = \frac{200 \cdot 800}{200 + 800} = 160 \text{ l/s available at quad}$$

Proposed configuration (small bellows)

$$Se = \frac{200 \cdot 600}{200 + 600} = 150 \text{ l/s available at quad}$$

Loss of pumping speed at quad (typically)

$$160 \text{ l/s} - 150 \text{ l/s} = 10 \text{ l/s}$$

The loss in pumping speed of 10 l/s (6 %) will therefore result in an increase in pressure in the quad chambers of about 6 % which will be negligable. (Conductance layouts pg 6+7)

The small bellows will have some effect on the pressure in the Tanks at D 201 and D 306, since these tanks have no ion pumps and must be pumped through the connecting tubes

Tank D 201

Present configuration (large bellows)

Speed available from tank D 202

$$\frac{1}{Se} = \frac{1}{200 \text{ l/s}} + \frac{1}{864 \text{ l/s}} + \frac{1}{182 \text{ l/s}} + \frac{1}{1209 \text{ l/s}}$$

$Se = 80$ l/s

Speed available from downstream ion pump

$$\frac{1}{Se} = \frac{1}{277 \text{ l/s}} + \frac{1}{1511 \text{ l/s}} + \frac{1}{269 \text{ l/s}}$$

$Se = 125$ l/s

Total pumping speed presently available

$$80 \text{ l/s} + 125 \text{ l/s} = 205 \text{ l/s}$$

Proposed configuration (small bellows)
Speed available from tank D 202

$$\frac{1}{Se} = \frac{1}{200\ l/s} + \frac{1}{614\ l/s} + \frac{1}{182\ l/s} + \frac{1}{771\ l/s}$$

$$Se = 74.5\ l/s$$

Speed available from downstream ion pump

$$\frac{1}{Se} = \frac{1}{277\ l/s} + \frac{1}{1511\ l/s} + \frac{1}{239\ l/s}$$

$$Se = 118\ l/s$$

Total pumping speed available (proposed)

$$74.5\ l/s + 118\ l/s = 192.5\ l/s$$

Net loss in pumping speed in tank D201 with proposed bellows change

$$205\ l/s - 192.5\ l/s = \boxed{12.5\ l/s}$$

Tank D 306

Present configuration (large bellows)
Speed available from tank D 305 (Same as D202)

$$80\ l/s$$

Speed available from downstream ion pump

$$\frac{1}{Se} = \frac{1}{277} + \frac{1}{1511} + \frac{1}{56} + \frac{1}{417} + \frac{1}{182} + \frac{1}{1209} + \frac{1}{470} + \frac{1}{269}$$

$$Se = 27\ l/s$$

Total speed presently available

$$80\ l/s + 27\ l/s = 107\ l/s$$

Proposed configuration (small bellows)
Speed available from tank D 305 (Same as D202)

$$74.5\ l/s$$

Speed available from downstream ion pump

$$\frac{1}{Se} = \frac{1}{277} + \frac{1}{1511} + \frac{1}{56} + \frac{1}{417} + \frac{1}{182} + \frac{1}{1209} + \frac{1}{470} + \frac{1}{239}$$

$Se = 26.9$ l/s

Total pumping speed available (proposed)

74.5 l/s + 26.9 l/s = 101.4 l/s

Net loss in pumping speed in tank D-306 with proposed bellows change

107 l/s − 101.4 l/s = **5.6 l/s**

The loss in pumping speed in both tanks D 201 and D 306 is minimal and should have no measurable effect on their pressure in the high-vacuum range.

Conclusion

Reducing the size of the bellows on the stochastic tanks in the debuncher will have only a slight affect on the performance of the vacuum system. There will be a small loss in the pumping speed in a few areas as stated. However, the losses will be minimal and compensated for by a reduction in outgassing as the system matures.

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SUBJECT: Debuncher Tanks D-10
Present conductances & proposed small bellows

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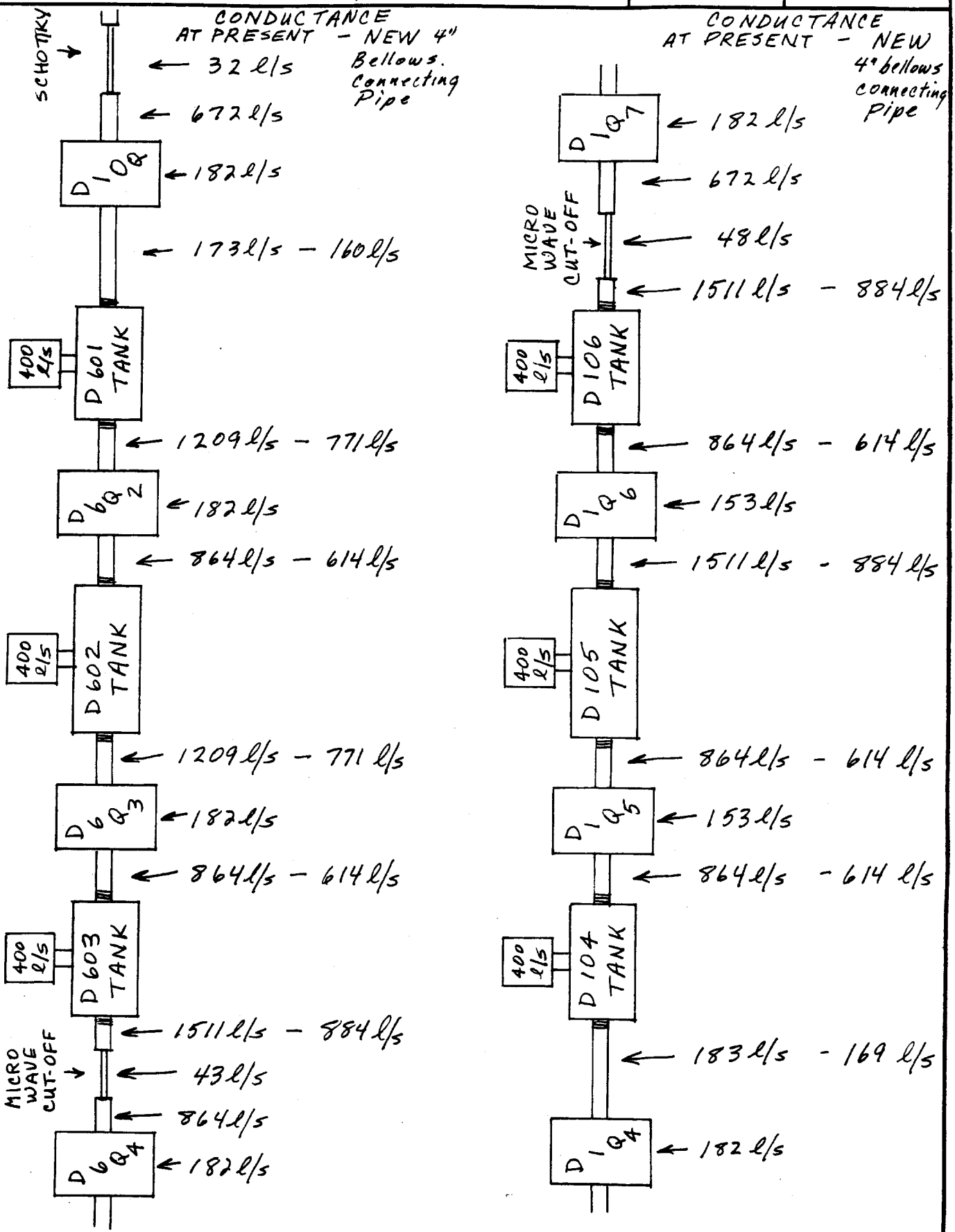

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SUBJECT: Debuncher Tanks D-30
Conductances: Present & Proposed small bellows

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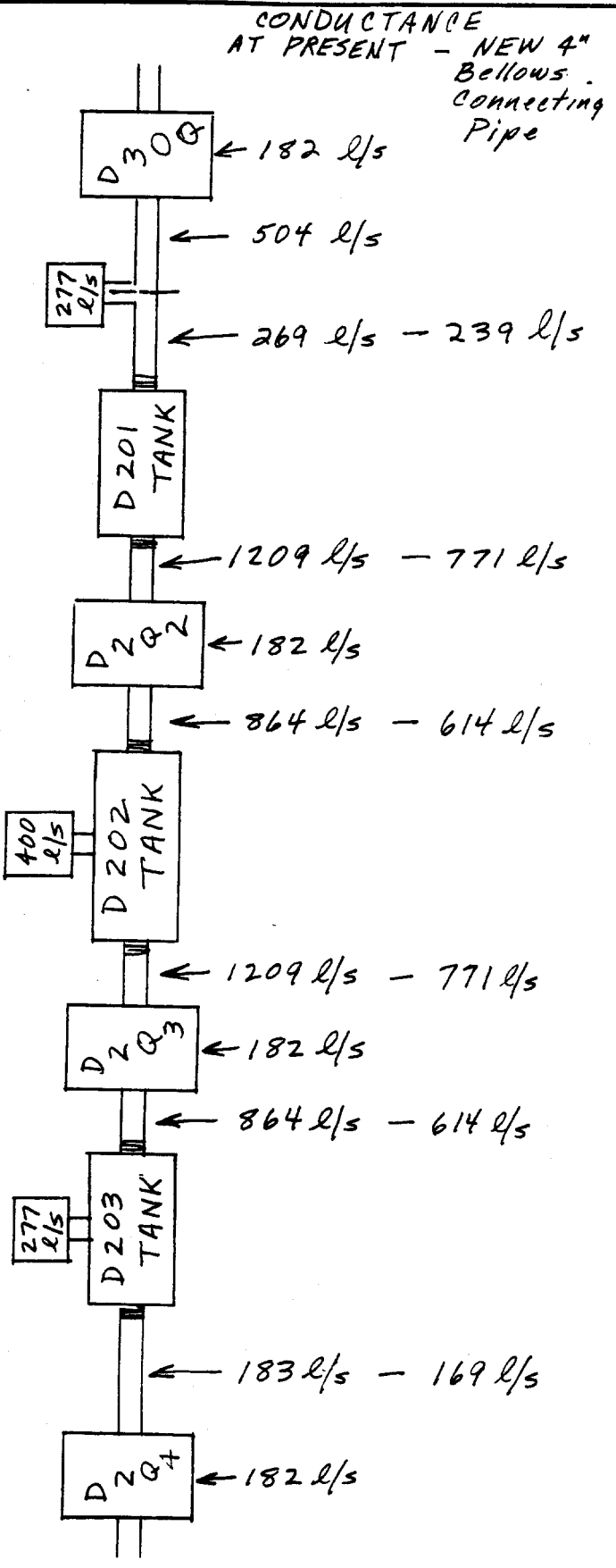

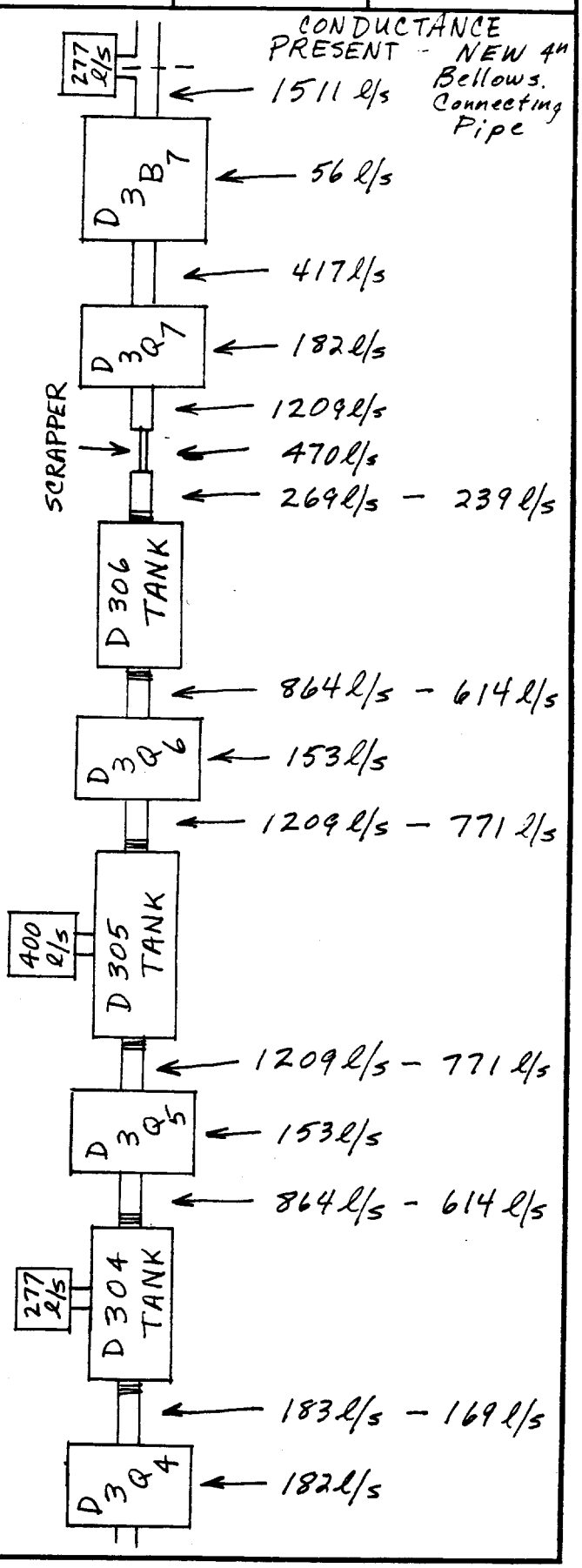

Quads (Star chambers)

$$C = 61.8 \frac{A^2 \cdot K}{B L}$$

A = cross section area = 87 cm²
B = perimeter = 42.7 cm
L = length = 66 cm, 79 cm
K = 1.1

$$C = 61.8 \frac{(87)^2 \cdot 1.1}{42.7 \cdot 66}$$

$$C = \boxed{182 \text{ l/s}}$$

$$C = 61.8 \frac{(87)^2 \cdot 1.1}{42.7 \cdot 79}$$

$$C = \boxed{153 \text{ l/s}}$$

Micro-wave Cut-offs

$$C = 12.1 \frac{d^3}{L}$$ d & L in cm

Cut-off at D603

$$C = 12.1 \frac{(7.4)^3}{114}$$

$$C = \boxed{43 \text{ l/s}}$$

Cut-off at D106

$$C = \frac{12.1 (7.4)^3}{102}$$

$$C = \boxed{48 \text{ l/s}}$$

Schottky (D101)

$$C = 12.1 \frac{d^3}{L}$$

$$C = 12.1 \frac{(6.1)^3}{86}$$

$$C = \boxed{32 \text{ l/s}}$$

Scrapper (D 306)

$$C = 12.1 \frac{d^3}{L} \qquad d \& L \text{ in cm}$$

$$C = 12.1 \frac{(9.9)^3}{25}$$

$$C = \boxed{470 \text{ l/s}}$$

Bending Magnet (D 3B7)

$$C = 30.9 \frac{a^2 b^2 K}{(a+b) L}$$

$$C = 30.9 \frac{(16.2)^2 (5.4)^2 1.2}{(16.2+5.4)\, 230}$$

$$C = \boxed{56 \text{ l/s}}$$

a = width = 16.2 cm
b = height = 5.4 cm
L = length = 230 cm
$K = 1.2$

Standard connecting tubes (5½" tube & 5½" bellows)

$$C = \frac{12.1\, d^3}{L} \qquad d \text{ \& } L \text{ in cm}$$

$$C_{4"} = \frac{12.1\,(13.64)^3}{10.16} = 3022 \text{ l/s}$$

$$C_{8"} = \frac{12.1\,(13.64)^3}{20.32} = 1511 \text{ l/s}$$

$$C_{10"} = \frac{12.1\,(13.64)^3}{25.4} = 1209 \text{ l/s}$$

$$C_{14"} = \frac{12.1\,(13.64)^3}{35.56} = 864 \text{ l/s}$$

$$C_{18"} = \frac{12.1\,(13.64)^3}{45.72} = 672 \text{ l/s}$$

$$C_{20"} = \frac{12.1\,(13.64)^3}{50.8} = 604 \text{ l/s}$$

$$C_{24"} = \frac{12.1\,(13.64)^3}{60.96} = 504 \text{ l/s}$$

$$C_{29"} = \frac{12.1\,(13.64)^3}{73.66} = 417 \text{ l/s}$$

$$C_{41"} = \frac{12.1\,(13.64)^3}{104.1} = 295 \text{ l/s}$$

$$C_{45"} = \frac{12.1\,(13.64)^3}{114.3} = 269 \text{ l/s}$$

$$C_{62"} = \frac{12.1\,(13.64)^3}{157.5} = 195 \text{ l/s}$$

$$C_{66"} = \frac{12.1\,(13.64)^3}{167.6} = 183 \text{ l/s}$$

$$C_{70"} = \frac{12.1\,(13.64)^3}{177.8} = 173 \text{ l/s}$$

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SUBJECT: Calculations: Conductance new pieces

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Proposed new bellows (4" ID × 4" long)

$$C_{\text{new bellows}} = \frac{12.1\,(10.16)^3}{10.16} = 1249 \text{ l/s}$$

Proposed new connecting tubes (5½" tube & 4" bellows)

$$\frac{1}{C_{\text{connecting tube}}} = \frac{1}{C_{5\frac{1}{2}\text{ tube}}} + \frac{1}{C_{4\text{" bellows}}}$$

$$C_{\text{proposed new tubes}} = \frac{C_{5\frac{1}{2}\text{ tube}} \cdot C_{4\text{" bellows}}}{C_{5\frac{1}{2}\text{ tube}} + C_{4\text{" bellows}}}$$

$$C_{\text{new 8"}} = \frac{3022 \cdot 1249}{3022 + 1249} = 884 \text{ l/s}$$

$$C_{\text{new 10"}} = \frac{2014 \cdot 1249}{2014 + 1249} = 771 \text{ l/s}$$

$$C_{\text{new 14"}} = \frac{1209 \cdot 1249}{1209 + 1249} = 614 \text{ l/s}$$

$$C_{\text{new 45"}} = \frac{295 \cdot 1249}{295 + 1249} = 239 \text{ l/s}$$

$$C_{\text{new 66"}} = \frac{195 \cdot 1249}{195 + 1249} = 169 \text{ l/s}$$

$$C_{\text{new 70"}} = \frac{183 \cdot 1249}{183 + 1249} = 160 \text{ l/s}$$