ASD PIPING AND FITTINGS AIRFLOW PRESSURE DROP

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Abstract

An Active Soil Depressurization (ASD) radon mitigation system uses a fan to generate a negative pressure field under a concrete slab. The fan generating the negative pressure must overcome the resistance to airflow in the sub-slab and also the airflow resistance of the system piping. In this study, the pressure drop of typical ASD system piping was measured at varying airflow rates through 2-, 3-, 4- and 6-inch piping and converted into single pressure drop calculating formula. The additional pressure drop induced by typical pipe fittings was measured at varying airflows by recording the difference between 20 feet of straight pipe and 20 feet of piping that included a fitting or fittings. The difference was then converted into the equivalent feet of straight pipe for each fitting type as well as the pipe inlet opening.

1.0 Introduction

1.1 Reasons for Measuring Pressure Drop in Piping

Active Soil Depressurization (ASD) is recognized as the primary method of reducing radon or chemical vapors in the soil from moving into a building. The 2023 version of the ANSI/AARST "Soil Gas Mitigation Standards for existing Multifamily, School, Commercial and Mixed-Use Buildings" (SGM-MFLB-2023) specifies that pressure field extension testing (PFE) shall be done prior to final design and system installation. The PFE defines the sub-slab resistance and how much airflow is required to depressurize the subslab. The final system performance with the chosen fan must also include the piping airflow resistance. In commercial buildings the piping can be extensive and the airflows significantly higher than typical residential ASD systems. Airflow pressure drop in piping increases at approximately the square of the increased airflow. In other words, if the airflow is doubled, the pressure drop in the piping is increased by a factor of four. Calculating the piping airflow resistance is necessary to be able to include optimal piping size and system layout and to predict the final system performance. This paper includes measured pressure drop in piping and pipe fittings of four different commonly used pipe sizes. The fitting pressure drop was converted to equivalent feet (EF) of piping resistance.

2.0 Methodology

2.1 Calibrating Flow Grid

Airflow measurements for all the testing done in this study were measured using circular inline flow grids and Energy Conservatory DG700 micro-monometers. The three flow grids used measured 4 inches, 5 inches and 6 inches. In a previous published paper, the author described obtaining the flow grid calibration factor (CF) by comparing the flow grid to transverse pitot measurements as specified by ASTM and versus Alnor Lo-Flow hood (Brodhead, B 1996). In June of 2019 SystemAir, at their facility in Kansas, tested WPB's 4-inch flow grid using their airflow measuring equipment. See Figure 1. The objective of this testing was to confirm the airflow measurements are within 5% accuracy. The result of this testing was the WPB flow grid original calibration factor of 59 needed to be adjusted 4.2% lower to 56.5 to match the flow of the SystemAir measurements. See Figure 2 comparison of the 4-inch flow grid using a calibration factor of 56.5 with SystemAir data. All airflow measurements are made using the current air density based on the temperature, relative humidity and barometric pressure. The formula for each of the flow grids is the following.

$$CFM = CF * (SqRt (velocity\ pressure/air\ density))$$

A second comparison test was run in 2024 using a new TSI Alnor 6200D LoFlo Balometer. TSI certifies their instruments have been calibrated using standards whose accuracies are traceable to the National Institute of Standards and Technology within the limitations of NIST calibration services. The balometer used in this study was calibrated at the factory 7/12/2023 to a tolerance of +/- 3% plus 5.0 CFM. See Table 1 that lists the performance of the balometer used in this comparison test versus the factory airflow measurements. The factory comparison data in supply mode was reported as less than 1% off. The comparison for the return mode was within 2%

except around 100 cfm which was about 5% high. WPB comparison testing also showed the balometer about 7% higher in this same CFM range compared to the WPB flow grid.

Figure (1): SystemAir Testing

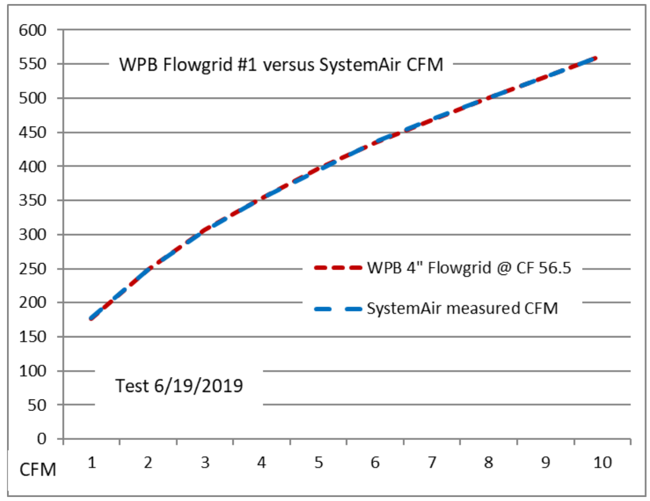


Figure (2): SystemAir vs WPB Flow Grid

Figure (3): Smooth transition from Balometer to 4” PVC

The transition setup used to compare the balometer with the 4” flow grid is shown in Figure 3. A 10” round to 4” round transition pipe is attached to the 22 square inch cardboard box that has all the seams taped. A ten-foot section of 4” pipe was installed from the 10” to 4” transition to an air flow straightener. Four-feet of piping was routed from the air straightener to the WPB 4” flow grid. Eleven-feet of 4” piping was routed from the flow grid to an RN4EC-4 fan that was setup in suction and then in pressure mode. The comparison between the WPB 4-inch flow grid and the balometer is shown in Figure 4. The comparison between the readings obtained from the balometer and the 4” flow grid using a calibration factor of 57 are displayed in Figure 5 and Figure 6.

Figure (4): Alnor Balometer to Flow Grid Comparison

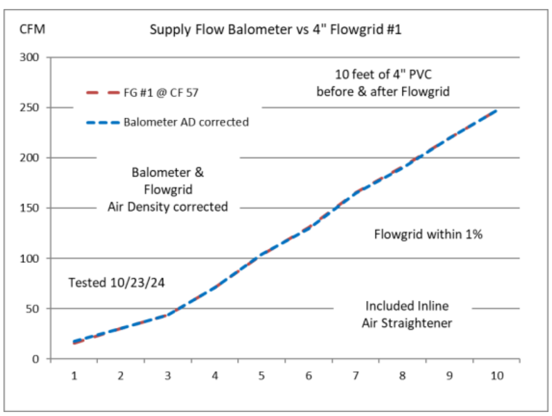


Figure (5): Supply Mode (Outflowing) balometer compared to WPB 4” flow grid

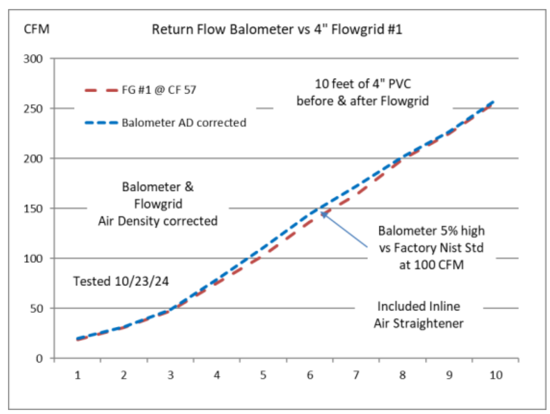
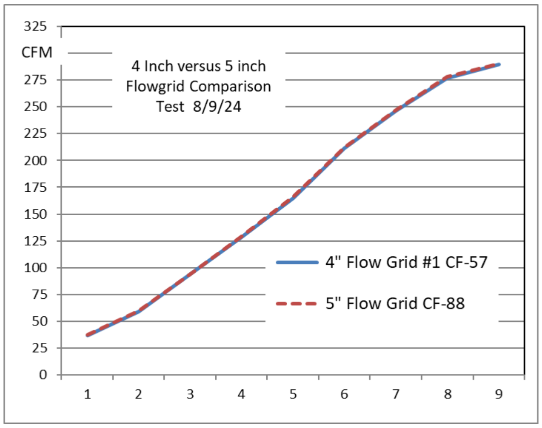


Figure (6): Return Mode (Inflowing) balometer compared to WPB 4” flow grid

2.2 Comparison to other Flow Grids

The 4-inch flow grid #1 was directly compared to the WPB 5-inch and 6-inch flow grids in order to obtain correct calibration factors for these two flow grids. See Figure 7.



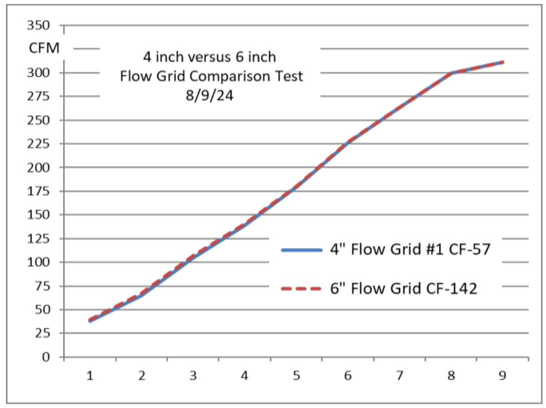


Figure (7): 4-inch flow grid compared to 5" flow grid and 6" flow grid

Supply Data		Return Data	
Factory Standard	Measured Output	Factory Standard	Measured Output
15	16	15	15
50	50	49	50
101	102	101	106
224	224	224	226
299	299	299	302

Table (1): Alnor Certificate of Calibration

MM 31003	MM60974
0.0103"	0.0103"
0.0318"	0.0318"
0.0820"	0.0820"
0.1423"	0.1425"
0.245"	0.245"
0.368"	0.368"
0.494"	0.494"
0.618"	0.619"
0.681"	0.682"

Table (2): Comparison of Micro-monometers

Two Energy Conservatory DG700 digital micro-monometers were used for all the velocity pressure readings to obtain the airflow rates and for the static pressure readings. The two micro-monometers compared with almost identical measurements to each other. The results are displayed in Table 2.

2.3 Comparison to HVI Fan Manufacturer Data

Home Ventilating Institute or HVI is a well-recognized label attached to home ventilating equipment that provides a uniform certified testing of fan performance. Radon fan manufacturers will often have independent testing done on their fans by HVI. A comparison of the WPB fan measured performance versus manufacturers listed HVI certified performance was made to compare the results. See Figure 8.

In general, the WPB fan performance measurements were significantly higher airflows than the HVI certified fan performance listings. The discrepancy could not be explained but was suggested that turbulent airflow in the fan testing setup used by WPB was the cause. WPB includes about 6 feet of 4” piping prior to the inlet to the flow grid for fan testing. The first testing with the Alnor Balometer in 2024 used a similar setup that was used for the fan testing setup. The results of this test confirmed that a CF of 57 was correct for the 4” flow grid.

The data provided by WPB on their website at www.wpb-radon.com, has been done uniformly for all fans, so direct comparisons can be made between different fan models. The piping and fitting pressure drop defined in this study is provided primarily to design commercial and residential ASD systems that are used in conjunction with PFE measurements that also measure airflow based on the same reference source so that all the data is compatible.

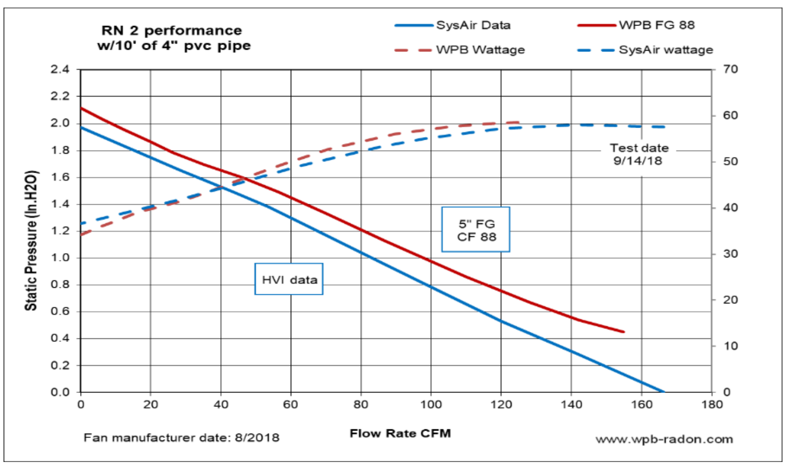


Figure (8): WPB RN2 Performance measurements versus HVI data

2.4 Straight Piping Experimental Setup

All of the piping, fittings and measurements used in this study were made using US Imperial size. In order to determine the pressure drop caused by airflow through straight piping, the author in 2007 set up approximately 100 feet of piping for each of the pipe sizes, 2-inch, 3-inch, 4-inch and 6-inch. Dwyer six-inch pitot tubes were used to measure the static pressure by inserting them half way into each pipe with the total pressure port sealed. The tube was held secure in place using a triangle square taped to the pipe. See Figure 9 and Figure 10. The static pressure port of the pitot tube was spaced 40-feet and 60-feet apart. See Figure 11. Pressure measurements were made using the averaging function of a DG700 and waiting until the micro-monitor readings stabilized. The airflow was measured using a flow grid that had been previously calibrated as reported in previous papers by the author (Brodhead, B 1996). The flow rates were later adjusted to the new calibration setting obtained from SystemAir testing in 2019 and confirmed in 2024 with the Alnor balometer.

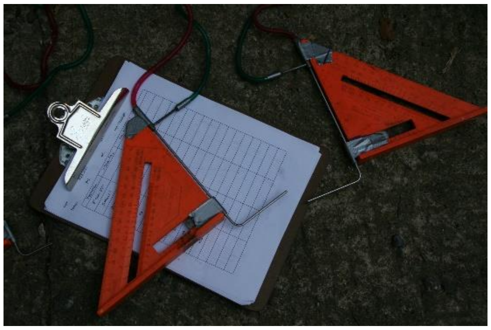


Figure (9): Dwyer Pitot tube secured in the piping

Figure (10): Dwyer Pitot tube using only static port

Figure (11): 100 feet of piping with pitot tubes and fan

The pressure drop for each distance of piping was converted to the pressure drop of 100 feet of that pipe size. The comparison of results of the airflow measurements made in 1996 versus 2007 are displayed in Figure 17 through Figure 18. Figure 21 and Figure 22 provide the combined results of different pipe sizes using the 60-foot-long pressure drop results.

In the 1996 paper listed in reference 1 (Brodhead 1996), the straight pipe pressure drops at different air flows were compared to the results of the Darcy formula given in the ASHRAE Fundamentals Handbook (ref 3) to determine how well they compared. In general, the Darcy equation given in ASHRAE Fundamentals over predicted the pressure drop of straight piping pressure drop by 9% to 18% for 3-to-6-inch piping. The variation in measured values versus calculated values for fittings varied more significant and in different directions. All of the piping used in the 1996 and this study was sewer and drain (ASTM D2729) which has the same ID as Schedule 40 piping (ASTM D1785) but has thinner pipe wall thickness. All of the fittings in the 1996 study were sewer and drain fittings. All of the fittings presented in this study are schedule 40 which used PVC adapters to transition between the sewer and drain piping and the schedule 40 fittings.

2.5 Pipe Fitting Experimental Setup

For the fitting pressure drop tests, a straight section of piping had a Dwyer pitot static pressure probe inserted about five to ten feet from the piping inlet. The inlet had an expanding flared fitting attached to the inlet to reduce turbulence. A second pitot tube was inserted exactly 20-feet upstream (closer to the suction fan) in a straight section of piping to record the pressure drop in 20-feet of straight pipe. See Figure 12. A PVC fitting was installed exactly ten feet upstream from the second pitot tube. A third pitot tube was installed exactly ten feet from the PVC fitting further upstream A triangle square and tape was used to secure each of the pitot tubes and allowed easy confirmation that the static port was parallel to the airstream and centered in the pipe. See Figure 10. The total pressure port of each pitot tube was sealed. Each pitot tube was set so that it minimized disturbance of the air stream. All of the piping and fitting connections were wrapped with tape to ensure air tightness. See Figure 30. The pressure difference between the 20 feet of straight pipe was measured and recorded at the same time the 20 feet of piping and fitting or fittings was measured and recorded. The fan airflow volume was adjusted from the highest to the lowest flow rate using the voltage adjustment knob of the Fantech RN4-EC diagnostic fan. The Energy Conservatory DG700 micro-monometers were reset to average mode for each air speed setting and the results recorded after all the measurements stabilized. Nine different airflows were measured and recorded for each fitting type that was tested.

The pipe fittings that were used were obtained from a local professional plumbing store. The fittings were defined as a sweep, a long sweep, an angled turn or a hard turn depending upon the radius of the turn. Hard turn 90-degree fittings in this case refer to a 90-degree fitting that makes a right angle turn on the inside edge. Angled turns refer to 45-degree fittings that have a sharp angle turn on the inside edge. Sweep fittings are typical PVC fittings that have a smooth radius turn on the inside edge. Long sweeps are fittings that have an extended inside radius that elongates the fitting for a more gradual turn. These types of fittings were not tested.

Pressure drop in ASD system piping was calculated based on the footage of piping used and the airflow velocity through the piping. The contribution of pressure drop from pipe fittings is defined in this paper as the amount of equivalent feet of straight piping each fitting or combination of fittings or initial open inlet of piping adds equivalent straight piping footage at the same airflow. In this study the term “equivalent feet” or “equivalent piping footage” will be referred to as “EF. The equivalent feet of piping for each fitting or fittings are displayed in graphs showing the variation in EF as the airflow changes. See Figures 23 through Figure 28.

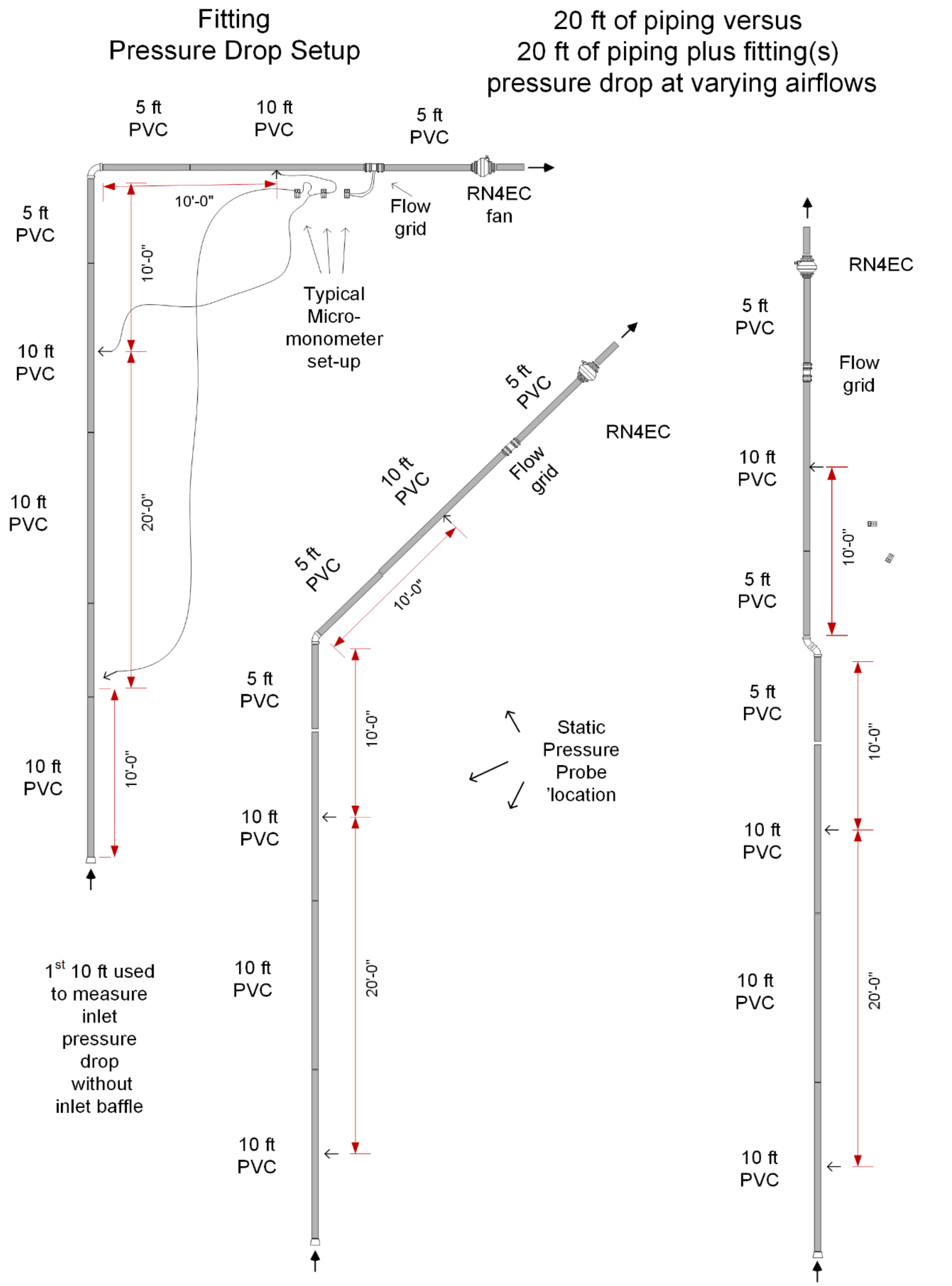


Figure (12): PVC fitting EF measurement test layout

Figure (13): 6" Sweep 90-degree elbow

Figure (14): Flared intake

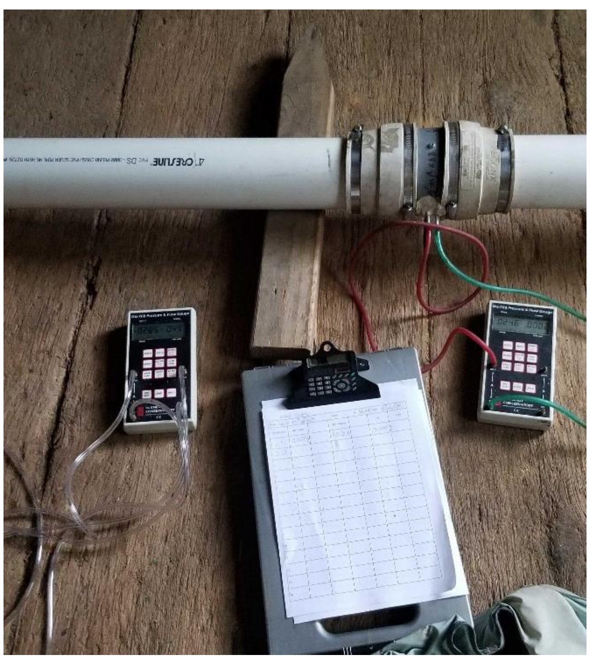


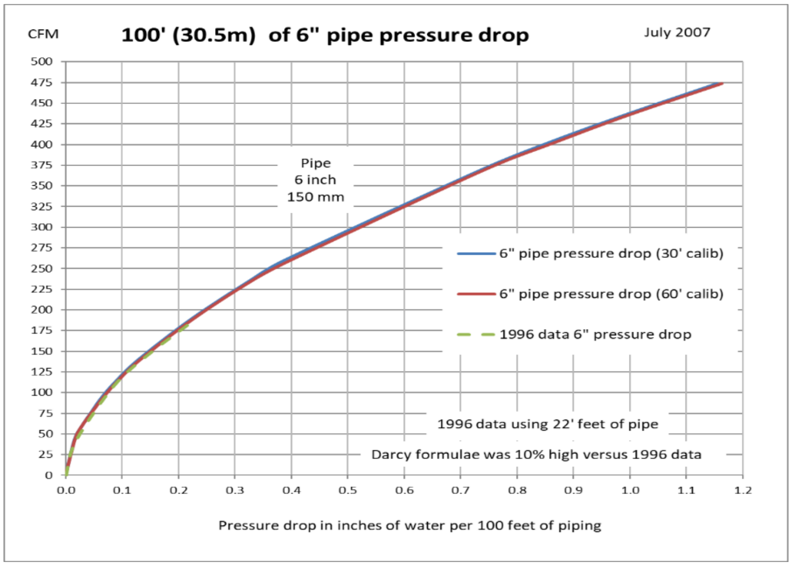
Figure (15): Five-inch flow grid used to make 4" PVC airflow measurements

Figure (16): Adjustable RN4EC fan

3.0 Results & Discussions

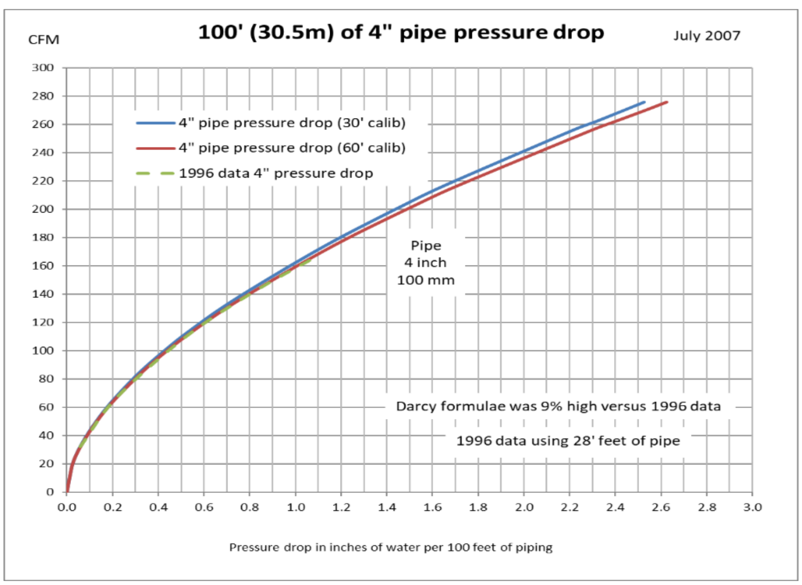
3.1 Airflow versus Pressure Drop Charts

Pressure drops for the 2”, 3”, 4” and 6” pipe sizes was measured across 30 feet and 60 feet of piping at increasing airflows. The results are illustrated in Figure 17 to Figure 20.



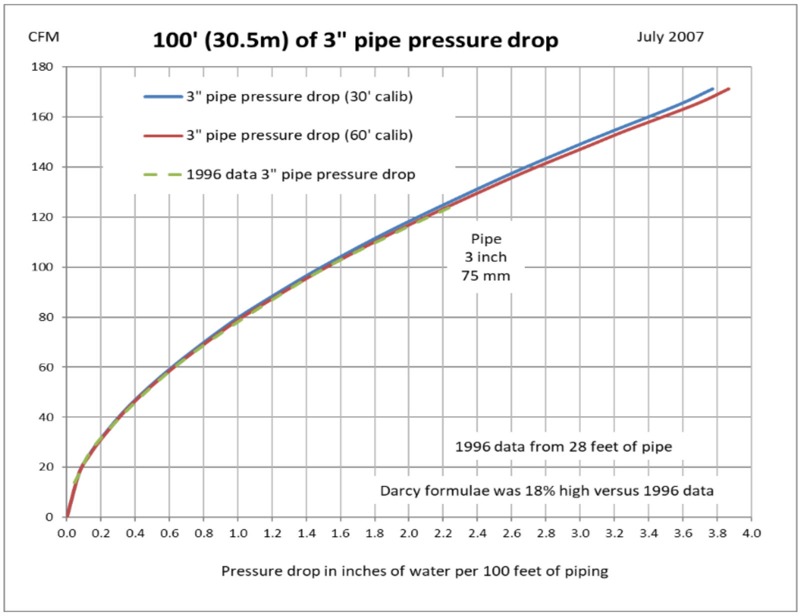
In Figure 17 the measurements made in 1996 duplicated the measurements made in 2007 using the flow grid 57 calibration factor.

Figure (17): Pressure drop of six -inch (150mm) piping per 100 feet



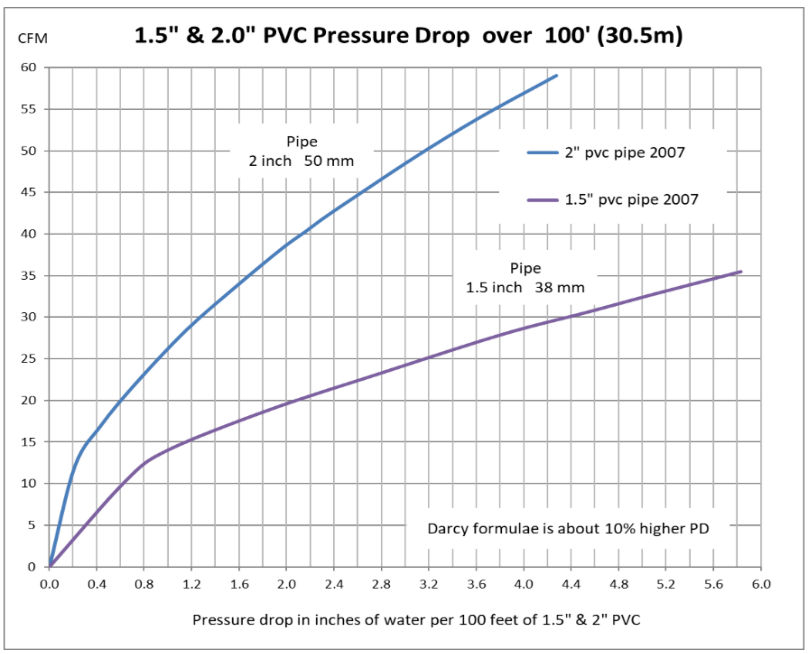
There was a difference of about 2% at the highest airflow between the 30-foot measurements and the 60-foot measurements with 4-inch piping. The 1996 measurements match the 60-foot measurements more perfectly. The 60-foot measurement was used for the pressure drop calculations of airflow through 4-inch piping.

Figure (18): Pressure drop of four -inch piping per 100 feet



In the Figure 19 the 60-foot measurements more closely match the 1996 data. The 30-foot measurement was about 2% higher at the highest airflow tested compared to the 60-foot measurements. The 60-foot measurement was used for calculating the pressure drop for three-inch piping.

Figure (19): Pressure drop of three -inch piping per 100-feet



In Figure 20 the 60-foot pressure drop test results are used to define the one and a half, and two inch 100-foot piping pressure drop.

Figure (20): Pressure drop of six-inch (150mm) piping per 100-feet

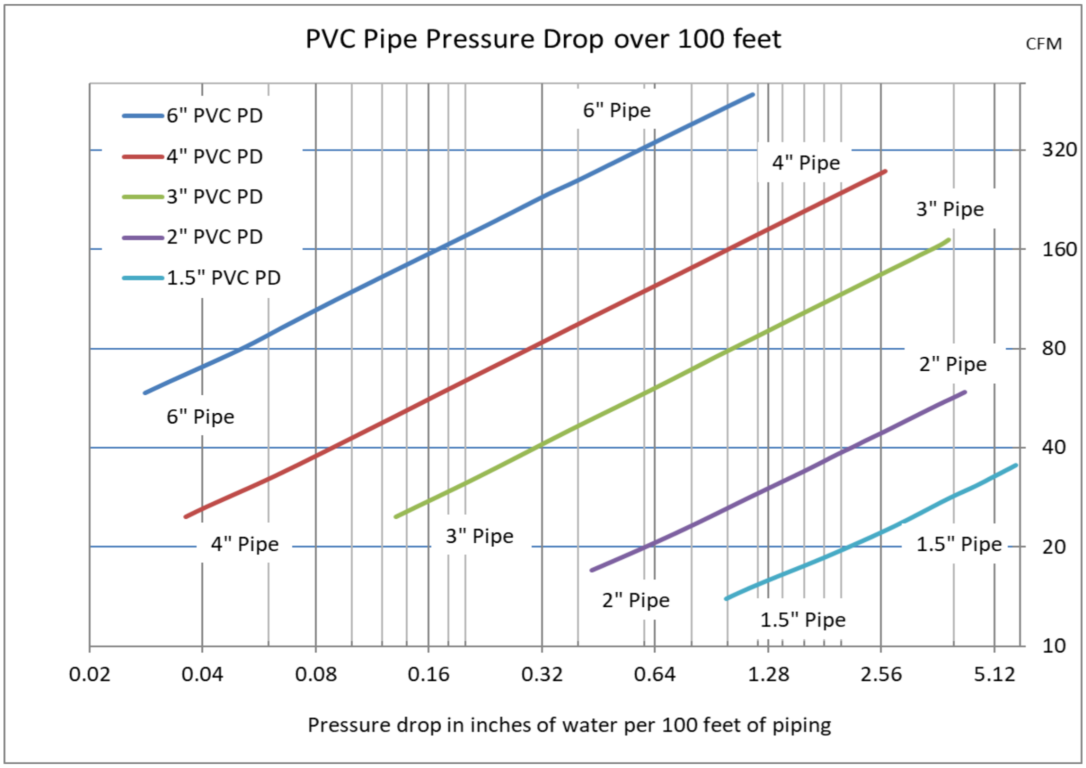


Figure 21 combines all the data into a double log xy scatter graph that allows extrapolation to higher airflows or a quick reference for the approximate pressure drop over 100-feet.

3.2 Simplified Pressure Drop Formula

In order to use the data collected, a formula was arrived at from contributions by Kevin Stewart. who determined a simplified single formula to provide the pressure drop value for all four pipe sizes measured in this study. See Reference 5 and Formula 1. The formula can be easily entered into a spreadsheet and used to determine piping pressure drop for a single suction ASD system. The formula allows using any of the study pipe sizes and any amount of total equivalent feet of piping.

$$\text{Pressure Drop} = ((0.205 * \text{CFM} * \text{Pipe inch size}^{\wedge 1.7})^{\wedge -2.5}) * (\text{Total EF}/100)$$

Formula (1): Spreadsheet formula to determine piping airflow pressure drop

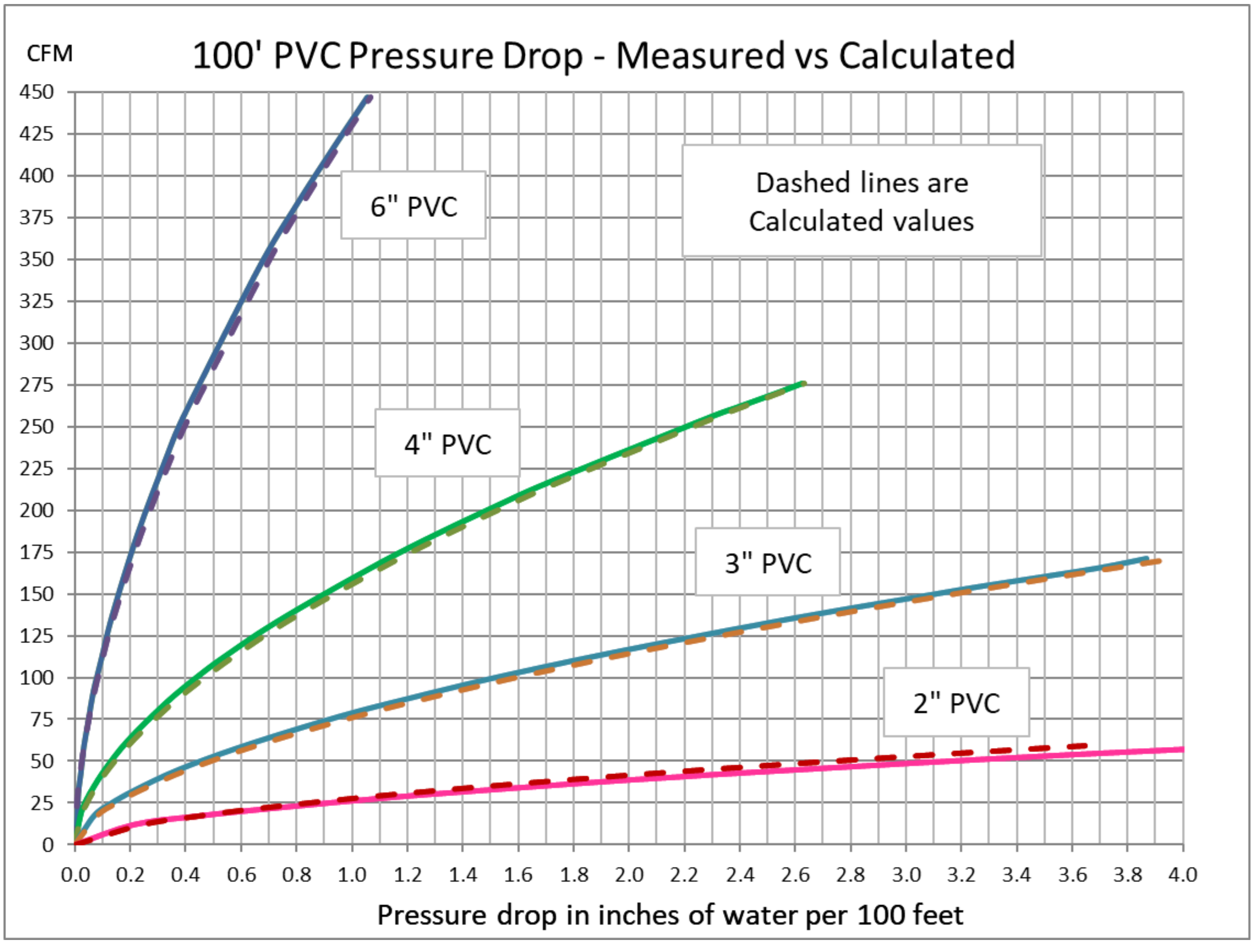


Figure (22): Piping pressure drop Measured vs Calculated (dash lines)

In Figure 22 the measured pressure drop per 100-feet of piping is compared to the results using Formula 1. The formula closely matches the measured values.

3.3 Comparing Total System Airflow Resistance to Fan Performance

The total EF of piping needs to include the proposed straight piping and additional equivalent feet from fittings and the pipe airflow opening. The PFE measurements made in the field, that measure the sub-slab airflow resistance to airflow, are then added to the piping airflow resistance. The total airflow resistance results are then plotted on a double log xy (scatter) graph which produces a straight line. Fan curves are then overlaid on the graph to depict what airflow individual fans can produce. The total resistance line can be extrapolated to higher airflows to match a fan curve that produces a higher airflow than what was generated by the PFE testing.

3.4 Pipe Fitting Pressure Drop Converted to EF of Piping at Varying Airflows

The equivalent feet of piping for individual pipe fittings were measured using the setup detailed in Section 2.5 and the results were graphed for easy comparison. Table 3 includes the results for the EF of all fittings tested. Figure 23 through Figure 32 depicts the graphs and pictures of the fitting test setup.

In each fitting test as the airflow increases, the EF also increases. The use of high-capacity fans in commercial ASD installations will often induce significantly higher airflow through the piping compared to residential ASD systems. Commercial ASD systems that require high flow through the piping can have more pressure drop induced by the piping than by the sub-slab airflow resistance. (Brodhead, B 2024)

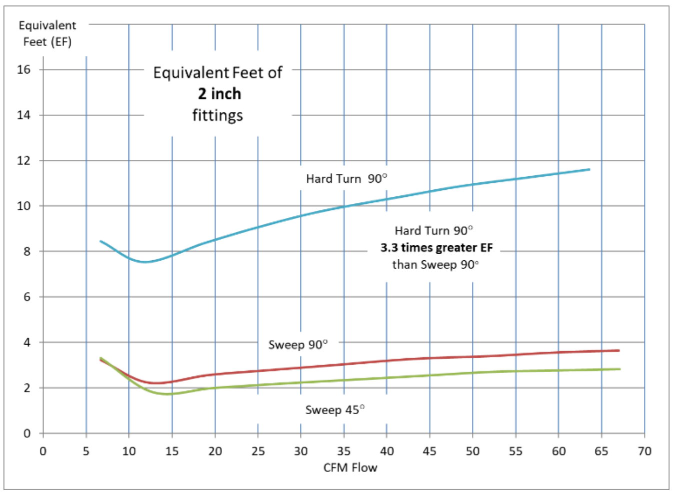


Figure (23): Two-inch (38mm) pipe fittings

In general, the smaller the pipe diameter, the less EF of piping each fitting adds to the total pressure drop of the piping system. In Figure 23, two-inch (38mm) sweep 45-degree and 90-degree fittings have a 2 to 3 or 3.5 EF for every elbow installed. A two-inch 90-degree hard turn fitting was tested and had an EF increase by a factor of three to an 8 to 11 EF. The two-inch fittings had a reverse increase in EF at the lowest airflow. This was not seen in other pipe sizes.

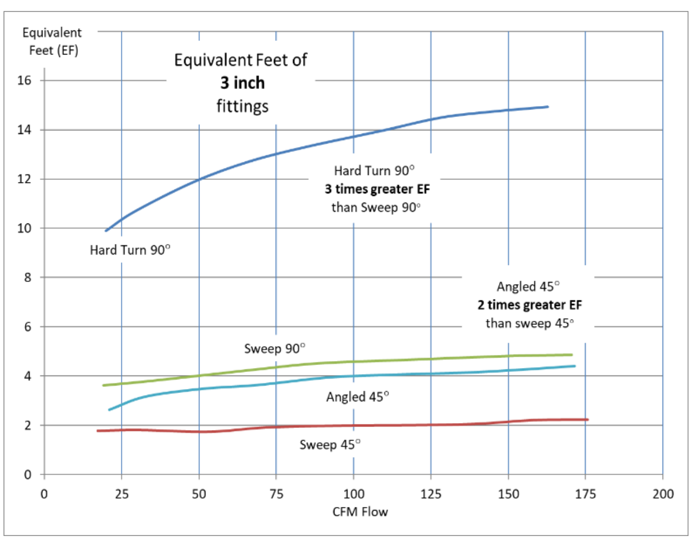


Figure (24): Three-inch (75mm) pipe fittings

The EF of three-inch (75mm) fittings was about two feet for a standard sweep 45 degree fitting and about four to five feet for a sweep 90-degree fitting. If the 45-degree fitting has an angular turn, the EF increases by about a 2.5 factor to about five feet. A 90-degree hard turn fitting increases the EF by almost a factor of three compared to a sweep 90-degree fitting. The two angled 45-degree offset fittings refers to the two fittings installed offset to each other with a short piece of piping installed between them. See Figure 12 that has a drawing of the offset testing layout.

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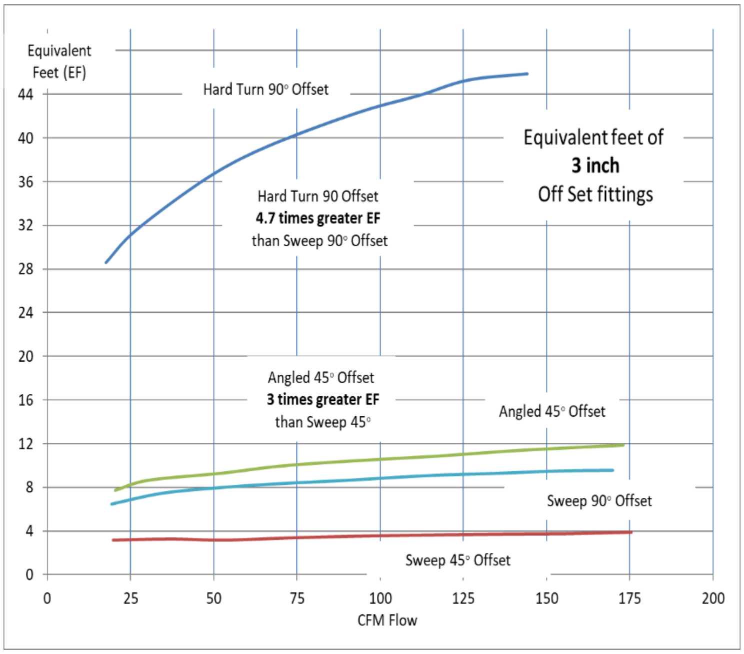

Figure (25): Three-inch (100m) pipe offset fittings

When two similar fittings are used to create an offset around an obstacle, the two fittings can be installed together using one male to female fitting that is referred to as a street and one double bell fitting or two double female fittings can be used with a short piece of pipe. This arrangement of two similar fittings offset a short distance are typically additive in EF if the fittings are sweep types. If 45-degree fittings are angular or even hard turn, then the EF of two fittings installed together is closer to three times the EF of a sweep 45-degree offset fittings. If the offset uses two hard turn 90-degree fittings, the EF increases by a factor of 4.5 times an sweep 90-degree offset. In general, if an offset uses two sweep fittings the individual EF of the fitting applies.

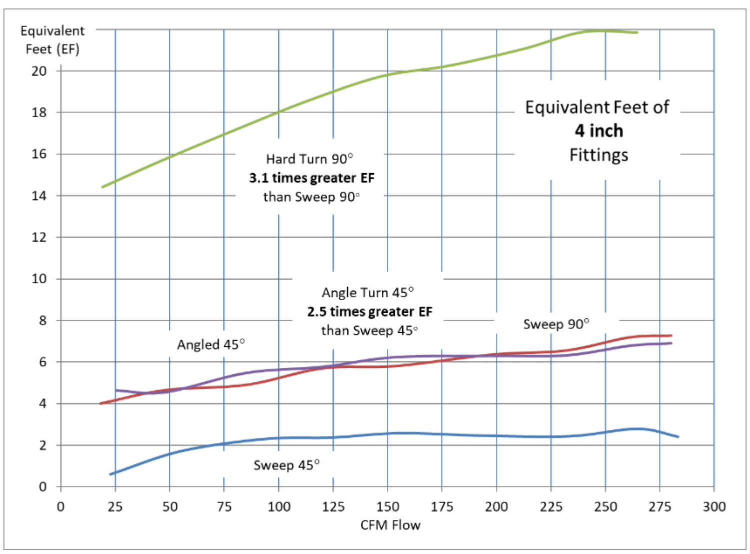

Figure (26): Four-inch pipe fittings

Four-inch (100mm) fittings EF was about two and a half feet (0.75m) for a single sweep 45-degree fitting and about six feet for a single sweep 90-degree fitting. If a single 45-degree fitting has an angular turn, the equivalent feet is about 5 to 7 or about 2.5 times greater than a sweep 3-inch 45-degree fitting. A single 90-degree hard turn fitting increases the EF by a factor of 3.3 compared to a single sweep 90-degree.

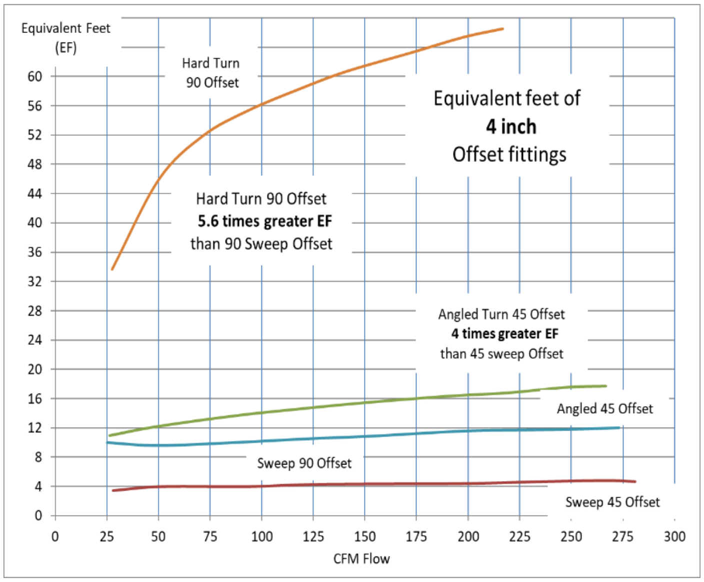

Figure (27): Hard Turn offsets had 5.6 times more EF than Sweep offsets.

Figure 27 are fitting pressure drops when two 4-inch fittings are offset to each other. The two hard turn fittings are listed as Sch20 or its other reference name of Sewer and Drain (S&D). Sch20 is a thinner walled pipe than schedule 40 but has the same ID size. Sch20 is often used for below grade drainage pipe. In comparing EF of fittings made for S&D piping, the pressure drop per fitting compared to schedule 40 fittings is typically greater. The hard turn Sch20 90-degree offset had 5.6 times the pressure drop of the offset sweep 90-degree fitting. The angled turn 45-degree offset was 4 times greater EF than the offset sweep 4-inch fittings.

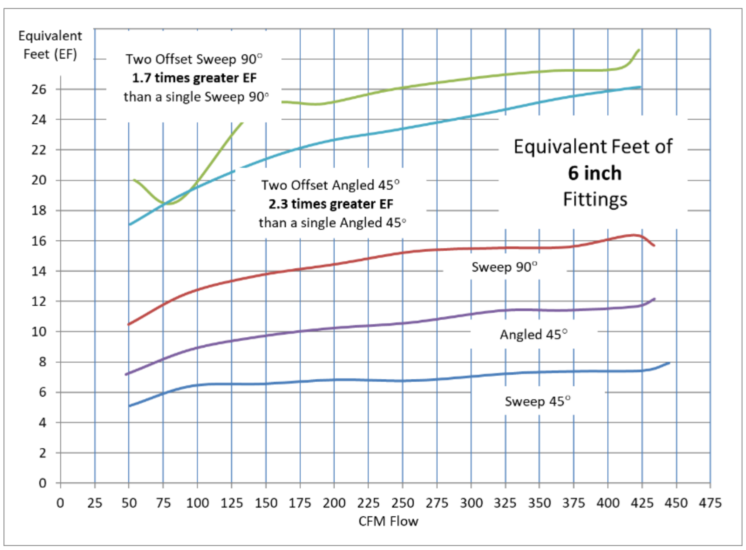

Figure (28): Six-inch pipe fittings

Figure (29): Six-inch 90 degree sweep offset fittings

Interestingly the EF of off-set six-inch (150mm) sweep 90-degree fittings had less than double the EF of a single 90-degree sweep fitting. The off-set angular 45-degree fittings were 2.2 times greater than a single angular turn 45-degree fitting.

Figure (30): Six inch angled 45 degree offset pipe fittings

3.5 Fitting Pressure Drop Calculations

In order to determine the approximate equivalent feet (EF) of piping for different fittings that would commonly be used by ASD installers, a simplified formula for each fitting was worked out that most closely match the measured EF of each fitting as airflow changed. The formula is given in Formula 2. Table 5, 6, and 7 includes all the C (constant) and V (Variable) factors for each fitting or fittings type.

$$EF = C * (V * CFM)$$

Where:
C is a constant for each fitting
V is a variable for each fitting
CFM is the airflow through the fitting.

Formula (2): Fitting pressure drop equivalent feet of piping

In Figure 31 to Figure 36 the measured EF of each fitting at varying airflows was compared to the results using Formula 2. The dashed lines represent a close as can be achieved linear calculation of the pressure drop as CFM increases. The fitting constant and variable is included in Table 5, 6 and7.

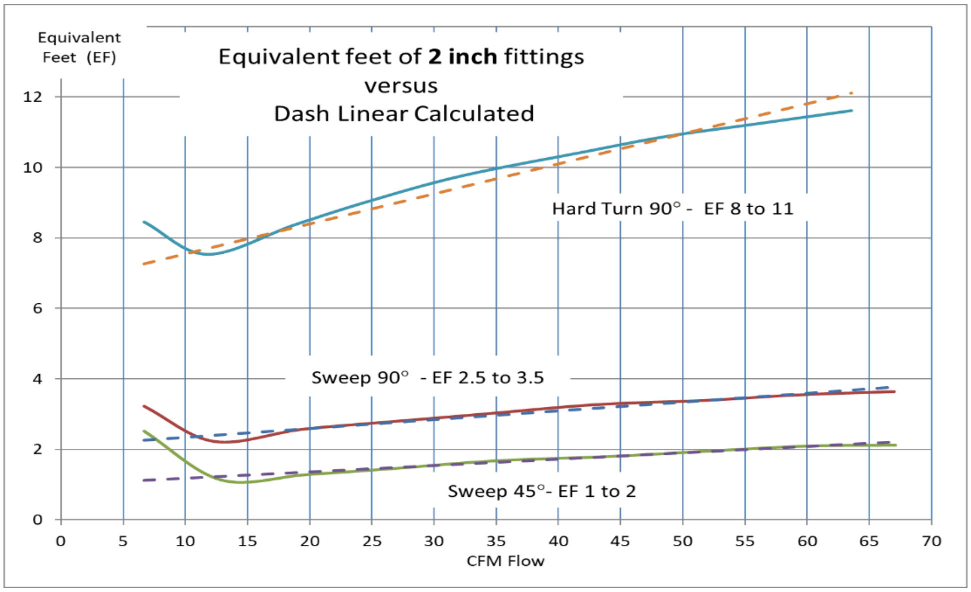

Figure (31): Comparison Calculated versus measured 2-inch fitting EF

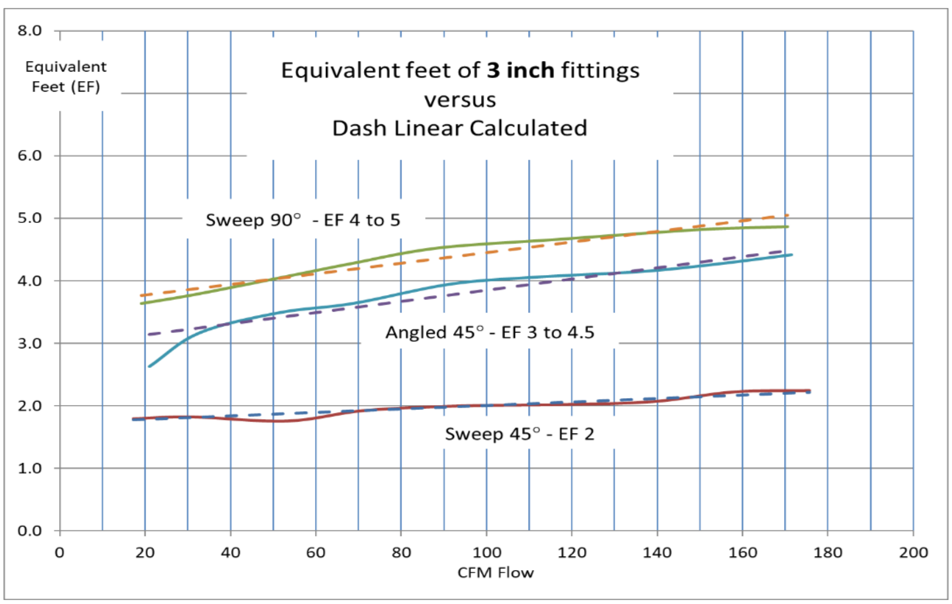

Figure (32): Comparison Calculated versus measured 3-inch fitting EF

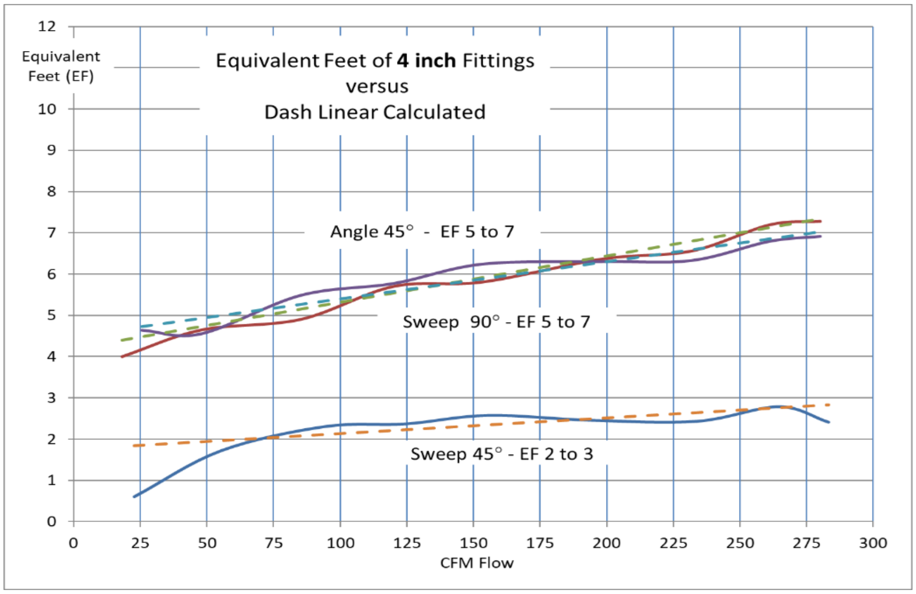

Figure (33): Comparison Calculated versus measured 4-inch fitting EF

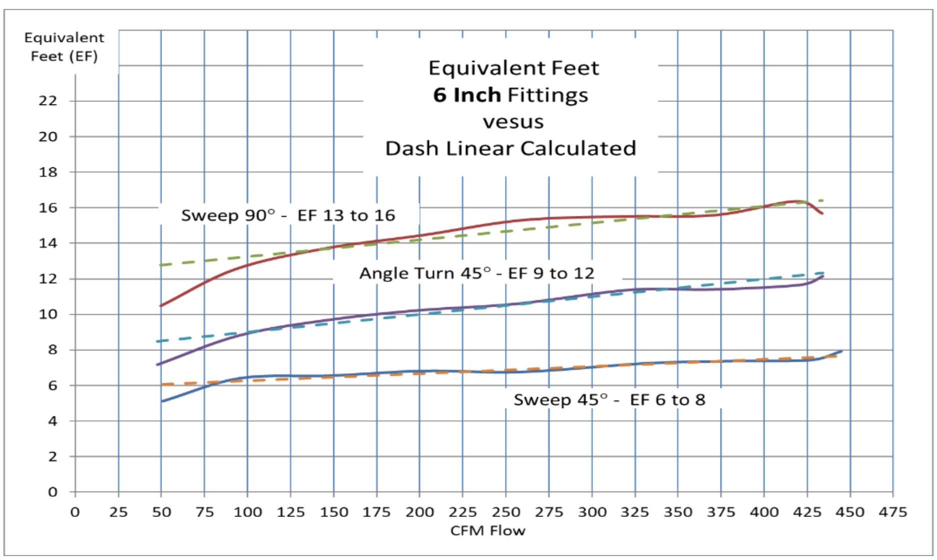

Figure (34): Comparison Calculated versus measured 6-inch fitting EF

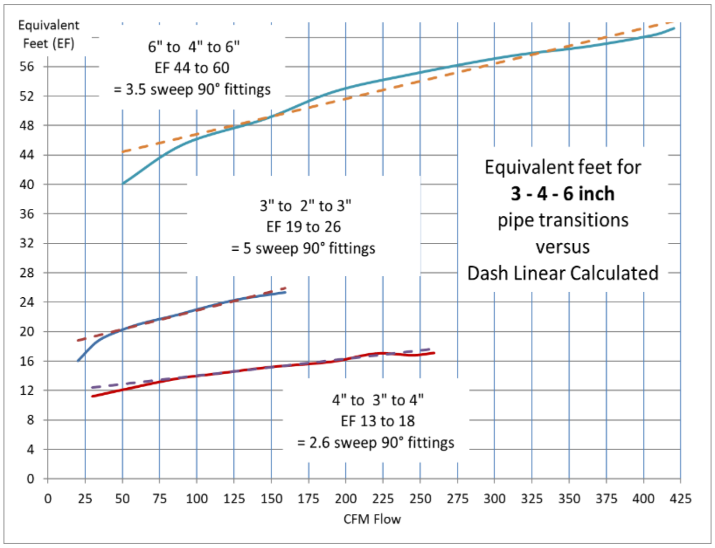

Figure (35): Reducing pipe size & calculated value

When running pipe in a commercial ASD installation there are often obstacles that require the piping size to be reduced and then transitioned back to the original size or just reduced in pipe size. In Figure 35 the pressure drop in EF was measured for transitions of 3-inch to 2-inch back to 3-inch piping, for 4-inch to 3-inch and back to 4-inch of piping and also for 6-inch to 4-inch back to 6-inch. The transition EF when piping is downsized to a small pipe size in piping networks is assumed to be a similar EF as the measured transition EF in this study.

The 4-inch to 3-inch to 4-inch piping transition was equal to about 2.6 sweep 90-degree 4-inch fittings. The 3-inch to 2-inch to 3-inch piping transition was a larger pressure drop equal to about 5 sweep 90-degree 3-inch fittings. The 6-inch to 4-inch to 6-inch transition equaled about 3.5 sweep 90-degree 6-inch fittings. The smaller EF of 4-inch to 3-inch transitions was unusual and may need to be remeasured to verify.

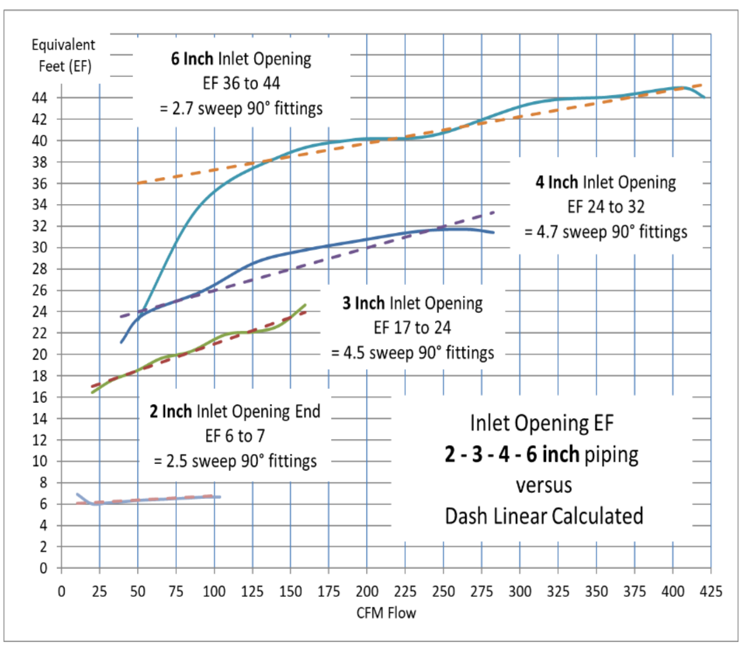

Figure (36): Piping EF at pipe inlet

As air enters the system piping in a typical suction pit there is no smooth transition of air flow. Some of the incoming air must make a hard turn at the edges to enter the pipe. The initial pressure drop was measured for both non-tapered openings and tapered from 3-inch and 4-inch piping runs to an 8-inch round tapered opening. In general, the tapered opening reduced the opening pressure drop EF by about 35%.

Without a tapered inlet, the opening to the 3-inch pipe had the EF of 4.5 sweep 90-degree 3-inch fittings. The open 4-inch pipe had the EF of 4.5 sweep 90-degree 4-inch fittings. The 6-inch pipe and 2-inch pipe inlet EF were the least pressure drop with EF of about 2.6 sweep 90-degree fittings of the same size pipe.

Pipe Size	CFM airflow	Sweep turn 45° EF	Angled Turn 45° EF	Sweep turn 90° EF	Hard turn 90° EF	Open Pipe inlet EF	Transition to smaller pipe
2-inch	10 - 60	2’ to 3’		2.5’ to 3.5’	8’ to 11’	6’ to 7’	
3-inch	25 - 175	2’ to 2’	3’ to 4.5’	4’ to 5’	11’ to 15’	17’ to 25’	16’ to 25’
4-inch	25 - 275	2’ to 2.5	3’ to 7’	3’ to 7’	15’ to 22’	22’ to 32’	11’ to 17’
6-inch	50 - 450	6’ to 8‘	8’ to 12’	12’ to 16’		36’ to 44’	44’ to 60’

Table (3): Fitting EF as airflow is varied

In Table 3 the range of EF recorded for each fitting is displayed. In general, it is recommended to use the higher EF result for ASD system design because it is predominately at higher airflows that the pressure drop from system piping is a significant portion of the total system airflow resistance. At lower air flow rates, the sub-slab airflow resistance is generally the predominate portion of the total system airflow resistance.

Pipe Size	Sweep turn 45° EF	Angled Turn 45° EF	Sweep turn 90° EF	Hard turn 90° EF	Open Pipe inlet EF	Transition to smaller pipe
2-inch	3’		3.5’	11’	7’	
3-inch	2’	4.5’	5’	15’	25’	25’
4-inch	2.5’	7’	7’	22’	32’	17’
6-inch	8‘	12’	16’		44’	60’

Table (4): Recommended EF for each fitting or pipe inlet used

Fitting Type Factor	Sweep 45° EF	Angled 45° EF	Sweep 90° EF
2” - C	**1.0**		**2.1**
2” - V	0.018		0.025
3” - C	**1.725**	**2.95**	**4.2**
3” - V	0.0028	0.009	0.0085
4” - C	**1.75**	**4.5**	**4.2**
4” - V	0.0038	0.009	0.0112
6” - C	**5.86**	**8.0**	**12.3**
6” - V	0.004	0.01	0.0095

Table (5): Fitting EF = C * (V * CFM)

Fitting Type Factor	3” to 2” to 3” EF	4” to 3” to 4” EF	6” to 4” to 6” EF
C	**17.8**	**11.7**	**42**
V	0.051	0.023	0.048

Table (6): Transitions EF = C * (V * CFM)

Fitting Type Factor	2” Inlet Opening - EF	3” Inlet Opening - EF	4” Inlet Opening - EF	6” Inlet Opening - EF
C	**5.9**	**16**	**22**	**34.75**
V	0.013	0.05	0.04	0.025

Table (7): Inlet Opening EF = C * (V * CFM)

Table 5, 6 and 7 list the Constant (C) and the Variable (V) used for each fitting or Inlet Opening to determine the equivalent feet of pipe as the CFM flow through the fittings or transitions changes.

4.0 Conclusion

4.0 Piping Pressure Drop and Fitting EF Conclusions

In designing an Active Soil Depressurization (ASD) system that is commonly used to reduce soil gas movement into a building, the resistance of airflow movement from a single suction pit location is determined by preforming a Pressure Field Extension (PFE) test. The additional pressure drop from the pipe and fittings used in the system must be included to calculate the total system airflow resistance. The results of both these resistances to airflow allows comparison to commonly available suction fans to determine the final system expected airflow. As the system airflow increases, the resistance of the airflow though the piping increases by approximately the square of the airflow increase. In high airflow systems that have low sub-slab airflow resistance, the piping can be a greater resistance to airflow than the sub-slab airflow resistance. Determining the airflow resistance of the required piping length and number of fittings becomes a crucial component of commercial ASD design. The calculation of piping resistance for different pipe sizes also allows choosing the optimal pipe size. This study measured the resistance of airflow though piping and pipe fittings for four common ASD pipe sizes. The study also measured pipe fitting resistance based on the sweep or angled or hard turn of the fitting. All of the fitting measurements were converted into equivalent feet (EF) of piping for the same airflow. Table 4 provides the recommended fitting or opening EF per fitting used. The total fitting EF can then be added to the piping length to obtain the total EF of the system piping. Formula 1 in this study can then be used with the total EF for the specified pipe size to determine the pressure drop for any given CFM airflow. This method can be repeated for all of the pipe sizes or any EF. For multiple suction systems connected to a single suction fan the airflow from each suction pit can be considered as a percentage of the total system airflow and piping pressure drop can be calculated at the given percentage of airflow for the individual legs of the system to approximate the pressure drop and final sub-slab suction that is applied for a given fan.

5.0 References

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