YORK	APPLYING VSO OPTION TO SOLUTION AIR HANDLING UNITS	
APPLICATION GUIDE	Supersedes: Nothing	Form: 102.20-AG14 (207)

GENERAL

The VSO (Variable Size Openings) option is now available in YorkWorks for the purpose of customizing the openings in various segments of the Solution Air Handling Units. This feature allows you to:

1. Change opening size
2. Change opening location
3. Change opening shape
4. Add new openings
5. Delete openings

Note: Not all segments are included in this option at this time. See YorkWorks program for available Custom Openings.

The power and advantage of the VSO option is its ability to provide our air-handlers with inlet and outlet openings that enhance the operation and efficiency of our customers air distribution system.

This document includes designing tips, which should be taken into consideration when designing a duct system and applying the VSO option to Solution Air Handling Units. It also covers instructions for configuring custom openings in the YorkWorks VSO option.

YORKWORKS VSO OPTION

Opening Pressure Drop Accounting

The YorkWorks VSO option takes into account the flow disturbances caused from the air contracting or expanding through the opening, with or without a damper. These disturbances are calculated losses known as opening pressure drops. Opening losses are accounted for using the Bernoulli formula: $PD0 = k_T\ (V/4005)^2$

Where:

PD0 = pressure drop through the opening

V = air velocity through the opening

kT = dimensionless coefficient which translates air velocity into pressure drop for a given opening type.

See ASHRAE Fundamentals Manual – Chapter 32- Duct Design)

If a damper is included in an opening the damper pressure drop (*in accordance with (AMCA) Air Movement and Control Association Standard 500*) is added to the opening pressure drop. Therefore the total segment Air

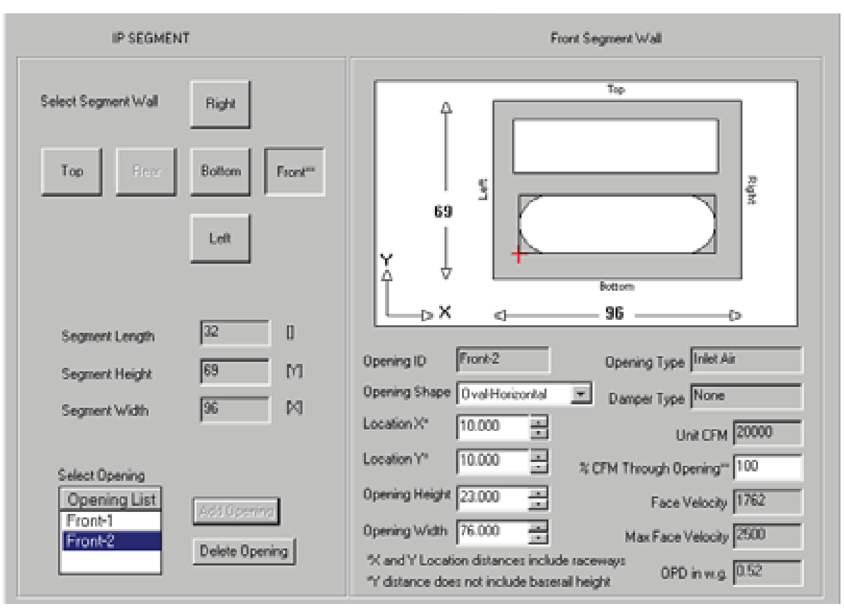


FIGURE 1. CUSTOM OPENINGS DIALOG BOX

Pressure Drop = max opening pressure drop (+) damper air pressure drop. All these calculations are automatically made using the YorkWorks VSO program.

The inefficiency of static and velocity pressure conversions must be carefully evaluated. In some air systems these losses may represent an appreciable part of the total resistance to be imposed on the supply fan.

VSO OPENING PARAMETERS

Opening sizes are dependent on the allowable velocity, the panel size and location. See Table below:

SHAPE	SIZE	LOCATION	DAMPER	MAX. VELOCITY
Rectangle	4" – 123"	Top, Bottom Front, Rear Sides	Available	1600 FPM (1200 w/ damper)
Round	6" – 44"		Not Available	2500 FPM
Oval	6" – 123"		Not Available	2500 FPM

Parameters For Placing Openings

A “No-zone” is defined as an area on a given segment where an opening can not be placed. The VSO Option in the YorkWorks Program automatically defines the no-zone(s) of any segment in which the VSO option can be used. See Table on page 3 for segments allowing VSO option. For more information, see Sizing and Locating Rules in the VSO YorkWorks Program on pages 3 and 4.

Other Parameters:

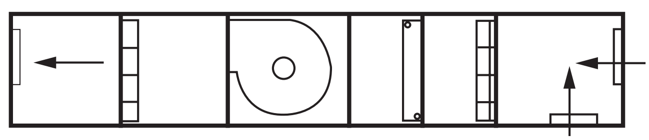
1. Opening with a damper must have an existing damper as standard.
2. You cannot mix Inlets and Outlets on the same segment panel face.
   a. Inlets are to be defined as: Return Air (RA), Outside Air (OA)
   b. Outlets are to be defined as: Exhaust Air (EA), Supply Air (SA)
3. Round and oval openings must be provided with a bellmouth fitting. This special low friction fitting is to be used at a duct takeoff from a plenum.
4. Openings may not be located on filter area panels of FM, EF or VF segments. (Note: Openings will be allowed upstream of the filter panel within the segment limits.)
5. Openings may not be located on the same panel as door.
6. Openings may not be located on the same panel which contains a electrical control panel
7. Openings may not be located on outdoor roof panels as a top inlet.
8. Openings may not be located on Energy Recovery segments.

Standard vs. Customized Openings

Standard Opening is defined per segment:

- One (1) opening per air-stream
- Traditional flat rectangular opening fixed within the panel face area
- Abrupt entrance and exit

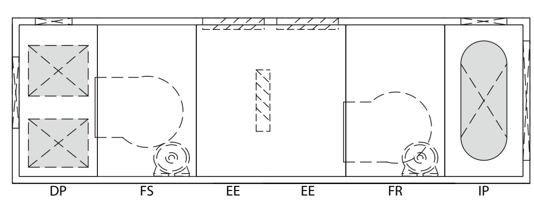
See drawing below:



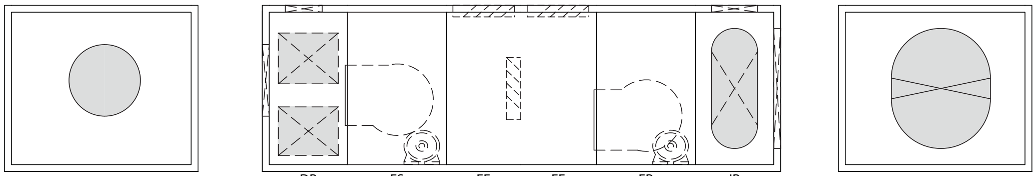
Variable Size Openings is defined per segment panel with maximum:

- Two (2) air-streams
- Two (2) openings
  1. Custom sized rectangular
  2. Custom sized round
  3. Custom sized oval

See drawing below:



Variable Size Openings (VSO) may be applied in a number of ways to a number of segments. For example; mixed shapes, different sizes and locations, maximum of (2) air streams per segment panel face as is shown in figure below.



SEGMENTS ALLOWING VSO OPTIONS

SEGMENT	MAXIMUM OPENINGS / PANEL	OPENINGS MAY VARY BY:	
OUTLET			
• DP	Up to 2 openings on any side*	Size, location and shape	
• VP	Up to 2 openings on any side*	Size, location and shape	
• FS (SWSI)	Up to 2 openings on any side*	Size, location and shape	
INLET			
• IP	Up to 2 openings on any side*	Size, location and shape	
• MB	Up to 2 openings on any side*	Size, location and shape	
• FM	Up to 2 openings on any side*	Size, location and shape	
• FR (DWDI)	Up to 2 openings on REAR side	Size, location and shape	
INLET (WITHOUT DAMPER)			
• EE	Up to 2 openings on any side	Size, location and shape	
• EF	Up to 2 openings on any side	Size, location and shape	
• VE	Up to 2 openings on any side	Size, location and shape	
• VF	Up to 2 openings on REAR side	Size, location and shape	
INLET (WITH DAMPER)			
• EE	Up to 2 openings on any side	Size, location	Shape Must Be Rectangular
• EF	Up to 2 openings on any side	Size, location	
• VE	Up to 2 openings on any side	Size, location	
• VF	Up to 2 openings on REAR side	Size, location	

* Includes top and bottom.

Sizing Rules for VSO Option

Sizing rules for custom openings as found in the YW Program:

1. Rectangular openings
   a. Width and height increments will be 1"
   b. Minimum width = 4", minimum height = 4"
   c. 4" minimum space is required between rectangular openings
2. Oval Openings
   a. Width and height increments will be according to standard bellmouth sizes using 1" increments as frequent as possible.
   b. Minimum width = 7", minimum height = 6"
   c. 10" minimum space is required between oval openings
   d. Opening will include a built-in bellmouth fitting
3. Round Openings
   a. Diameter increment will be according to standard bellmouth sizes using 1" increments as frequent as possible.
   b. Minimum diameter = 6"
   c. 10" minimum space is required between round openings
   d. Opening will include a built-in bellmouth fitting

Locating Rules for Custom Opening(s)

Openings without a damper

Opening must be located at minimum:

2" from 'panel' edge for unit height <42"
(Add 1.5" for wireway if unit includes electrical wiring)
4" from 'panel' edge for unit height >42"
(Add 1.5" for wireway if unit includes electrical wiring)

Note: 3" must be added for raceway if measurement is taken to 'unit' edge.

SWSI Fan segment supply air (SA) opening:

Top and Side openings must be at minimum 4" from panel edge

Bottom opening – only (1) one allowed per segment

1. Opening cannot be increased beyond standard size, only decreased
2. Opening must be centered on the standard opening

Openings with a damper only - no hood or louver EAML

- Opening must have an existing damper as standard.
- Only a rectangular opening will be available for variable size damper applications.
- The rectangular damper will be located a minimum 6" from the panel edge.
- Front or Rear minimum location restrictions:
  a. 12" above segment bottom to avoid bottom damper interference.
  b. 7" below segment top to avoid indoor top damper interference.
  c. 9" below segment top to avoid outdoor top damper interference.
- Side minimum location restrictions:
  a. 8.5" downstream from segment front to avoid front damper interference.
  b. 10.5" downstream from a Mixed Air wall damper to avoid interference.
  c. 12" above segment bottom to avoid bottom damper interference.
  d. 7" below segment top to avoid indoor top damper interference.
  e. 9" below segment top to avoid outdoor top damper interference
- Top/Bottom minimum location restrictions:
  a. 8.5" downstream from segment front to avoid front damper interference.
  b. 10.5" downstream from a Mixed Air wall damper to avoid interference

Openings with a damper and hood or louver EAML

- Opening must have an existing damper as standard.
- Only a rectangular opening will be available for variable size damper applications.
- Front/Rear minimum location restriction:
  Note: Opening/Damper width is not changeable
- Side minimum location restrictions:
  Note: Opening/Damper width is not changeable and opening/Damper height cannot be increased beyond standard size, only decreased

OPENING CONSIDERATIONS

Inlet and outlet openings have a direct link to duct design considerations. When properly designed and installed the duct system can have an efficiency of 80% or higher. As a result a highly efficient design will reduce energy consumption as well as reduce equipment size.

A key factor to remember in selecting a variable size opening is that the duct cross sectional area connecting to any opening should be no greater than 105.5% or no less than 85.5% of the inlet or outlet cross sectional area.

Under-Sizing Not Recommended

The practice of under-sizing openings and ducts is not recommended since it has been known to be the cause, in many cases, of serious acoustical problems due to generating a rumble and other noise in the duct system. Any air handling system is a potential source of noise which may enter the conditioned area through the supply, return or exhaust ducts The excessive system noise is usually generated by the turbulence of the air stream and is not noise originating at the fan and transmitted through the distribution system. Generally, low-velocity conventional systems present relatively few acoustical design problems. (Reference 'ACOUSTICHECKS FOR AIR HANDLING PROJECTS' Form 100.00-AG2 (303).

Multiple Inlets & Outlets

In an application requiring multiple inlets or multiple outlets within the same plenum it is important to remember the opening which has a larger cross-sectional area will allow the air to enter or leave the plenum with a minimum of effort (path of least resistance). This situation may arise when a system is designed to feed both exterior and interior zones and unavoidable changes occur in load distribution. To avoid a mechanically unstable system a simplified procedure should be used to establish air quantities for sizing openings and ducts. Refer to “Equal Friction Design Method” section on page 6.

DESIGN FUNDAMENTALS OF DELIVERY SYSTEMS

The design of an air handling system using variable size openings for air distribution does not involve any new concepts. The basic items necessary for evaluation when selecting a custom inlet or outlet are:

- air flow
- pressure (static & velocity)
- duct design

For more detailed information on principles, procedures and standards of designing delivery systems refer to the “REFERENCES” listed at the end of this document.

Friction Loss

Friction losses for a duct system are easily calculated since application engineers depend upon published friction charts. Refer to HVAC Duct System Design Tables and Charts found in the SMACNA manual. It would be extremely time consuming and somewhat complex to calculate friction losses since many of the formula that describes gas flow are not constant and require factors. The charts used for friction losses are based on straight ductwork measurements and are typically ‘*calculated*’ using standard air conditions. If you know any two of the three factors: duct diameter, air velocity, and air flow rate, the third factor and the friction loss may be determined.

Friction loss in ductwork is due to the actual rubbing action of the air against the side of the duct and the turbulence of the air rubbing against itself while moving through the duct system. Air tumbles down the duct rubbing against itself and the ductwork building resistance when it encounters a fitting. The friction loss caused by a sharp turn is greater than that caused by a slow gradual turn (i.e.; long radius elbow). A square fitting creates a greater friction loss than a rounded fitting. Friction due to rubbing the walls of the ductwork cannot be eliminated but can be minimized with good design practices.

Design Velocity

The air flowing in a duct system moves along the duct path at a specific velocity. Any change made in the velocity profile will directly relate to the efficiency and function of the air moving systems.

Some things effecting velocity are:

- Poorly sized openings
- The number of connecting joints
- Leaky connections
- Abrupt transitions
- Poorly configured duct system

A velocity change is typically defined as a ‘Pressure Loss’. The velocity of the air and the weight of the air create a velocity pressure.

- Velocity pressure exists only due to the velocity of the moving air stream.
- Velocity pressure is a measure of energy (kinetic) possessed by the air due to its velocity.
- Velocity pressure exerts itself only in the direction of the airflow.

Dynamic Loss

Dynamic losses relate to the things that obstruct the path of the air flowing through a duct system causing a loss of cooling or heating efficiency. Improperly designed duct systems create disturbances and unnecessary turbulence in the air flowing through them. Abrupt changes in the flow direction, flow area or duct design and other obstructions to the path of the air flow can drastically reduce the efficiency of the duct system.

Dynamic loss occurs when the uniform flow is forced to change. This causes an imbalance of the calculated constant velocity. Predominant dynamic losses result from expanding ducts or areas (decreasing velocities). Less severe dynamic losses result from reducing ducts or areas (increasing velocities). In some air systems these losses may represent an appreciable part of the total resistance to be imposed on the supply fan.

DUCT DESIGN

The openings of a plenum and the duct connections made to a plenum should be made as streamlined as possible to reduce the entrance loss to and from the duct. See Figure 2. Every effort should be made to have a smooth air flow transition. The correct transition will serve to conserve uniform air flow motion and momentum and in turn reduce the total power needed to produce the require rate of flow in the supply system.

Equal Friction Design Method

The 'equal friction' design method attempts to establish a "root pressure" which is a constant pressure loss per unit of duct length. A number of sources recommend using 0.1" WG pressure loss per 100 ft total length. The length selected is considered the "critical path," which is the longest branch in the air distribution system. It is assumed that the longest run will have the highest sum of total pressure loss. The Engineer will assign total pressure losses to each section of the "critical path" as the recommended pressure loss per unit of length multiplied by the actual section length. The better process will achieve pressure balancing by selecting proper duct cross-sections rather than by using dampers. For more information about equal friction methods go to "Equal Friction @ www. EngineeringToolBox.com" or refer to ASHRAE Fundamentals Handbook. Chapter 34, "Duct Design": American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2001.

Connection Basics

The purpose of this review of basics is to help you make the best possible choices in designing a duct system. For more detailed information, see the Reference Section at the back of this document. The basics for connection and duct design are shown in the following illustrations:

Figure 3 shows Elbow Basics (see below).

Figure 4 shows Duct Take-off Connections and Guidelines (on page 7).

Figure 5 shows Recommended Elbow Connection for a Roof Mounted AHU (on page 7).

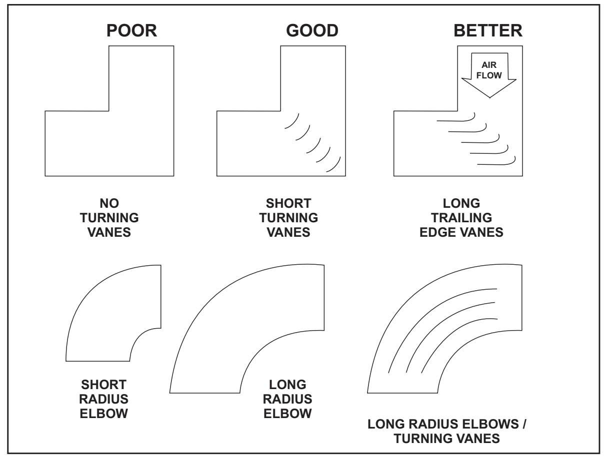
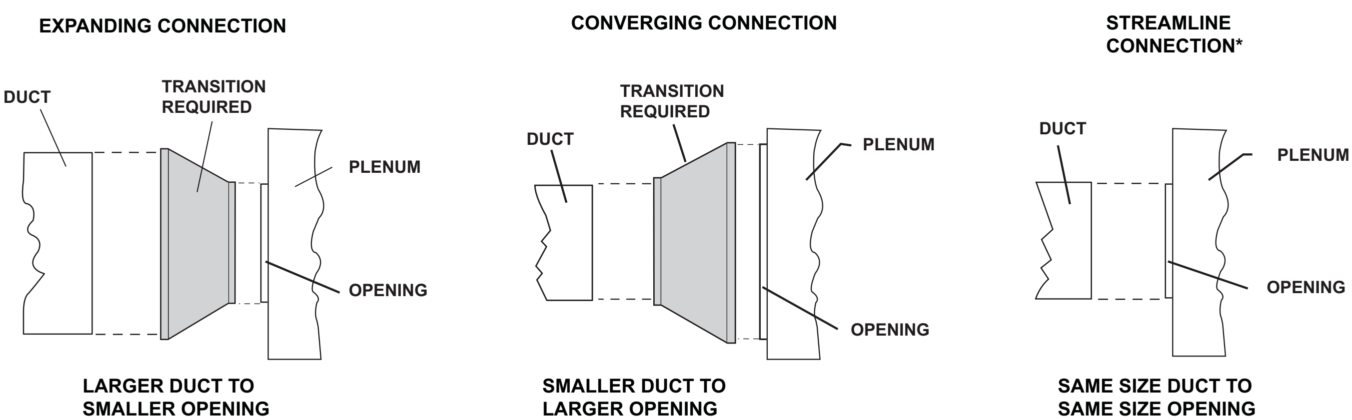


FIGURE 3. ELBOW BASICS

NOTE: Available to you is an easy-to-use calculating device that aids in the layout of air handling systems, sizing ducts and the checking of existing duct systems. Order Form No. 246967 "SIZE-A-DUCT".



***NOTE:** The best connection scenario is the streamline connection.

FIGURE 2. DUCT TO PLENUM CONNECTION BASICS

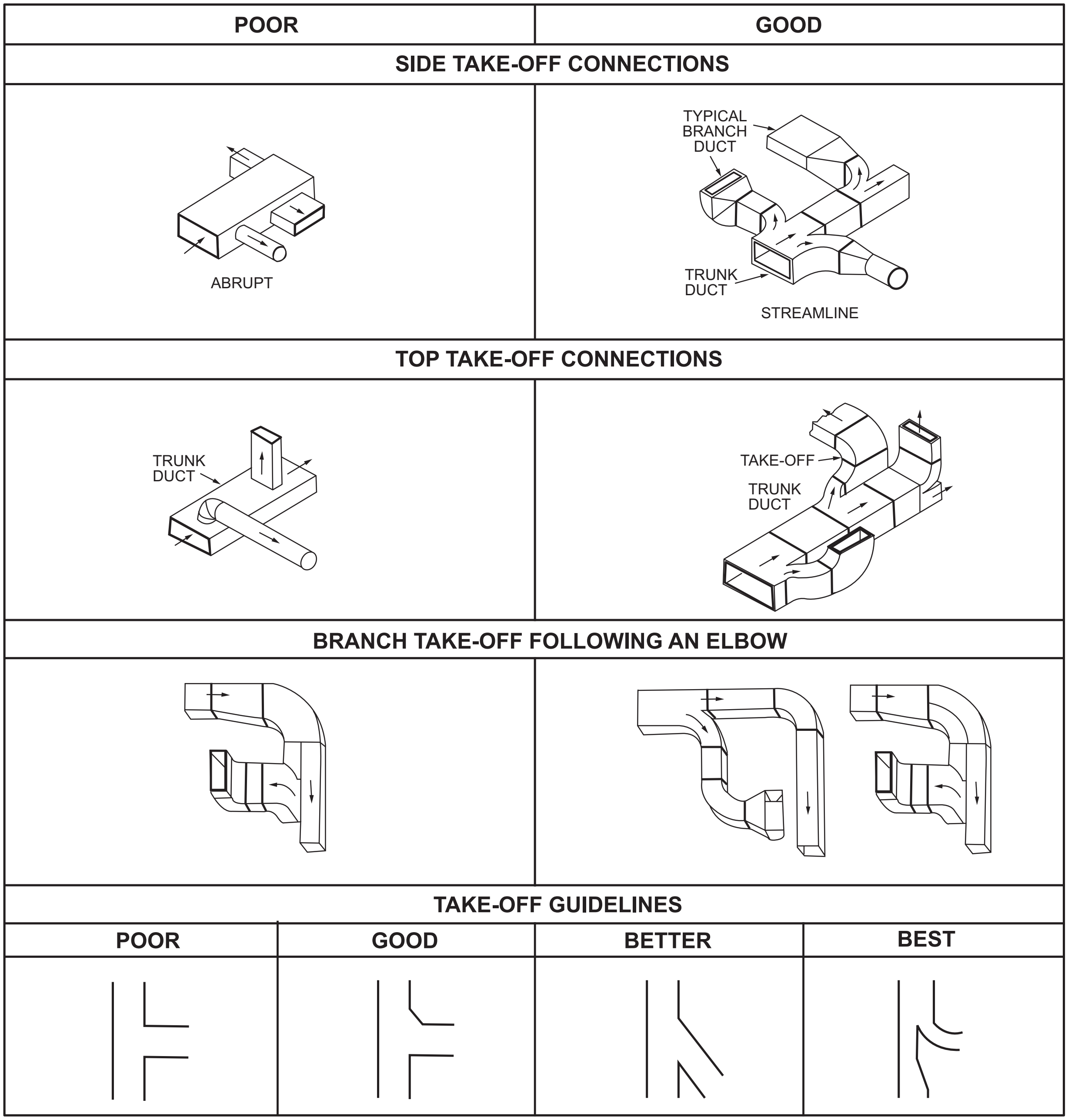


FIGURE 4. DUCT TAKE-OFF CONNECTIONS AND GUIDELINES

Discharge Plenums

Discharge plenums should be used on roof mounted air handlers to help eliminate the potential for breakout noise. Heavy gage radius elbows should be used, with the elbow below the roof as far from the plenum outlet as possible.

Note: Take-offs from the discharge plenum should be in two directions if possible to lower outlet velocity.

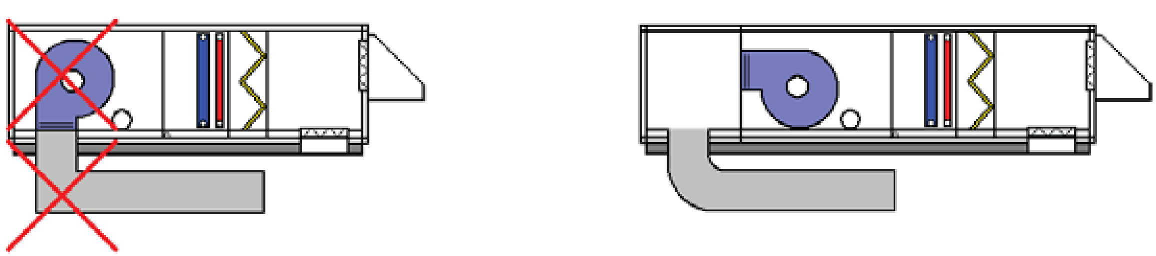


FIGURE 5. RECOMMENDED ELBOW CONNECTION FOR ROOF-MOUNTED AHU'S

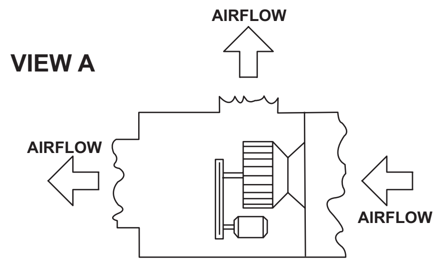
Other Designing Tips

The following should also be taken into consideration when determining opening sizes:

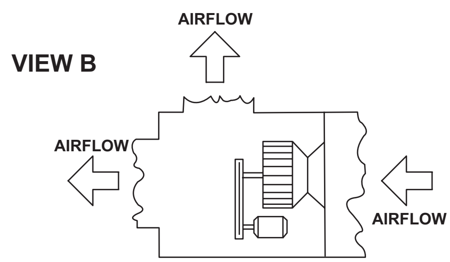
1. Discharge duct opening size should be based on clear inside dimensions of the duct.
2. Ensure adequate spacing between opening to accommodate connections (flanges, bell mouths, etc.).
3. Duct construction is based on SMACNA pressure classification. Typically, round and oval have higher pressure classifications than rectangular and, consequently, can handle higher velocities than rectangular.
4. Supply ducts must be designed to allow air to move towards the conditioned space as freely as possible, but the duct should not be exceedingly oversized. Over-sizing a duct is not economical.
5. Return-air ducts are designed in much the same way as supply duct except that the return duct may be sized slightly larger than the supply. There is normally less resistance in to the airflow in a return system than in the supply system.
6. Duct turns and transitions must be made carefully to hold the friction loss to a very minimum.
   a. The smoother the transition the less friction there will be.
   b. The air will take a slight pressure drop as it goes around each corner.
   c. Turning vanes will improve the air flow around a corner.
7. A well designed system will have balancing dampers in the branch ducts to balance the air in the various parts of the system. The damper should be located as close as practical to the trunk line. The place to balance the air is near the trunk. This allows any noise from air velocity to be absorbed in the branch duct before it enters the space.
8. Following SMACNA recommendations/guidelines for duct layout is best practice.

Plenum Pitfall #1

View "A" places an opening in direct line with a plenum fan. This arrangement will increase discharge noise levels.



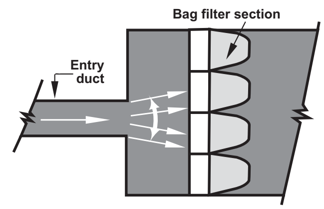
View "B" places an opening which is not in direct line with a plenum fan. This arrangement will increase the opening pressure drop.



NOTE: Care must be taken in the selection of openings to ensure the most critical issues.

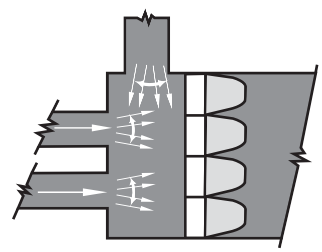
Plenum Pitfall #2

Poorly sizing and placing of an opening and ineffectively transitioning the duct to the plenum.



An improperly sized and located opening along with an improperly designed transition from a duct causes un-even flow through the plenum and across the filters (heavy in the center and lighter at the outer filters), resulting in un-even filter loading.

The same example can be used to illustrate mixing box requirements. See below.

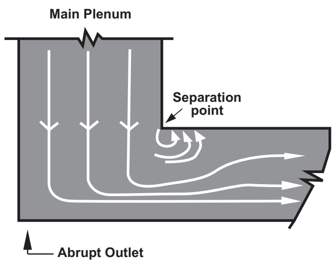


Some designs use multiple high velocity air streams without additional downstream space for mixing. This rapid change results in uneven velocity profiles that affect the performance of any components located downstream, giving up to some degree, control of the system. In addition, the pressure drop of the mixing box is typically increased to unacceptable levels.

Plenum Pitfall #3

Causing an abrupt change in direction to the air leaving a plenum by installing square elbows with no turning vanes. Note how the momentum of the airflow bunches the air toward the bottom of the duct in the elbow.

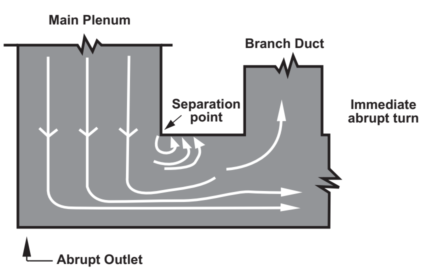
This illustration typifies the characteristics of airflow when air is forced to turn abruptly. The slight decrease in pressure at the top of the bend causes turbulence, resulting in a total pressure loss downstream.



Turning vanes improve the airflow around a corner. See elbow basics in Figure 3.

Plenum Pitfall #4

Placing a branch duct to close to the square elbow compounds the problem created by plenum pitfall #3. A turn placed too close to an elbow will seriously effect the performance of the unit. The flow streamlines and naturally oppose entry into the opening or branch duct. This severe short turn should be avoided.



At the very least, the duct should contain splitters and turning vanes.

REFERENCES

AMCA Air Systems - *Publication 200*

AMCA Fans and Systems Manual - *Publication 201*

HVAC Duct System Design - *SMACNA*

'ACOUSTICHECKS FOR AIR HANDLING PROJECTS' Form 100.00-AG2 (303)

'Engineering Design Reference Manual for Supply Air Handling Systems' (Copyright 1993 United McGill Corporation Sheet Metal Division Catalog)

'Air System Basics' by Gerald J. Williams, PE. (Vice President McClure Engineering Associates, St. Louis, Mo.)

'Handbook of Air Conditioning Heating and Ventilating' (2nd Edition, 1965)

NOTES

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