PRESSURE DROP IN RADON CONTROL PIPES

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ABSTRACT

Design of radon mitigation systems requires the designer to choose among the available fan sizes and to choose a fan with pressure-flow characteristics which match the application. The mitigator is also faced with a choice of pipe size and material, and must choose a routing through the structure which is acceptable to the customer and which will not disrupt system function with excessive pressure drop. This paper presents a tabulation of pressure drops for use in selecting pipe size and routing for radon control system pipes. The calculated pressure drop in the pipework can also be used to assist in fan selection.

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INTRODUCTION

When a radon mitigation system is designed, the designer is faced with a number of decisions. In the ideal situation, there would be an adequate bed of crushed stone under the concrete floor of the basement. There would be a convenient place to run the suction pipe from the basement directly to the attic, and an electrical connection for the fan. There would be no need for elbows in the suction pipe, and the walls (or chase) would be big enough to accommodate whatever pipe size is chosen.

Unfortunately, in a real mitigation these conditions are seldom found. Instead, the mitigator is forced to route the pipes through walls which are too small to accommodate 4 inch pipe, go around corners using many elbows, and generally install the pipework in a non-optimum fashion. The question that must be asked is whether the fan chosen can move the required volume of air through all this pipe. Will a bigger fan be needed, or will the pipe size and routing have to be changed?

This paper presents a simple scheme to calculate the pressure drop in smooth-walled radon control pipe. Pipe sizes from 1.5 inch to 6 inch are treated. The calculations are for plastic pipe as is commonly used in radon control applications. Once the required flow has been determined and the pipe size and routing chosen, it is relatively easy to determine if the pressure drop will be excessive. If the required flow is not known, it can be determined experimentally. In general, the required flow will be sufficient to produce a .015 inch water column vacuum across the entire slab. While good radon reduction may be achieved with lesser flow under some conditions, "Application of Radon Reduction Methods" (EPA/625/5-88-024) suggests that .015 inch of vacuum is needed to assure reliable system operation.

CALCULATIONS

Pressure drop in the pipe may be calculated from the equivalent length of straight pipe used in the system. This equivalent length may be calculated by adding the length of straight run to the equivalent length of the elbows and transitions. Each elbow and each reducer can be assumed to have an equivalent length of 10 times the diameter of the pipe. Thus an elbow in a 4 inch pipe would have an equivalent length of 10 times 1/3 foot or 3.3 feet. For a reducer, use either the outlet (downstream) size. A 3x4 reducer would have an equivalent length of either 3.3 feet of 4 inch pipe or 2.5 feet of 3 inch pipe.

DERIVATION OF PRESSURE DROP TABLES:

For fully turbulent flow $h_f = f\frac{L}{D}\frac{V^2}{2g}$ (1)

This is the Darcy-Weisbach equation.

For laminar flow $h_f = \frac{64}{Re}\frac{L}{D}\frac{V^2}{2g}$ (2)

where: h_f is the head in feet of air (which must be transformed into inches of water).

f is a friction factor which is a function of pipe roughness and other parameters.

L is the length of the pipe.

V is the velocity of fluid flow.

D id the pipe diameter.

Re is the Reynolds number.

g is gravitational acceleration.

From the Moody diagram, f will be about .03 for smooth pipes at the flow rates which are most likely. f tends to decrease at large Reynolds numbers for very smooth pipes, but less so for slightly rough pipes. Because the internal roughness of the pipe is not closely controlled, f is assumed to be .03 for all flow rates. This will yield a somewhat higher pressure drop at very high flow rates, but will prevent underestimation of the pipe size required.

The transition from laminar to turbulent flow in pipes occurs at Re between 2000 and 4000.

$Re = \frac{V\ D}{v}$ (3)

where: v, the kinematic viscosity of air at sea level is $1.6 \times 10^{-4}\ ft^2/sec$.

For a 4 inch pipe, this gives a transition velocity of 1 to 2 feet per second. For 6-inch pipe the transition velocity is somewhat lower. In a 4-inch pipe, this corresponds to only 5 to 10 cfm, so most radon control systems will operate in the turbulent regime. In addition, the presence of elbows and other discontinuities will favor turbulent flow. For this reason, turbulent flow equations are used for pressure drop calculations in this paper. This will yield an estimate of the maximum expected pressure drop.

The pressure drop h_f is given in feet of air in the Darcy-Weisbach equation(1). This may be converted to inches of water by multiplying by 0.0147. Solving for head loss in inches of water for one foot of pipe yields the following:

$$\text{head loss (inches of water)} = .0147 \times .03 \times \frac{1}{D} \times \frac{V^2}{64} \qquad (4)$$

where: V is velocity in feet per second or

$$.0147 \times .03 \times \frac{1}{D} \times \frac{V^2}{230400} \qquad (5)$$

where: V is velocity in feet per minute.

Performing the arithmetic, this translates to

$$\text{head loss in inches of water} = 1.9 \times 10^{-9} \times \frac{V^2}{D} \qquad (6)$$

per foot of pipe where D is in feet.

For 1.5 inch pipe, this yields $15.2 \times 10^{-9} \times V^2$ per foot.

For 3 inch pipe, this yields $7.6 \times 10^{-9} \times V^2$ per foot.

For 4 inch pipe, this yields $5.7 \times 10^{-9} \times V^2$ per foot.

For 6 inch pipe, this yields $3.8 \times 10^{-9} \times V^2$ per foot.

For the calculation of pressure drop, the equivalent pipe length should be used. This means that 10 times the diameter (in feet) of the pipe should be added for each elbow and size transition to be used.

Example:

A radon system must have a flow of 65 CFM in order to maintain a required vacuum of .5 inches of water. The pipe routing requires 7 elbows and forty feet of straight run. What will be the pressure drop in a four inch pipe?

Seven elbows in four inch pipe are equivalent to 3.3 x 7 or 23.1 feet of straight pipe. Adding the 40 feet of straight run yields 63.1 feet equivalent length.

The cross sectional area of a 4 inch pipe is .09 sq ft, so to carry 65 cfm will require a velocity of 722 ft. per minute. 722 squared times 5.7×10^{-9} = .003 inches of water column per foot or .19 inches of water for the whole pipe.

The fan must therefore operate at about .7 inches of water (.5 +.19) at 65 cfm to make the system work. A larger pipe would reduce the pressure drop, while a smaller pipe could produce so much restriction that the system might fail to work.

For example, a 3 inch pipe of the same length and same number of elbows would have an equivalent length of 57.5 feet. The velocity would be 1324 fpm and the pressure drop would be .76 inches of water. A small fan would not adequately run this system.

PRESSURE DROP TABLES

The calculations presented above are not difficult if a scientific calculator is available. However, for use on the jobsite it is far more convenient to use a table look-up. The author has therefore compiled tables for use in calculating pressure drop for each of the commonly used pipe sizes. To use the tables, first determine the length of straight pipe to be used. Then add to this length ten times the diameter of each elbow or transition. Divide the pipe diameter by 12 first so the result will be in feet. If there are reducers, add 10 times the diameter (in feet) of the downstream pipe from each reducer.

Round off the length to the nearest 10 feet and use the nearest available flow rate from the table. This will not be the exact answer, but will be close enough to determine whether the system will have to be redesigned before it is installed. This is a lot easier and cheaper than installing a marginal system and finding out later that it does not work. The example above can be worked out using the tables. This exercise is left to the reader. It can be seen that the results from the tables is about the same as given by the calculations.

REFERENCES

Handbook of Engineering Fundamentals; Eshbach, O. W.; John Wiley & Sons; New York, NY

Application of Radon Reduction Methods; Environmental Protection Agency; EPA 625/5-88/024; 1988

HEAD LOSS USING 1.5 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 10	20	30	40	50	60
2	163	0.00	0.01	0.01	0.02	0.02	0.02
4	326	0.02	0.03	0.05	0.07	0.08	0.10
6	489	0.04	0.07	0.11	0.15	0.18	0.22
8	652	0.07	0.13	0.20	0.26	0.33	0.39
10	815	0.10	0.20	0.31	0.41	0.51	0.61
12	978	0.15	0.29	0.44	0.59	0.73	0.88
14	1141	0.20	0.40	0.60	0.80	1.0	1.2
16	1304	0.26	0.52	0.78	1.0	1.3	1.6
18	1467	0.33	0.66	1.0	1.3	1.6	2.0
20	1630	0.41	0.81	1.2	1.6	2.0	2.4
22	1793	0.49	1.0	1.5	2.0	2.5	3.0
24	1956	0.59	1.2	1.8	2.3	2.9	3.5
26	2119	0.69	1.4	2.1	2.7	3.4	4.1
28	2282	0.80	1.6	2.4	3.2	4.0	4.8
30	2445	0.92	1.8	2.7	3.7	4.6	5.5
32	2608	1.0	2.1	3.1	4.2	5.2	6.2
34	2771	1.2	2.4	3.5	4.7	5.9	7.1
36	2934	1.3	2.6	4.0	5.3	6.6	7.9
38	3097	1.5	2.9	4.4	5.9	7.3	8.8
40	3259	1.6	3.3	4.9	6.5	8.1	10
42	3422	1.8	3.6	5.4	7.2	9.0	11
44	3585	2.0	3.9	5.9	7.9	10	12
46	3748	2.2	4.3	6.5	8.6	11	13
48	3911	2.3	4.7	7.0	9.4	12	14
50	4074	2.5	5.1	7.6	10	13	15
52	4237	2.7	5.5	8.2	11	14	16
54	4400	3.0	5.9	8.9	12	15	18
56	4563	3.2	6.4	10	13	16	19
58	4726	3.4	6.8	10	14	17	21
60	4889	3.7	7.3	11	15	18	22
62	5052	3.9	7.8	12	16	20	23
64	5215	4.2	8.3	12	17	21	25
66	5378	4.4	8.9	13	18	22	27
68	5541	4.7	9.4	14	19	24	28
70	5704	5.0	10	15	20	25	30
72	5867	5.3	11	16	21	26	32
74	6030	5.6	11	17	22	28	33
76	6193	5.9	12	18	23	29	35
78	6356	6.2	12	19	25	31	37
80	6519	6.5	13	20	26	33	39
82	6682	6.8	14	21	27	34	41
84	6845	7.2	14	22	29	36	43
86	7008	7.5	15	23	30	38	45
88	7171	7.9	16	24	31	39	47
90	7334	8.2	16	25	33	41	49
92	7497	8.6	17	26	34	43	52
94	7660	9.0	18	27	36	45	54
96	7823	9.4	19	28	37	47	56
98	7986	10	20	29	39	49	59
100	8149	10	20	31	41	51	61

HEAD LOSS USING 1.5 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 70	80	90	100	110	120
2	163	0.03	0.03	0.04	0.04	0.04	0.05
4	326	0.1	0.1	0.1	0.2	0.2	0.2
6	489	0.3	0.3	0.3	0.4	0.4	0.4
8	652	0.5	0.5	0.6	0.7	0.7	0.8
10	815	0.7	0.8	0.9	1.0	1.1	1.2
12	978	1.0	1.2	1.3	1.5	1.6	1.8
14	1141	1.4	1.6	1.8	2.0	2.2	2.4
16	1304	1.8	2.1	2.3	2.6	2.9	3.1
18	1467	2.3	2.6	3.0	3.3	3.6	4.0
20	1630	2.8	3.3	3.7	4.1	4.5	4.9
22	1793	3.4	3.9	4.4	4.9	5.4	5.9
24	1956	4.1	4.7	5.3	5.9	6.4	7.0
26	2119	4.8	5.5	6.2	6.9	7.6	8.2
28	2282	5.6	6.4	7.2	8.0	8.8	9.6
30	2445	6.4	7.3	8.2	9.2	10	11
32	2608	7.3	8.3	9.4	10	11	12
34	2771	8.2	9.4	11	12	13	14
36	2934	9.2	11	12	13	14	16
38	3097	10	12	13	15	16	18
40	3259	11	13	15	16	18	20
42	3422	13	14	16	18	20	22
44	3585	14	16	18	20	22	24
46	3748	15	17	19	22	24	26
48	3911	16	19	21	23	26	28
50	4074	18	20	23	25	28	31
52	4237	19	22	25	27	30	33
54	4400	21	24	27	30	33	36
56	4563	22	26	29	32	35	38
58	4726	24	27	31	34	38	41
60	4889	26	29	33	37	40	44
62	5052	27	31	35	39	43	47
64	5215	29	33	37	42	46	50
66	5378	31	35	40	44	49	53
68	5541	33	38	42	47	52	56
70	5704	35	40	45	50	55	60
72	5867	37	42	47	53	58	63
74	6030	39	45	50	56	61	67
76	6193	41	47	53	59	65	70
78	6356	43	49	56	62	68	74
80	6519	46	52	59	65	72	78
82	6682	48	55	62	68	75	82
84	6845	50	57	65	72	79	86
86	7008	53	60	68	75	83	90
88	7171	55	63	71	79	87	94
90	7334	58	66	74	82	91	99
92	7497	60	69	77	86	95	103
94	7660	63	72	81	90	99	108
96	7823	66	75	84	94	103	112
98	7986	68	78	88	98	107	117
100	8149	71	81	92	102	112	122

HEAD LOSS USING 2 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 10	20	30	40	50	60
5	229	0.01	0.01	0.02	0.02	0.03	0.04
10	458	0.02	0.05	0.07	0.10	0.12	0.14
15	688	0.05	0.11	0.16	0.22	0.27	0.33
20	917	0.10	0.19	0.29	0.39	0.48	0.58
25	1146	0.15	0.30	0.45	0.60	0.75	0.90
30	1375	0.22	0.43	0.65	0.87	1.1	1.3
35	1604	0.30	0.59	0.89	1.2	1.5	1.8
40	1833	0.39	0.77	1.2	1.5	1.9	2.3
45	2063	0.49	1.0	1.5	2.0	2.4	2.9
50	2292	0.60	1.2	1.8	2.4	3.0	3.6
55	2521	0.73	1.5	2.2	2.9	3.6	4.4
60	2750	0.87	1.7	2.6	3.5	4.3	5.2
65	2979	1.0	2.0	3.1	4.1	5.1	6.1
70	3209	1.2	2.4	3.5	4.7	5.9	7.1
75	3438	1.4	2.7	4.1	5.4	6.8	8.1
80	3667	1.5	3.1	4.6	6.2	7.7	9.3
85	3896	1.7	3.5	5.2	7.0	8.7	10
90	4125	2.0	3.9	5.9	7.8	9.8	12
95	4354	2.2	4.4	6.5	8.7	11	13
100	4584	2.4	4.8	7.2	9.7	12	14
105	4813	2.7	5.3	8.0	11	13	16
110	5042	2.9	5.8	8.8	12	15	18
115	5271	3.2	6.4	9.6	13	16	19
120	5500	3.5	6.9	10	14	17	21
125	5730	3.8	7.5	11	15	19	23
130	5959	4.1	8.2	12	16	20	24
135	6188	4.4	8.8	13	18	22	26
140	6417	4.7	9.5	14	19	24	28
145	6646	5.1	10	15	20	25	30
150	6875	5.4	11	16	22	27	33
155	7105	5.8	12	17	23	29	35
160	7334	6.2	12	19	25	31	37
165	7563	6.6	13	20	26	33	39
170	7792	7.0	14	21	28	35	42
175	8021	7.4	15	22	30	37	44
180	8251	7.8	16	23	31	39	47
185	8480	8.3	17	25	33	41	50
190	8709	8.7	17	26	35	44	52
195	8938	9.2	18	28	37	46	55
200	9167	9.7	19	29	39	48	58
205	9396	10	20	30	41	51	61
210	9626	11	21	32	43	53	64
215	9855	11	22	33	45	56	67
220	10084	12	23	35	47	58	70
225	10313	12	24	37	49	61	73
230	10542	13	26	38	51	64	77
235	10772	13	27	40	53	67	80
240	11001	14	28	42	56	69	83
245	11230	14	29	43	58	72	87
250	11459	15	30	45	60	75	90

HEAD LOSS USING 2 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 70	80	90	100	110	120
5	229	0.04	0.05	0.05	0.06	0.07	0.07
10	458	0.17	0.19	0.22	0.24	0.27	0.29
15	688	0.38	0.43	0.49	0.54	0.60	0.65
20	917	0.68	0.77	0.87	0.97	1.1	1.2
25	1146	1.1	1.2	1.4	1.5	1.7	1.8
30	1375	1.5	1.7	2.0	2.2	2.4	2.6
35	1604	2.1	2.4	2.7	3.0	3.3	3.5
40	1833	2.7	3.1	3.5	3.9	4.2	4.6
45	2063	3.4	3.9	4.4	4.9	5.4	5.9
50	2292	4.2	4.8	5.4	6.0	6.6	7.2
55	2521	5.1	5.8	6.6	7.3	8.0	8.8
60	2750	6.1	6.9	7.8	8.7	9.6	10
65	2979	7.1	8.2	9.2	10	11	12
70	3209	8.3	9.5	11	12	13	14
75	3438	9.5	11	12	14	15	16
80	3667	11	12	14	15	17	19
85	3896	12	14	16	17	19	21
90	4125	14	16	18	20	21	23
95	4354	15	17	20	22	24	26
100	4584	17	19	22	24	27	29
105	4813	19	21	24	27	29	32
110	5042	20	23	26	29	32	35
115	5271	22	26	29	32	35	38
120	5500	24	28	31	35	38	42
125	5730	26	30	34	38	41	45
130	5959	29	33	37	41	45	49
135	6188	31	35	40	44	48	53
140	6417	33	38	43	47	52	57
145	6646	36	41	46	51	56	61
150	6875	38	43	49	54	60	65
155	7105	41	46	52	58	64	70
160	7334	43	49	56	62	68	74
165	7563	46	53	59	66	72	79
170	7792	49	56	63	70	77	84
175	8021	52	59	67	74	81	89
180	8251	55	63	70	78	86	94
185	8480	58	66	74	83	91	99
190	8709	61	70	78	87	96	105
195	8938	64	73	83	92	101	110
200	9167	68	77	87	97	106	116
205	9396	71	81	91	101	112	122
210	9626	74	85	96	106	117	128
215	9855	78	89	100	112	123	134
220	10084	82	93	105	117	128	140
225	10313	86	98	110	122	134	147
230	10542	89	102	115	128	140	153
235	10772	93	107	120	133	147	160
240	11001	97	111	125	139	153	167
245	11230	101	116	130	145	159	174
250	11459	106	121	136	151	166	181

HEAD LOSS USING 3 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 10	20	30	40	50	60
10	204	0.003	0.006	0.01	0.01	0.02	0.02
20	407	0.01	0.03	0.04	0.05	0.06	0.08
30	611	0.03	0.06	0.09	0.11	0.14	0.17
40	815	0.05	0.10	0.15	0.20	0.25	0.31
50	1019	0.08	0.16	0.24	0.32	0.40	0.48
60	1222	0.11	0.23	0.34	0.46	0.57	0.69
70	1426	0.16	0.31	0.47	0.62	0.78	0.93
80	1630	0.20	0.41	0.61	0.81	1.0	1.2
90	1833	0.26	0.51	0.77	1.0	1.3	1.5
100	2037	0.32	0.64	0.95	1.3	1.6	1.9
110	2241	0.38	0.77	1.2	1.5	1.9	2.3
120	2445	0.46	0.92	1.4	1.8	2.3	2.7
130	2648	0.54	1.1	1.6	2.1	2.7	3.2
140	2852	0.62	1.2	1.9	2.5	3.1	3.7
150	3056	0.71	1.4	2.1	2.9	3.6	4.3
160	3259	0.81	1.6	2.4	3.3	4.1	4.9
170	3463	0.92	1.8	2.8	3.7	4.6	5.5
180	3667	1.0	2.1	3.1	4.1	5.1	6.2
190	3871	1.1	2.3	3.4	4.6	5.7	6.9
200	4074	1.3	2.5	3.8	5.1	6.4	7.6
210	4278	1.4	2.8	4.2	5.6	7.0	8.4
220	4482	1.5	3.1	4.6	6.2	7.7	9.2
230	4686	1.7	3.4	5.0	6.7	8.4	10
240	4889	1.8	3.7	5.5	7.3	9.2	11
250	5093	2.0	4.0	6.0	7.9	9.9	12
260	5297	2.1	4.3	6.4	8.6	11	13
270	5500	2.3	4.6	6.9	9.3	12	14
280	5704	2.5	5.0	7.5	10	12	15
290	5908	2.7	5.3	8.0	11	13	16
300	6112	2.9	5.7	8.6	11	14	17
310	6315	3.1	6.1	9.2	12	15	18
320	6519	3.3	6.5	9.8	13	16	20
330	6723	3.5	6.9	10	14	17	21
340	6926	3.7	7.3	11	15	18	22
350	7130	3.9	7.8	12	16	19	23
360	7334	4.1	8.2	12	16	21	25
370	7538	4.3	8.7	13	17	22	26
380	7741	4.6	9.2	14	18	23	28
390	7945	4.8	9.7	14	19	24	29
400	8149	5.1	10	15	20	25	31
410	8352	5.3	11	16	21	27	32
420	8556	5.6	11	17	22	28	34
430	8760	5.9	12	18	24	29	35
440	8964	6.2	12	18	25	31	37
450	9167	6.4	13	19	26	32	39
460	9371	6.7	13	20	27	34	40
470	9575	7.0	14	21	28	35	42
480	9778	7.3	15	22	29	37	44
490	9982	7.6	15	23	31	38	46
500	10186	7.9	16	24	32	40	48

HEAD LOSS USING 3 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 70	80	90	100	110	120
10	204	0.02	0.03	0.03	0.03	0.03	0.04
20	407	0.09	0.10	0.11	0.13	0.14	0.15
30	611	0.20	0.23	0.26	0.29	0.31	0.34
40	815	0.36	0.41	0.46	0.51	0.56	0.61
50	1019	0.56	0.64	0.71	0.79	0.87	0.95
60	1222	0.80	0.92	1.0	1.1	1.3	1.4
70	1426	1.1	1.2	1.4	1.6	1.7	1.9
80	1630	1.4	1.6	1.8	2.0	2.2	2.4
90	1833	1.8	2.1	2.3	2.6	2.8	3.1
100	2037	2.2	2.5	2.9	3.2	3.5	3.8
110	2241	2.7	3.1	3.5	3.8	4.2	4.6
120	2445	3.2	3.7	4.1	4.6	5.0	5.5
130	2648	3.8	4.3	4.8	5.4	5.9	6.4
140	2852	4.4	5.0	5.6	6.2	6.9	7.5
150	3056	5.0	5.7	6.4	7.1	7.9	8.6
160	3259	5.7	6.5	7.3	8.1	8.9	9.8
170	3463	6.4	7.3	8.3	9.2	10	11
180	3667	7.2	8.2	9.3	10	11	12
190	3871	8.0	9.2	10	11	13	14
200	4074	8.9	10	11	13	14	15
210	4278	9.8	11	13	14	15	17
220	4482	11	12	14	15	17	18
230	4686	12	13	15	17	18	20
240	4889	13	15	16	18	20	22
250	5093	14	16	18	20	22	24
260	5297	15	17	19	21	24	26
270	5500	16	19	21	23	25	28
280	5704	17	20	22	25	27	30
290	5908	19	21	24	27	29	32
300	6112	20	23	26	29	31	34
310	6315	21	24	27	31	34	37
320	6519	23	26	29	33	36	39
330	6723	24	28	31	35	38	42
340	6926	26	29	33	37	40	44
350	7130	27	31	35	39	43	47
360	7334	29	33	37	41	45	49
370	7538	30	35	39	43	48	52
380	7741	32	37	41	46	50	55
390	7945	34	39	43	48	53	58
400	8149	36	41	46	51	56	61
410	8352	37	43	48	53	59	64
420	8556	39	45	50	56	62	67
430	8760	41	47	53	59	65	71
440	8964	43	49	55	62	68	74
450	9167	45	51	58	64	71	77
460	9371	47	54	61	67	74	81
470	9575	49	56	63	70	77	84
480	9778	51	59	66	73	81	88
490	9982	53	61	69	76	84	92
500	10186	56	64	71	79	87	95

HEAD LOSS USING 4 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 10	20	30	40	50	60
10	115	0.0008	0.002	0.002	0.003	0.004	0.005
20	229	0.003	0.006	0.009	0.01	0.02	0.02
30	344	0.007	0.01	0.02	0.03	0.03	0.04
40	458	0.01	0.02	0.04	0.05	0.06	0.07
50	573	0.02	0.04	0.06	0.08	0.09	0.11
60	688	0.03	0.05	0.08	0.11	0.14	0.16
70	802	0.04	0.07	0.11	0.15	0.18	0.22
80	917	0.05	0.10	0.14	0.19	0.24	0.29
90	1031	0.06	0.12	0.18	0.24	0.31	0.37
100	1146	0.08	0.15	0.23	0.30	0.38	0.45
110	1261	0.09	0.18	0.27	0.36	0.46	0.55
120	1375	0.11	0.22	0.33	0.43	0.54	0.65
130	1490	0.13	0.25	0.38	0.51	0.64	0.76
140	1604	0.15	0.30	0.44	0.59	0.74	0.89
150	1719	0.17	0.34	0.51	0.68	0.85	1.0
160	1833	0.19	0.39	0.58	0.77	0.97	1.2
170	1948	0.22	0.44	0.65	0.87	1.1	1.3
180	2063	0.24	0.49	0.73	0.98	1.2	1.5
190	2177	0.27	0.54	0.82	1.1	1.4	1.6
200	2292	0.30	0.60	0.90	1.2	1.5	1.8
210	2406	0.33	0.67	1.00	1.3	1.7	2.0
220	2521	0.36	0.73	1.1	1.5	1.8	2.2
230	2636	0.40	0.80	1.2	1.6	2.0	2.4
240	2750	0.43	0.87	1.3	1.7	2.2	2.6
250	2865	0.47	0.94	1.4	1.9	2.4	2.8
260	2979	0.51	1.0	1.5	2.0	2.5	3.1
270	3094	0.55	1.1	1.6	2.2	2.7	3.3
280	3209	0.59	1.2	1.8	2.4	3.0	3.5
290	3323	0.63	1.3	1.9	2.5	3.2	3.8
300	3438	0.68	1.4	2.0	2.7	3.4	4.1
310	3552	0.72	1.4	2.2	2.9	3.6	4.3
320	3667	0.77	1.5	2.3	3.1	3.9	4.6
330	3782	0.82	1.6	2.5	3.3	4.1	4.9
340	3896	0.87	1.7	2.6	3.5	4.4	5.2
350	4011	0.92	1.8	2.8	3.7	4.6	5.5
360	4125	0.98	2.0	2.9	3.9	4.9	5.9
370	4240	1.0	2.1	3.1	4.1	5.2	6.2
380	4354	1.1	2.2	3.3	4.4	5.4	6.5
390	4469	1.1	2.3	3.4	4.6	5.7	6.9
400	4584	1.2	2.4	3.6	4.8	6.0	7.2
410	4698	1.3	2.5	3.8	5.1	6.3	7.6
420	4813	1.3	2.7	4.0	5.3	6.7	8.0
430	4927	1.4	2.8	4.2	5.6	7.0	8.4
440	5042	1.5	2.9	4.4	5.8	7.3	8.8
450	5157	1.5	3.1	4.6	6.1	7.6	9.2
460	5271	1.6	3.2	4.8	6.4	8.0	9.6
470	5386	1.7	3.3	5.0	6.7	8.3	10
480	5500	1.7	3.5	5.2	6.9	8.7	10
490	5615	1.8	3.6	5.4	7.2	9.1	11
500	5730	1.9	3.8	5.7	7.5	9.4	11

HEAD LOSS USING 4 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 70	80	90	100	110	120
10	115	0.005	0.006	0.007	0.008	0.008	0.009
20	229	0.02	0.02	0.03	0.03	0.03	0.04
30	344	0.05	0.05	0.06	0.07	0.07	0.08
40	458	0.08	0.10	0.11	0.12	0.13	0.14
50	573	0.13	0.15	0.17	0.19	0.21	0.23
60	688	0.19	0.22	0.24	0.27	0.30	0.33
70	802	0.26	0.30	0.33	0.37	0.41	0.44
80	917	0.34	0.39	0.43	0.48	0.53	0.58
90	1031	0.43	0.49	0.55	0.61	0.67	0.73
100	1146	0.53	0.60	0.68	0.75	0.83	0.90
110	1261	0.64	0.73	0.82	0.91	1.0	1.1
120	1375	0.76	0.87	0.98	1.1	1.2	1.3
130	1490	0.89	1.0	1.1	1.3	1.4	1.5
140	1604	1.0	1.2	1.3	1.5	1.6	1.8
150	1719	1.2	1.4	1.5	1.7	1.9	2.0
160	1833	1.4	1.5	1.7	1.9	2.1	2.3
170	1948	1.5	1.7	2.0	2.2	2.4	2.6
180	2063	1.7	2.0	2.2	2.4	2.7	2.9
190	2177	1.9	2.2	2.4	2.7	3.0	3.3
200	2292	2.1	2.4	2.7	3.0	3.3	3.6
210	2406	2.3	2.7	3.0	3.3	3.7	4.0
220	2521	2.6	2.9	3.3	3.6	4.0	4.4
230	2636	2.8	3.2	3.6	4.0	4.4	4.8
240	2750	3.0	3.5	3.9	4.3	4.8	5.2
250	2865	3.3	3.8	4.2	4.7	5.2	5.7
260	2979	3.6	4.1	4.6	5.1	5.6	6.1
270	3094	3.8	4.4	4.9	5.5	6.0	6.6
280	3209	4.1	4.7	5.3	5.9	6.5	7.1
290	3323	4.4	5.1	5.7	6.3	7.0	7.6
300	3438	4.8	5.4	6.1	6.8	7.5	8.1
310	3552	5.1	5.8	6.5	7.2	8.0	8.7
320	3667	5.4	6.2	6.9	7.7	8.5	9.3
330	3782	5.7	6.6	7.4	8.2	9.0	9.9
340	3896	6.1	7.0	7.8	8.7	9.6	10
350	4011	6.5	7.4	8.3	9.2	10	11
360	4125	6.8	7.8	8.8	9.8	11	12
370	4240	7.2	8.3	9.3	10	11	12
380	4354	7.6	8.7	9.8	11	12	13
390	4469	8.0	9.2	10	11	13	14
400	4584	8.4	9.7	11	12	13	14
410	4698	8.9	10	11	13	14	15
420	4813	9.3	11	12	13	15	16
430	4927	9.8	11	13	14	15	17
440	5042	10	12	13	15	16	18
450	5157	11	12	14	15	17.	18
460	5271	11	13	14	16	18	19
470	5386	12	13	15	17	18	20
480	5500	12	14	16	17	19	21
490	5615	13	14	16	18	20	22
500	5730	13	15	17	19	21	23

HEAD LOSS USING 6 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 10	20	30	40	50	60
10	51	0.000	0.000	0.000	0.000	0.000	0.001
20	102	0.000	0.001	0.001	0.002	0.002	0.002
30	153	0.001	0.002	0.003	0.004	0.004	0.01
40	204	0.002	0.003	0.005	0.01	0.01	0.01
50	255	0.002	0.005	0.01	0.01	0.01	0.01
60	306	0.004	0.01	0.01	0.01	0.02	0.02
70	357	0.005	0.01	0.01	0.02	0.02	0.03
80	407	0.01	0.01	0.02	0.03	0.03	0.04
90	458	0.01	0.02	0.02	0.03	0.04	0.05
100	509	0.01	0.02	0.03	0.04	0.05	0.06
110	560	0.01	0.02	0.04	0.05	0.06	0.07
120	611	0.01	0.03	0.04	0.06	0.07	0.09
130	662	0.02	0.03	0.05	0.07	0.08	0.10
140	713	0.02	0.04	0.06	0.08	0.10	0.12
150	764	0.02	0.04	0.07	0.09	0.11	0.13
160	815	0.03	0.05	0.08	0.10	0.13	0.15
170	866	0.03	0.06	0.09	0.11	0.14	0.17
180	917	0.03	0.06	0.10	0.13	0.16	0.19
190	968	0.04	0.07	0.11	0.14	0.18	0.22
200	1019	0.04	0.08	0.12	0.16	0.20	0.24
210	1070	0.04	0.09	0.13	0.18	0.22	0.26
220	1120	0.05	0.10	0.14	0.19	0.24	0.29
230	1171	0.05	0.11	0.16	0.21	0.26	0.32
240	1222	0.06	0.11	0.17	0.23	0.29	0.34
250	1273	0.06	0.12	0.19	0.25	0.31	0.37
260	1324	0.07	0.13	0.20	0.27	0.34	0.40
270	1375	0.07	0.14	0.22	0.29	0.36	0.43
280	1426	0.08	0.16	0.23	0.31	0.39	0.47
290	1477	0.08	0.17	0.25	0.33	0.42	0.50
300	1528	0.09	0.18	0.27	0.36	0.45	0.54
310	1579	0.10	0.19	0.29	0.38	0.48	0.57
320	1630	0.10	0.20	0.31	0.41	0.51	0.61
330	1681	0.11	0.22	0.32	0.43	0.54	0.65
340	1732	0.11	0.23	0.34	0.46	0.57	0.69
350	1783	0.12	0.24	0.36	0.49	0.61	0.73
360	1833	0.13	0.26	0.39	0.51	0.64	0.77
370	1884	0.14	0.27	0.41	0.54	0.68	0.82
380	1935	0.14	0.29	0.43	0.57	0.72	0.86
390	1986	0.15	0.30	0.45	0.60	0.76	0.91
400	2037	0.16	0.32	0.48	0.64	0.79	1.0
410	2088	0.17	0.33	0.50	0.67	0.83	1.0
420	2139	0.18	0.35	0.53	0.70	0.88	1.1
430	2190	0.18	0.37	0.55	0.73	0.92	1.1
440	2241	0.19	0.38	0.58	0.77	1.0	1.2
450	2292	0.20	0.40	0.60	0.80	1.0	1.2
460	2343	0.21	0.42	0.63	0.84	1.1	1.3
470	2394	0.22	0.44	0.66	0.88	1.1	1.3
480	2445	0.23	0.46	0.69	0.92	1.1	1.4
490	2496	0.24	0.48	0.72	1.0	1.2	1.4
500	2546	0.25	0.50	0.74	1.0	1.2	1.5

HEAD LOSS USING 6 INCH PIPE (INCHES OF WATER)

FLOW CFM	VELOCITY FEET/MIN	EQUIVALENT PIPE LENGTH IN FEET 70	80	90	100	110	120
10	51	0.001	0.001	0.001	0.001	0.001	0.001
20	102	0.003	0.003	0.004	0.004	0.004	0.005
30	153	0.01	0.01	0.01	0.01	0.01	0.01
40	204	0.01	0.01	0.01	0.02	0.02	0.02
50	255	0.02	0.02	0.02	0.02	0.03	0.03
60	306	0.03	0.03	0.03	0.04	0.04	0.04
70	357	0.03	0.04	0.04	0.05	0.05	0.06
80	407	0.04	0.05	0.06	0.06	0.07	0.08
90	458	0.06	0.06	0.07	0.08	0.09	0.10
100	509	0.07	0.08	0.09	0.10	0.11	0.12
110	560	0.08	0.10	0.11	0.12	0.13	0.14
120	611	0.10	0.11	0.13	0.14	0.16	0.17
130	662	0.12	0.13	0.15	0.17	0.18	0.20
140	713	0.14	0.16	0.18	0.19	0.21	0.23
150	764	0.16	0.18	0.20	0.22	0.25	0.27
160	815	0.18	0.20	0.23	0.25	0.28	0.31
170	866	0.20	0.23	0.26	0.29	0.32	0.34
180	917	0.23	0.26	0.29	0.32	0.35	0.39
190	968	0.25	0.29	0.32	0.36	0.39	0.43
200	1019	0.28	0.32	0.36	0.40	0.44	0.48
210	1070	0.31	0.35	0.39	0.44	0.48	0.53
220	1120	0.34	0.38	0.43	0.48	0.53	0.58
230	1171	0.37	0.42	0.47	0.53	0.58	0.63
240	1222	0.40	0.46	0.51	0.57	0.63	0.69
250	1273	0.43	0.50	0.56	0.62	0.68	0.74
260	1324	0.47	0.54	0.60	0.67	0.74	0.81
270	1375	0.51	0.58	0.65	0.72	0.80	0.87
280	1426	0.54	0.62	0.70	0.78	0.86	0.93
290	1477	0.58	0.67	0.75	0.84	0.92	1.0
300	1528	0.63	0.71	0.80	0.89	1.0	1.1
310	1579	0.67	0.76	0.86	1.0	1.0	1.1
320	1630	0.71	0.81	0.92	1.0	1.1	1.2
330	1681	0.76	0.87	1.0	1.1	1.2	1.3
340	1732	0.80	0.92	1.0	1.1	1.3	1.4
350	1783	0.85	1.0	1.1	1.2	1.3	1.5
360	1833	0.90	1.0	1.2	1.3	1.4	1.5
370	1884	1.0	1.1	1.2	1.4	1.5	1.6
380	1935	1.0	1.1	1.3	1.4	1.6	1.7
390	1986	1.1	1.2	1.4	1.5	1.7	1.8
400	2037	1.1	1.3	1.4	1.6	1.7	1.9
410	2088	1.2	1.3	1.5	1.7	1.8	2.0
420	2139	1.2	1.4	1.6	1.8	1.9	2.1
430	2190	1.3	1.5	1.7	1.8	2.0	2.2
440	2241	1.3	1.5	1.7	1.9	2.1	2.3
450	2292	1.4	1.6	1.8	2.0	2.2	2.4
460	2343	1.5	1.7	1.9	2.1	2.3	2.5
470	2394	1.5	1.8	2.0	2.2	2.4	2.6
480	2445	1.6	1.8	2.1	2.3	2.5	2.7
490	2496	1.7	1.9	2.1	2.4	2.6	2.9
500	2546	1.7	2.0	2.2	2.5	2.7	3.0