AEROVENT
INDUSTRIAL VENTILATION SYSTEMS

Airflow Measuring System Using Piezometer Ring

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General Installation, Operation and Maintenance Instructions For Aerovent Products

Aerovent now offers an air measuring device as an option on centrifugal fans. It is based on the principle of a flow nozzle. The inlet cone of the fan is used as the flow nozzle. By measuring the pressure drop through the inlet cone, the flow can be calculated. The system consists of a piezometer ring mounted in the throat and a static pressure tap mounted on the face of the inlet cone. A differential pressure transducer and a digital display can be provided. The display must be capable of performing the square root function in order to read out in CFM directly. By testing fans in the laboratory, Aerovent was able to determine flow coefficients for various fan types. The flow coefficients were combined to give the equations listed below by fan type. Based on testing performed in Aerovent's laboratory, the accuracy of the system was determined to be +/- 5%.

The pressure drop is measured from the tap located on the face of the funnel to the piezometer ring in the throat. The inlet tap is connected to the high-pressure side of the transducer and the piezometer ring is connected to the low-pressure side.

Measurement of Airflow

The equations below are accurate for flow estimation for flows from 40% to 100% of wide-open volume. According to testing done previously at Aerovent, several factors affect the accuracy of this method of determining flow. The equations below assume the following:

- There are no vanes or other obstructions in or near the inlet
- Even flow entering the funnel (no pre-swirl)
- Standard wheel to inlet cone overlap
- Accurate determination of air density at the inlet
- Free inlet (consult Aerovent for ducted inlet factors)

Non-Standard Density Method

One of the following equations is used to measure the flow:

$$ACFM = C1 * A * \sqrt{(\Delta P/\rho)}$$

where:
- A = Actual inlet funnel throat area (square feet) - from tables on pages 2 and 3
- ΔP = The differential in static pressure from the piezometer ring and the front pressure tap (inches w.g.)
- ρ = Air density (pounds mass/cubic foot)
- C1 = Value from Table 1 below

Standard Density Method

The equations can be simplified by assuming standard density and assuming funnel dimensions match drawing dimensions. The following tables show the factor (F) for each fan size and type. The equation then becomes the following:

For standard air (ρ = 0.075 lb/ft^3):

$$ACFM = F \sqrt{\Delta P}$$

where:
- F = factor from tables on pages 2 and 3
- ΔP = The differential in static pressure from the piezometer ring and the front pressure tap (inches w.g.)

Table 1: C1 Values

Product	C1 Free Inlet	C1* Ducted Inlet
CPLFN/CPLQN (Arr. 1 or 4), Sizes 122-165	753.06	794.06
CPLFN/CPLQN (Arr. 1 or 4), Sizes 122A-165A	887.78	949.49
CPLFN/CPLQN (Arr. 1 or 4), Sizes 182-982	692.03	740.14
CPLF/CPLQ (Arr. 3), Sizes 122-165	726.39	765.94
CPLF/CPLQ (Arr. 3), Sizes 122A-165A, 182-982	856.34	915.87
CPLF/CPLQ (Arr. 3), Sizes 182-982	667.52	713.93
CB/CBA SWSI	735.42	786.56
CB/CBA DWDI	1470.84	1573.12
AFE	735.42	753.56
AMX	696.00	735.83
CAE-SW **	720.40	735.80
CAE-DW**	1440.80	1471.60
CPG	753.06	794.06
MH (Std. Inlet Bell)	913.33	997.49

* Values for ducted C1 factors are based on duct diameter matching standard inlet collar diameter.

** CAE sizes smaller than 182 use CB\CBA Factors.

Table 2: CPLF/CPLQ (Arrangement 3), CPLFN/CPLQN (Arrangement 1 & 4)

Size	CPLF/ CPLQ Free Inlet F	CPLFN/ CPLQN CPL-Series Free Inlet F	CPLF/CPLQ Ducted Inlet F	CPLFN/ CPLQN CPL-Series Ducted Inlet F	A
122	911.46	944.92	961.07	996.36	0.344
122A, 122MK2	1194.48	1238.33	1277.52	1324.41	0.382
150	1163.68	1206.40	1227.04	1272.08	0.439
150A, 150MK2	1779.21	1844.54	1902.90	1972.75	0.569
165	1464.80	1518.58	1544.56	1601.26	0.552
165A, 165MK2	2138.81	2217.33	2287.49	2371.46	0.684
182	1757.39	1821.92	1879.58	1948.58	0.721
200	2108.38	2185.80	2254.97	2337.76	0.865
222	2617.81	2713.93	2799.81	2902.60	1.074
245	3168.67	3285.02	3388.97	3513.39	1.300
270	3856.03	3997.61	4124.12	4275.53	1.582
300	4770.07	4945.21	5101.71	5289.01	1.957
330	5757.23	5968.62	6157.51	6383.56	2.362
365	7032.01	7290.21	7520.92	7797.03	2.885
402	8555.41	8869.55	9150.23	9486.16	3.510
445	10444.42	10827.92	11170.58	11580.68	4.285
490	12669.80	13135.01	13550.69	14048.16	5.198
542	15541.11	16111.75	16621.62	17231.84	6.376
600	19004.71	19702.52	20326.03	21072.24	7.797
660	22994.79	23839.12	24593.53	25496.41	9.434
730	28128.04	29160.84	30083.67	31188.11	11.54

Table 3: CB/CBA

Size	SWSI Free Inlet F	DWDI Free Inlet F	SWSI Ducted Inlet F	DWDI Ducted Inlet F	A
105	641.87	1283.74	686.51	1373.01	0.239
122	872.90	1745.81	933.61	1867.21	0.325
135	1058.21	2116.41	1131.79	2263.58	0.394
150	1305.20	2610.39	1395.96	2791.92	0.486
165	1587.21	3174.41	1697.58	3395.16	0.591
182	1936.99	3873.98	2071.69	4143.38	0.721
200	2321.58	4643.16	2483.02	4966.04	0.865
222	2883.02	5766.04	3083.50	6167.00	1.074
245	3491.62	6983.24	3734.42	7468.84	1.300
270	4247.77	8495.55	4543.16	9086.32	1.582
300	5254.03	10508.05	5619.38	11238.86	1.957
330	6342.73	12685.46	6783.80	13567.59	2.362
365	7747.97	15495.94	8286.75	16573.50	2.885
402	9426.99	18853.98	10082.53	20165.06	3.510
445	11507.43	23014.86	12307.64	24615.28	4.285
490	13957.43	27914.86	14928.01	29856.02	5.198
542	17121.05	34242.10	18311.62	36623.24	6.376
600	20938.50	41877.00	22394.53	44789.06	7.797
660	25334.37	50668.73	27096.08	54192.16	9.434
730	30991.88	61983.75	33147.00	66294.01	11.54
807	37901.44	75802.87	40537.05	81074.09	14.11
890	46079.00	92158.01	49283.27	98566.54	17.16
982	56192.01	112384.00	60099.52	120199.04	20.93

Table 4: CAE-SW/CAE-DW (Sizes smaller than 182 use Table 3: CB\CBA)

Size	SWSI Free Inlet F	DWDI Free Inlet F	SWSI Ducted Inlet F	DWDI Ducted Inlet F	A
182	1896.61	3793.22	1937.16	3874.31	0.721
200	2275.41	4550.82	2324.05	4648.10	0.865
222	2825.19	5650.38	2885.58	5771.16	1.074
245	3419.69	6839.38	3492.79	6985.58	1.300
270	4161.50	8322.99	4250.46	8500.91	1.582
300	5147.95	10295.89	5257.99	10515.99	1.957
330	6213.31	12426.62	6346.13	12692.26	2.362
365	7589.08	15178.15	7751.31	15502.62	2.885
402	9233.16	18466.31	9430.53	18861.07	3.510
445	11271.82	22543.63	11512.77	23025.55	4.285
490	13673.49	27346.98	13965.79	27931.57	5.198
542	16772.25	33544.50	17130.79	34261.59	6.376
600	20510.23	41020.47	20948.68	41897.36	7.797
660	24816.41	49632.82	25346.91	50693.82	9.434
730	30356.30	60712.61	31005.23	62010.46	11.540
807	37116.76	74233.52	37910.21	75820.42	14.110
890	45139.88	90279.75	46104.83	92209.66	17.160
982	55056.97	110113.94	56233.92	112467.85	20.930

Table 5: AMX

Size	Free Inlet F	Ducted Inlet F	A
150	1832.36	1937.23	0.721
165	2198.32	2324.14	0.865
182	2729.48	2885.70	1.074
200	3303.84	3492.93	1.300
222	4020.52	4250.63	1.582
245	4973.55	5258.21	1.957
270	6002.82	6346.39	2.362
300	7331.98	7751.62	2.885
330	8920.36	9430.92	3.510
365	10889.96	11513.24	4.285
402	13210.27	13966.36	5.198
445	16204.06	17131.49	6.376
490	19815.41	20949.54	7.797
542	23975.70	25347.94	9.434
600	29327.92	31006.49	11.54
660	35859.36	37911.75	14.11
730	43610.67	46106.71	17.16

Table 6: CPG

Size	Free Inlet F	Ducted Inlet F	A
121	944.92	996.36	0.344
141	1206.40	1272.08	0.439
161	1518.58	1601.26	0.552
181	1929.92	2035.00	0.702
201	2378.68	2508.19	0.865
221	2979.06	3141.26	1.083
251	3779.67	3985.45	1.375
281	4792.02	5052.92	1.743
321	6093.21	6424.95	2.216
351	7719.69	8139.98	2.807
391	9514.73	10032.75	3.460
441	11916.25	12565.02	4.334
491	14881.53	15691.74	5.412

Table 7: AFE

Size	Free Inlet F	Ducted Inlet F	A
122	872.75	894.27	0.325
150	1305.09	1337.28	0.486
165	1587.06	1626.20	0.591
182	1936.15	1983.91	0.721
200	2322.85	2380.14	0.865
222	2884.09	2955.23	1.074
245	3490.99	3577.10	1.300
270	4248.26	4353.05	1.582
300	5255.28	5384.90	1.957
330	6342.85	6499.31	2.362
365	7747.30	7938.40	2.885
402	9425.66	9658.16	3.510
445	11506.83	11790.66	4.285
490	13958.57	14302.88	5.198
542	17121.95	17544.28	6.376
600	20937.86	21454.32	7.797
660	25333.82	25958.71	9.434
730	30989.22	31753.60	11.54
807	37890.63	38825.25	14.11
890	46081.02	47217.66	17.16

Table 8: MH Industrial

Size	Free Inlet F	Ducted Inlet F	A
905	410.40	448.22	0.123
907	828.77	905.13	0.249
909	1392.65	1520.97	0.418
911	2102.04	2295.74	0.630
913	2956.96	3229.43	0.887
915	3957.39	4322.05	1.187
917	5103.34	5573.59	1.530
919	6394.80	6984.06	1.917
921	7831.78	8553.45	2.348
923	9311.11	10169.10	2.792
926	11944.07	13044.67	3.581
929	14904.43	16277.82	4.469
933	19360.90	21144.93	5.805
937	24399.43	26647.75	7.316
941	30020.04	32786.27	9.001
945	36222.71	39560.50	10.861
949	43007.45	46970.43	12.896
954	51820.34	56595.39	15.538
960	64125.64	70034.58	19.228

Transducer Sizing for Piezometer Ring

Selecting a pressure transducer with the appropriate range is critical in order to get accurate measurements using the piezometer ring. Since most transducers list accuracy as a percent of full scale, if the range selected is too high, this can have a significant impact on the accuracy of the flow measurement. If the range is too low, there is risk of damaging the instrument and/or getting inaccurate readings or no reading at all.

The following steps are for sizing the pressure transducer for use with the piezometer ring flow measurement system:

1. Determine the maximum flow rate in CFM that the fan is expected to produce. This maximum should be the greater of normal, maximum, and/or emergency conditions.
2. Find the formula for calculating the actual flow rate from page 1 of this document for the corresponding size and type of fan being used.
3. Calculate the pressure drop corresponding to the maximum flow rate determined in Step 1.
4. Select the pressure transducer with the smallest range that includes the pressure drop calculated in Step 3.
5. Now take the maximum range from the pressure transducer selected in Step 4 and use that to calculate the maximum flow rate that could be measured with this transducer.
6. Determine an acceptable safety factor for sizing the transducer.
7. Multiply the maximum flow rate from Step 1 by the safety factor. If the maximum flow rate from Step 5 is less than the result, bump up the transducer to the next largest size. Otherwise, the transducer from Step 4 should be used.

Example:
Company XYZ has a size 270 CB SWSI fan to be installed with design conditions of 12,000 CFM at 5 inches w.g. and standard density. What size transducer should be used?

1. After speaking to the design engineer, it was determined that 12,000 CFM is the actual maximum and most of the time the fan will be running closer to 10,000 CFM. Therefore, 12,000 CFM will be used for the calculations.
2. The calculation for this fan type and size is:
   $ACFM = 4247.77 * \sqrt{(\Delta P)}$ for standard density
   Note that if the density was other than standard air, the formula would be different.
3. By rearranging the formula in Step 2, the following formula is obtained:
   $\Delta P = (ACFM/4247.77)^2$
   so, $\Delta P = (12000/4247.77)^2 = 7.98$ inches w.g.
4. For the pressure transducer models being considered, the ranges are 0-3, 0-6, 0-10, and 0-20. Therefore, for this flow rate the transducer model is the 0-10 inches w.g. model.
5. The maximum for this transducer is 10 inches, which corresponds to the following flow rate:
   $ACFM = 4247.77 * \sqrt{(10)} = 13433$ CFM
6. Since 12,000 CFM is the maximum and normal operating conditions are 10,000 CFM, a 10% safety factor should be plenty for this application
7. From Step 1, 12000 CFM * 1.1 = 13200 CFM. This is less than 13433 CFM, so the 0-10 inch pressure transducer is acceptable.