Underground Duct

Advantages, Description & Installation of Underground Duct Systems

Underground Duct

PVS (Polyvinyl Steel) coated underground HVAC duct (also known as PCD, PVC coated, and PVCS) is UL® listed and specified more often by architects, engineers, and contractors than any other underground air delivery system because it offers both the strength of steel and the inertness of plastic. These attributes make PVS ideal for in underground as well as corrosive fume exhaust applications, such as in the plating industry.

How PVS is manufactured

PVS is manufactured by a three step process: 1) hot-dipped, galvanized G-60 steel is cleaned and fire treated; 2) a special epoxy primer is baked onto both sides of the sheet; 3) Finally, a 4 mil. polyvinyl chloride coating is heat fused onto one side (4 x 1) for underground HVAC or onto both sides (4 x 4) for chemical fume exhaust applications. The result is a tough, corrosion resistant surface that will not crack, chip, peel, or rust.

Advantages of underground PVS duct

- Placing ductwork underground results in a more aesthetically pleasing interior. *Acoustical* aesthetics is also improved since most or all of the "rumble" associated with interior duct is significantly reduced or eliminated.
- The space between the ceiling and roof can be reduced, making it easier to install electrical and fire suppression systems.
- Installing duct underground allows the air delivery system to be designed for optimum efficiency because ducts do not have to run through, or parallel to roof supports. In addition, runs inside interior or exterior walls can often be eliminated.
- Underground duct is a cost effective solution when air needs to be supplied to adjacent or contiguous buildings because a central unit can serve all locations.
- PVS duct requires no protection from concrete or the minerals and salts found in backfill.
- It is strong enough to walk on and will carry moderate soil loads; yet it can be cut or modified on the jobsite with circular or saber saws fitted with metal cutting blades.

Installation

Although PVS duct has been used successfully in underground applications for over 30 years, successful results depend on correct installation procedures.

Engineering Considerations:

- It is always recommended that duct systems–whether above or below grade–be designed by a qualified engineer and installed by a qualified contractor. When a concrete slab ***will not*** cover underground duct, special consideration must be given to potential future loading from heavy equipment. If such loading is expected, PVS duct can be incased in concrete, in which case the duct will need to be securely tied down to prevent "floating." When a concrete slab *will* cover the duct, loading is not as critical, but it is recommended that the duct not be buried deeper than 2.5 times its diameter. At depths greater than 2.5 times the diameter, additional measures must be taken to insure the duct does not collapse. Such measures include the use of painted angle-iron flange connectors for added stiffness at joints, special reinforcing around the duct, or (on ducts 36" or larger) internal reinforcement. *Consult a qualified engineer when such measures are required or when there is any concern about loading.*

Preparing the sub grade:

- PVS duct can be placed directly on the soil with no special precautions to protect the duct. However, drainage needs to be considered because standing water may eventually find its way into the duct causing mold and odor problems. The grade should always be sloped back to the utility room, and ***never*** *place PVS duct at or below the water table*.
- It is recommeded that the duct be placed on 2" to 6" of pea gravel or other material that will permit easy drainage, especially when soil conditions are marginal. (Although not required to protect the duct, a vapor barrier should be placed under the duct and below the entire slab to prevent moisture from percolating through the concrete.)

Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Connecting and fastening:

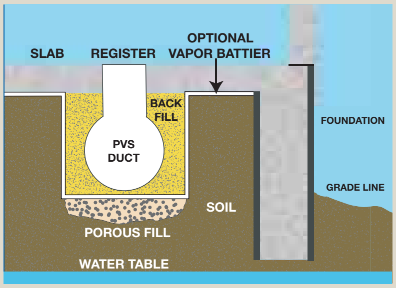
PVS Duct and fittings (or connectors) have male and female ends, respectively, and they are designed to slip together. Before joining, PVC sealant must be applied to the outside of the female fitting (or connector) and the inside of the duct. The joint must then be fastened around its circumference with sheet metal screws spaced no more than 6” apart and with a minimum of three screws per joint. Sealant should then be applied to the joint’s edge and to screw heads. After the sealant has cured, the joint should be wrapped with two to three layers of PVC tape.

Spot surface repair:

The plastic surface of PVS duct is exceptionally tough, but it can be scratched. When scratches expose bare metal, they should be sealed with PVC tape or PVC Touch-Up Paint spray. Having these remedies available at the jobsite helps to assure that this detail is not neglected.

Backfilling:

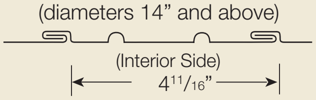
After the duct has been placed, spread backfill evenly in several layers (depending on the diameter of the pipe) and tamp each layer. Tamping should be done carefully to avoid denting or scratching the pipe’s surface; do not use mechanical tampers since their shockwaves can severly damage the duct. Do not toss backfill directly on the duct since this may cause denting, scratching, or even collapse if a large weight of fill is dumped directly onto the pipe. Similar care should be taken if concrete is being used to encase the duct.



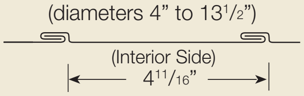
The duct, encased either in concrete or buried directly below a concrete slab, is installed above the original line of undisturbed soil and above the water table. Encasing the duct in concrete with porous fill beneath is the best way to install PVS duct. An optional vapor barrier can be placed between the pipe and the fill. Always consult local building codes for specific installation instructions.

Table 36-1: Load Specifications	
Diameter (inches)	**Max. Loading (lbs./linear ft.)**
8” or less*	400
9” to 13–1/2”*	600
14” to 36”**	1800
*Uncorrugated **Corrugated	
All ducts 14” or larger are corrugated for underground applications. Loading specifications for ducts larger than 36” have not been determined.	

Corrugated Lateral Section (diameters 14” and above)



Standard Lateral Section (diameters 4” to 13 1/2”)



Precautions and limits:

Sheet metal duct is flexible, not rigid, so greater care must be taken when installing PVS duct. Three parameters need to be considered: External load (soil load = point load), soil stiffness (modulus), and pipe stiffness. In the absence of test data, a soil modulus of 200 PSI and a soil density of 120 lbs/ft^3 can be used in calculations. Consult with an engineer. ***PVS Temperature Limits:*** Operating temperatures for PVS range from -40° F to 250° F, with limited exposure to 400° F.

Spiral Manufacturing Co., Inc. offers a broad line of Class 1 PVS Spiral pipe and fittings. We build custom made fittings and hoods on request to accompany our standard product line. Our PVS products comply with the following codes and industry standards:

UL 181 Class 1
International Mechanical Code 1996 Section 603
ICBO Uniform Mechanical Code - (UMC) 1997
SMACNA Sheet Metal Air Conditioning Contractors National Association

Low Pressure

A complete line of low pressure duct & fittings — in stock and available

The terms “low” pressure and “high” pressure in duct design and selection have, unfortunately, been given a rather wide latitude of meanings in the HVAC industry over the years. The terms have been applied to “pressure” and “velocity” simultaneously because they are inter-dependant in ductwork design. This section of the catalog is devoted to the definition and selection of “low” pressure equipment and components.

The dividing line for “velocity” of air in ducts has been defined in various applications as anywhere from 1500 to 2500 fpm and nominally as 2000 fpm. Empirical data has shown that duct sections operate satisfactorily over the above range of velocities at 1″ water gage (″wg).

Low pressure systems are chosen where duct space allows, where air noise is a consideration, and where particle conveyance such as wood chips or grain is not a requirement.

Space limitations in modern buildings have restricted the size of air conditioning ducts and equipment. Therefore, to convey the necessary volumes of air, higher velocities must be employed. Increased velocities produce higher duct friction losses. In order to maintain flow against the higher duct friction, it is necessary to have greater pressures at the air source. Therefore, the terms “high pressure” and “high velocity” generally go hand in hand. Conversely, this is true of “low pressure” and “low velocity”.

The use of the terms “high velocity” and “high and medium pressure” in this catalog refer to any static pressure class of 3″ wg or greater, and “low pressure” refers to 2″ wg or less.

SMACNA recommendations on pressure and velocity are shown in Table 37-1. The listed classifications pertain to ducts only. Casing and plenum construction designs are provided in the SMACNA “Low Pressure” manual and in the “High Pressure” manual, but their respective designs have been based on historical acceptability.

Table 37-1: Pressure Velocity Classification [1]

Former Duct Class	Pressure Rating	Pressure	Seal Class[2]	Velocity (fpm)[3]
High Pres.	10”	Pos.	A	2000 Up
Medium Pres.	6”	Pos.	A	2000 Up
Medium Pres.	4”	Pos.	A	2000 Up
Medium Pres.	3”	Pos. or Neg.	A	4000 Dn
Low Pres.	2”	Pos. or Neg.		2000 Dn
Low Pres.	1”	Pos. or Neg.		2000 Dn
Low Pres.	½”	Pos. or Neg.		1500 Dn

[1] Reproduced in part by Permission From SMACNA High Pressure Duct Standards - 3rd Ed.

[2] Seal Class A: All seams, joints, fastener penetrations and connections sealed.

[3] General velocity level through this pressure rated section of the system. Certain points may have higher or lower velocities, e.g., fan outlet or restricted passage, yet not require a different pressure class. The designer makes determinations of duct class after analyzing velocities and operating pressures.

Spiral Manufacturing stocks a complete line of low pressure fittings and installation accessories.

Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Low Pressure

A complete line of low pressure duct & fittings. Custom fittings available

Adjustable Elbows

Concentric Reducer

Shoe Tap

90° Angle Boot (PVS)

Loop Head Saddle (PVS)

Register End Boot (PVS)

Conical Takeoff *

Air Intake Hood

Canvas Connections

Airflow Takeoff (HET) *

45° Register Saddle (PVS)

Starting Collar with damper

* Preinstalled Peel n' Stick gasket. Available with or without damper.

Dust Collection

The importance of dust collection & choosing the right type of duct for dust collection

Why you need a dust collection system

Installing an efficient dust collection system should be a priority for the small shop as well as the large shop, whether the material being machined is wood, plastic, or a composite. Not only is this essential for health reasons and compliance with many national and local codes, but it is also good business because it saves money and helps to maintain the quality of the finished product.

The harmful health effects of inhaled particulates (many of which are carcinogens) are well documented, and skin, eye, and nose problems as well as allergic reactions are frequently reported. In addition, a dusty shop increases the risk of worker injury and fire, which can result in lost production, higher insurance rates, and lawsuits.

A dusty shop compromises the quality of the finished product: Accurate measurements and cuts are more difficult due to lack of visibility; airborne dust finds its way into finishing areas causing defects in the final product; and larger particles cling to surfaces cause scoring and other defects.

Finally, dust that is not automatically collected must be collected manually as a recurring direct labor expense.

By any measure, an efficient dust collection system is an investment that more than pays for itself.

Designing a dust collection system

In the simplest terms, a dust collection system is comprised of a ducting system to transport the dust from the source (table saw, planer, etc.) and a collection device (such as a bag and filter system or a cyclone), which pulls the dust through the ducting and collects it. The very first decision you must make is whether your ducting will be metal or plastic—and here there is only one logical choice: metal. (See "Metal vs. Plastic Duct" below.) The next step is to size your system. (See "Designing Your System" on pages 41-44.)

Metal vs. Plastic Duct

Plastic pipe (or PVC pipe) is unsuitable for dust collection for three reasons:

- First, plastic pipe fittings are not offered in the diversity required to meet design requirements.
- Second, plastic pipe elbows have a short radius, which encourages clogs and compromises system efficiency.
- Third, and most important, plastic pipe is non-conductive and builds up a static charge as charged particles pass through it. This static charge can discharge at any time causing shock and surprise, which is dangerous around running machinery. More serious is the risk of explosion and fire. Fine dust particles suspended in air have significant explosion potential—all that is needed is a spark, which the static charge on plastic pipe conveniently supplies. Grounding plastic pipe requires wrapping it in wire both inside and out—an expensive (and never certain) proposition that negates the minimal price savings in going to plastic in the first place.

Spiral steel pipe has none of these disadvantages. An incredible variety of fittings are available and custom fittings can be easily fabricated. The fittings are designed with long radius to minimize clogging, and special fittings such as clean-outs and quick disconnects are available. Most important, Spiral metal pipe is conductive, and simple and easy to ground, even when flexible rubber hose is used to connect the duct to the machine.

Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Standard dust collection components
& accessories

Dust Collection

Spiral Manufacturing has all the duct components you need to design and build a safe and efficient dust collection system

***Laterals** (Pages 12-14)*

***Reducers** (Page 15)*

***Elbows** (Pages 5-6)*

***Blast Gates** (Pages 31-32)*

***Clean-outs** (Page 30)*

***Floor Sweeps** (Page 17)*

***Clear Flex Hose** (Page 33)*

***Manifolds** (Page 14)*

***Custom Hoods** (Page19)*

***Clamps** (Page 34)*

***Bellmouth** (Page 17)*

***Duct Sealants** (Page 27)*

Spiral Manufacturing Co., Inc.

Dust Collection

How to design an efficient dust collection system with Spiral pipe.

Designing Your System

There are two phases to designing your dust collection system: The first phase is sizing your duct work for adequate volume and velocity of flow for the type of dust you will be creating; and the second phase is computing the *static pressure* (SP) of your system to determine the size and power of your dust collection unit.

Prior to making your calculations, diagram the floor plan of your shop to scale on graph paper. Include the size and location of each machine, and the location of its dust port or outlet; the floor to joist dimension; the location of the dust collecting unit; and the most efficient (fewest number of turns or bends) path for routing your duct lines. This is also a good time to start your take-off list of duct components for your system.

You will also need to familiarize yourself with the following concepts:

CFM (Cubic Feet per Minute) is the volume of air moved per minute.
FPM (Feet per Minute) is the velocity of the airstream.
SP (Static Pressure) is defined as the pressure in the duct that tends to burst or collapse the duct and is expressed in inches of water gage (˝wg).
VP (Velocity Pressure), expressed in inches of water gage (˝wg), is the pressure in the direction of flow required to move air at rest to a given velocity.

CFM is related to FPM by the formula CFM = FPM x cross-sectional area (ft^2). FPM is important because a minimum FPM is required to keep particles entrained in the air stream. Below this minmum FPM, particles will begin to settle out of the air stream, forming clogs—especially in vertical runs. Table 41-1 shows the minimum FPM that Spiral Manufacturing recommends for several types of dust in branch and main runs.

Step 1

From the Table 41-1 determine the velocity (FPM) of your system for the type of dust that will be produced. For the purpose of the following examples assume woodworking dust. Wood dust requires 4500 FPM in branches and 4000 FPM in mains.

Table 41-1: Velocity for Type of Dust

Type of Dust	Velocity in Branches (FPM)	Velocity in Main (FPM)
Metalworking Dust	5000	4500
Woodworking Dust	4500	4000
Plastic/Other Light Dust	4500	4000

Step 2

Determine the diameter of each branch line. You can use the diameter of a factory installed collar or port, or consult the manufacturer. Convert metric ports to the nearest inch. Convert rectangular ports to the equivalent round diameter. Ports less than 3” will require a reducer to 4”. Record any reducers or rectangular to round transitions on your take off list.

Step 3

Using Table 41-2, determine the CFM requirement of each branch. Remember the FPM for wood dust in branch lines is 4500.

Example: Table saw 4” dia. 390 CFM (rounded)
Planer 5” dia. 610 CFM (rounded)
Lathe 6” dia. 880 CFM (rounded)
Continue for all branches.

Table 41-2: CFM for for pipe diameter at specified velocity

Diameter	3500 FPM	4000 FPM	4500 FPM
3”	277	316	356
4”	305	348	392
5”	477	546	614
6”	686	784	882
7”	935	1068	1202
8”	1222	1396	1570
9”	1546	1767	1988
10”	1909	2182	2455
12”	2749	3142	3534
14”	3742	4276	4810

For larger diameters see pages 59-60.

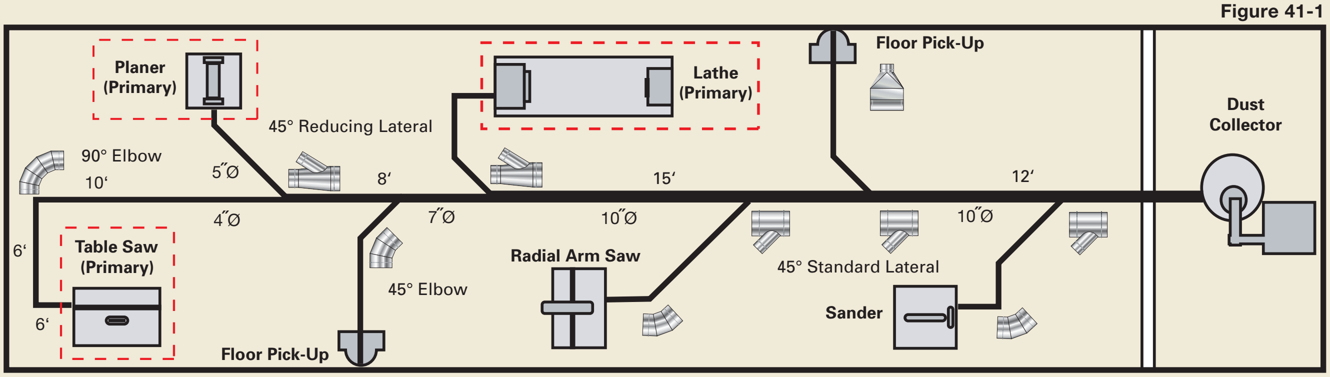
Step 4

Identify your primary or high-use machines. These are the machines that operate simultaneously on a frequent basis. The objective here is to define your heaviest use scenario so you can size your system to meet it. Including infrequently used machines and floor pick-ups in your calculations will only result in an over-designed system that will cost more to purchase and to operate. At this point, all of your branch lines are sized, and you have a list of all components required for your branch lines.

Step 5

Now you are ready to size the main trunk line. Begin with the primary machine that is *furthest* from where you will place the dust

Figure 41-1



Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

collecting unit. In our example, this is the table saw, which has a branch diameter of 4”. Run this 4˝ Spiral pipe to the point where the second primary machine (the planer on a 5˝ branch) will enter the main. (Note: If a non-primary machine or pick-up is added to the system between primary machines, the size of the run is not increased.)

You now have a 390 CFM line (table saw) and a 610 CFM line (planer) combining for a total of 1000 CFM. Using Table 41-2 again, you will see that for 4000 FPM (the velocity requirement for main line that you determined in Step 1) the required pipe diameter falls between 6” and 7”. (Note: Spiral Manufacturung recommends that you round up to 7”. This not only assures adequate air flow but also anticipates a future upgrade in machine size.)

Now calculate for the addition of the third primary machine (the lathe on a 6˝ branch). You have an 1000 CFM main + an 880 CFM branch line (for the lathe) for a total of 1880 CFM. Using Table 41-2 once again, 1880 CFM at 4000 FPM requires between a 9” and 10” pipe. We recommed rounding up to a 10” main after the addition of the lathe. The main going to your dust collecting unit will be 10”, and your dust collection unit must be capable of pulling 1880 CFM through a 10” duct at 4000 FPM.

Step 6

In this step, you calculate the Static Pressure (SP) or the resistance of your system that your dust collection unit must overcome. Static Pressure is measured in inches of water gage (˝wg). To do this you total the Static Pressures of the following system component groups**:**

1) The branch line with the greatest SP or resistance (see Figure 42-1). Calculate the SP of all branchs to determine which has the greatest SP. Only the branch with the greatest SP or resistance is added to the total.
2) The SP of the main run (see Figure 42-2).
3) The SP for the collection unit’s filter, if any, and for the pre-separator, if any (see Figure 42-3).
(You can use the charts on pages 51-60 to assist in your calculations.)

Figure 42-1

1) Calculate the SP of the branch with the greatest SP:
(4 feet of flex hose and one 90° elbow not shown)

Starting at the machine and working toward the main, determine the SP of each branch line component, and then total them. In our example, the branch with the greatest loss is the table saw branch, and it calculates out as follows using an FPM of 4500 for branch lines:

	SP (˝wg)
Entry loss at machine adaptor collar is 1.5 SP (a constant)	= 1.5
Four feet of 4˝ flex-hose*: Chart 57-1 shows 4˝ flex-hose (at 390 CFM) = .8 SP ÷ 100 x 4 x 27.7 = .886 SP (˝wg)	= 0.886
Three 4˝ 90° elbows: Chart 51-1 shows one elbow = .28 SP loss (˝wg) x 3	= 0.84
Three branch runs of 4˝ pipe (6+6+10) = 22’: Table 55-2 shows 8.8 ÷ 100 x 22’	= 1.94
Total SP loss (˝wg) for the table saw branch equals:	**5.17**

Figure 42-2

2) Calculate the SP of the main:

In our example the main has one 8’ run of 7” Spiral pipe, two runs (15’ and 12’) of 10” Spiral pipe connecting the main to the dust collector. In addition, there are 5 lateral reducers in the main. Our calculations for 4000 FPM in the main are as follows:

	SP (˝wg)
Eight feet of 7˝ Spiral pipe: Table 55-2 shows 3.55 ÷ 100 x 8	= 0.28
Twenty-seven feet (15 + 12) of 10˝ pipe: Table 55-2 shows 2.30 ÷ 100 x 27	= 0.62
Total SP loss (˝wg) for the main run:	**.90**

Figure 42-3

3) Calculate the SP for the collection units filter and seperator:

For these calculations, consult with the manufacturer of the collection units you are considering. For this example, we will assume that there is no pre-separator an that the SP for the filter is 1.5.

Total SP for filter:	1.50

Summing the SP loss for the system, we have:

1) Highest loss branch:	5.17
2) Loss for main:	.90
3) Filter loss:	1.50
Total SP loss (˝wg) loss in the system):	**7.57**

You now have the information you need to specify your dust collector. ***Your dust collection unit must provide a mimimum of 1880 CFM through a 10” duct at 4000 FPM, and have a static pressure capability of no less than 7.57 (˝wg).***

Additional Considerations and Recommendations:

The above example is for a small system with few variables. It is recommended that for larger systems a professional engineer be consulted to assure that the system is properly designed and sized.

If the dust collector is located in a seperate enclosure, it is essential to provide a source of make-up air to the shop to prevent a down draft through the flue of the heating system. If this is not done, carbon monoxide poisoning could result. If a return duct is necessary from the dust collector, it should be sized two inches larger than the main duct entrance and its SP loss added into your calcualtions.

Some dust collection units may not include fan curve information that shows CFM or Static Pressure variables. We do not recommend procuring collector equipment without this information.

Blast gates should be installed on all branch lines to maintain system balance.

Dust suspended in air has a potential for explosion, so it is recommended that you ground all of your duct runs, including flex-hose.

If your system has areas where long slivers of material could possibly hang-up and cause a clog, install a clean-out near that area.

Many types of dust, including many woods are toxic, so take special care to choose a filtering system that will provide optimal safety.

*** Flex-hose should be wire wrapped helix hose to permit grounding. See photo on page 33.**

Dust Collection

Exhaust Volumes & Conveying Velocities for a Variety of Production Machines

This list of recommended exhaust volumes and pipe sizes for average sized metal working and woodworking machines is based on many years of experience and the work of many people. Some modern high speed or extra large machines will require higher velocities than shown. Smaller machines may use less air than shown. The air volume required to capture the dust at the machine will vary with each operation. Particle size and hood type must be considered. The following charts will provide an excellent guide to determine your total air volume requirements.

Caution: One of the most important factors in an efficient dust collection system is proper hood design. Hoods must be designed so that the dispersed particles are thrown or deflected directly into the hood opening. The large heavy particles thrown out by the cutting heads or wheels have such a high speed that their trajectories cannot be altered by a vacuum system regardless of its velocity. In addition hoods should be placed as close to the source of dust contamination as possible since the effectiveness of an exhaust hood decreases very rapidly as it is moved away from the source. The following recommended pipe sizes are based on the use of reasonably good hoods.

Wide belt and abrasive sanders, moulders and shapers with high R.P.M. spindles often call for higher duct velocity (through hoods supplied by manufacturers) than those indicated on the charts. In these cases caution must be used.

The following charts are recommended for machines with good hood enclosures. (Also check with the machine manufacturer for their recommended velocities.)

Table 43-1: Recommended Conveying Velocities for Various Production Machines

Gang Rip Saws

Recommended Velocity 4,200 to 5,000 F.P.M.

Total Blade Dia. (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity			
	CFM	Dia.	CFM	Dia.
Up to 24'' incl.	610	5"	390	4"
25'' to 36 incl.	880	6"	610	5"
36'' to 48'' incl.	1200	7"	610	5"
Over 48'' incl.	1570	8"	880	6"

Jointer

Recommended Velocity 4,200 to 5,000 F.P.M.

Knife Width (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
Up to 6"	390	4"
7'' to 8''	610	5"
8'' to 18''	880	6"

Disc Sander

Recommended Velocity 4,200 to 5,000 F.P.M.

Disc Dia. (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
Up to 12"	390	4"
13'' to 18''	610	5"
19'' to 32''	880	6"
33'' to 38''	1200	7"
39'' to 48''	1570	8"

Turning Lathes

Recommended Velocity 4,200 to 5,000 F.P.M.

Turning Length (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
Up to 12"	880	6"
13'' to 24''	1570	8"
25'' to 36''	1985	9"
37'' to 48''	2450	10"

Floor Sweep

Recommended Velocity 4,200 to 5,000 F.P.M.

Size	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
5"	610	5"
6"	880	6"
7"	1200	7"

Floor Sweeps are not added to the total load of the exhauster as they are in operation only a few minutes at a time.
(Mouth of floor sweep 10'' x 4'' to 12'' x 4" approx.)

Horizontal Belt Sander

Recommended Velocity 4,200 to 5,000 F.P.M.

Belt Width (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity			
	CFM	Dia.	CFM	Dia.
Up to 6"	880	6"	610	5"
7'' to 9''	1200	7"	880	6"
10'' to 14''	1985	9"	1200	7"
Over 14"	2450	10"	1200	7"

Single Surfacer

Recommended Velocity 4,200 to 5,000 F.P.M.

Knife Width (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
Up to 6'' wide	390	4"
7'' to 12'' wide	610	5"
13'' to 20'' wide	880	6"
21" to 26" wide	1570	8"
27'' to 36'' wide	1985	9"
Over 36'' wide	2450	10"

Circular Saw

Recommended Velocity 4,200 to 5,000 F.P.M.

Blade Dia. (in.)	Exhaust Volumes and Pipe Diameters at 4500 ft. Velocity	
	CFM	Dia.
Up to 10"	390	4"
12'' to 14''	610	5"
16'' to 20''	880	6"
24'' to 30''	1570	8"
Variety Saws with Dado Heads	1200	7"

Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Exhaust Volumes & Conveying Velocities for Dust Producing Equipment

Table 44-1: Usual Exhaust Volumes and Conveying Velocities for Dust Producing Equipment

Dust producing equipment	Exhaust hood	Exhaust requirements	Conveying velocities in FPM
Abrasive blast rooms (sand, grit or shot)	Tight enclosure with air inlets (usually in roof)	60 - 100 fpm downdraft (long rooms of tunnel proportions 100 fpm cross-draft)	4,000
Abrasive blast cabinets	Tight enclosure with access openings	20 air changes per minute but not less than 500 fpm through all openings. Openings to be baffled	4,000
Bag tube packer	Booth or enclosure (provide spillage hopper)	500 cfm/filling tube; 500 cfm at feed hopper; 950 cfm at spill hopper	4,000
Barrels (for filling or removing material)	Local hood 180 deg. around top of barrel	100 cfm/sq. ft. barrel top min.	4,000
Belt conveyors	Hoods at transfer point	Belt speeds less than 200 fpm - 350 cfm per foot of belt width, but not less than 150 fpm through open area. Belt speeds over 200 fpm - 500 cfm per foot of belt width but not less than 200 fpm through open area	4,000
Shakeout conveyor	Continuous hood with take-off max. of 30 ft. apart	350 cfm per ft. of belt width with air inlets every 30 ft.	4,000
Belt wiper (may required with high speed belts)	Tight fitting hood held against under side of belt	200 cfm per foot of belt width. Not recommended for wet belts as in ore conveying	4,500
Bins (closed bin top)	Connect to bin top away from feed point	200 fpm through open area at feed points, but not less than 0.5 cfm per cu. ft. of bin capacity	4,000
Bucket elevators	Tight casing required	150-200 fpm at all openings.	4,000
Ceramics Dry Pan Dry Press	Enclosure Local	200 fpm through all openings 500 fpm Automatic feed, 1-5 in. dia. branch at die. Manual feed, 1-5 in. dia. branch at die. 500 cfm	4,000 4,000
Vibrating feeders-shakeout hopper to conveyor	Complete enclosure	200 cfm per sq. ft. of opening (Provide rubber or canvas flexible seals between shake-out hopper sides and end and also feeder sides and end)	4,000
Floor grate	Side hood	For heavy loads of dry dust and continuous dumping or feeding operations, treat same as shake-out side hoods, see below	4,000
	Downdraft	When used occasionally, 200-250 cfm per sq. ft. of grate area - depending on fineness and dryness of material	4,000
Grinder Swing frame	Booth	100-150 fpm indraft through opening in booth face for large opening. Never below 100 fpm. Small opening with grinder in front use 200 fpm	3,500
Grinders Portable and flexible shaft	Downdraft grilles Use side shields where possible	Bench type, 150-250 cfm per sq. ft. of exhaust grille but not less than 150 cfm per sq. ft. of plan working area Floor grille, 200-400 cfm per sq. ft. of exhaust grille but not less than 100 cfm per sq. ft. of plan working area	4,000
Mixer	Enclosure	150 minimum fpm through working and inspection openings	4,000
Shake-outs Foundry	Enclosure	200 fpm through all openings in enclosure, but not less than 200 cfm per sq. ft. of grate area	4,000
Apron conveyor for light flask work	None	Ventilate conveyor equivalent to 75 to 100 cfm per sq. ft. of gross grate area, assuming all grates open at any one time	4,000
Belt conveyor for light flast non-ferrous castings	None	Same as above	4,000
Shaker conveyor above floor-snap flask work	Side or overhead hood	Ventilate housing at rate of 125 to 150 cfm per sq. ft. gross open area. Assume all doors open at one time. Include area between housing and conveyor sides in volume determination. Usual clearance 1 in. or less on each conveyor side	4,000
Tunnel ventilation	Enclosure	When vibrating shake-out hoppers are located in a closed tunnel, ventilate the tunnel at 100 cfm per sq. ft. of tunnel cross section. Exhaust from transfer points can provide all, or part of, air required. Any additional exhaust required should be taken in rear of shake-out hopper	4,000
Screens Vibrating flat deck	Enclosure	200 fmp indraft through hood openings, but not less than 50 cfm per sq. ft. of screen area	4,000
Cylindrical	Enclosure	100 cfm per sq. ft. of circular cross-section but not less than 400 fpm indraft through openings in enclosure	4,000
Miscellaneous, Packaging, machines, granulators, enclosed dust producing units. Packaging, weighing, container filling inspection	Complete enclosure Booth Downdraft	100-400 fpm indraft through inspection or working openings, but not less than 25 cfm per sq. ft. of enclosed plan area 50-150 cfm per sq. ft. of open face area 95-150 cfm per sq. ft. of dust producing plan area	4,000 4,000 4,000

Spiral Manufacturing Co., Inc.

Materials Transfer

Types of pneumatic conveying & design considerations

Pneumatic Conveying

Pneumatic conveying has been used to transfer bulk solids for well over 100 years. Common applications include loading and unloading of trucks, rail cars, and barges; transferring materials to and from storage silos; and transferring of materials to production machinery within manufacturing plants. In fact, pneumatic conveying of bulk materials is used more widely in industry today than any other conveying method.

Transporting bulk materials by mechanical methods such as belt, screw, drag, bucket, and other conveyors not only presents difficult problems in system design and routing, but also presents problems of environmental contamination and contamination of the material being conveyed. Pneumatic systems are, by comparison, much easier to design: it is easier to route the high pressure Spiral pipe that is used in these systems, and a broad range of fittings and specialized components, such as diverters and blast gates, are readily available to control the flow of materials. Cross contamination between the environment and the conveyed material is also eliminated since pneumatic systems are closed. In addition, pneumatic conveying can achieve relatively high transfer rates (up to or exceeding 300 tons per hour), and the range of materials that can be transferred pneumatically is nearly unlimited.

Dilute Phase Pneumatic Conveying

There are two primary methods of pneumatic conveyance: “dilute phase” and “dense phase.” In dilute phase, relatively high volumes of air moving at high speeds are used to transfer materials entrained in the air (or other gas) stream. In dense phase, low volumes of air at high pressures are used to transfer nearly solid masses of materials. Dilute phase systems can be further divided into “pull” systems that operate below atmospheric pressure, “push” systems that operate above atmospheric pressure, and hybrid “push-pull“ systems, which are frequently used when materials need to be unloaded and then conveyed over long distances.

Design considerations

The design of dilute phase pneumatic transfer systems (whether push or pull) requires careful consideration of a number of important considerations:

- Material considerations include particle attributes such as particle size and size distribution; particle shape, density, hardness and friability; physical properties such as density, compressibility, permeability, and cohesion; and other properties such as toxicity, reactivity, and electrostatic effects.
- System attributes include the resistance of pipe and fittings to chemical reactivity and abrasion, the efficient design or routing of the system to transfer materials from and to multiple points, and the maintenance of adequate airflow over the range of conditions expected.

These considerations can be complex and it is recommended that you consult with a qualified and experienced sales engineer to assure that your system is properly designed.

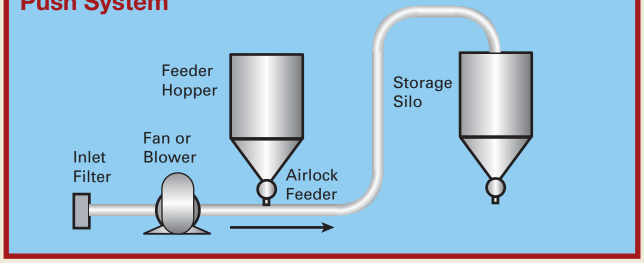
Spiral pipe is specified for dilute phase pneumatic transfer systems due to its strength, durability, and abrasion resistance, **Spiral Manufacturing** offers Spiral pipe in a variety of sizes, gauges, and materials to meet your requirements as, well as a complete line of fittings and specialized components. We can also build custom components to meet your specific requirements.

Trailer Loading

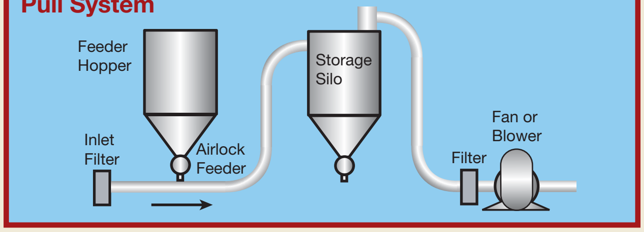
Trailer loading (see next page) is a common application of dilute phase pneumatic conveying. The following example illustrates a basic method to calculate system requirements. Before reading the example, aquaint yourself with the following terms and definitions:

Material Conveying:

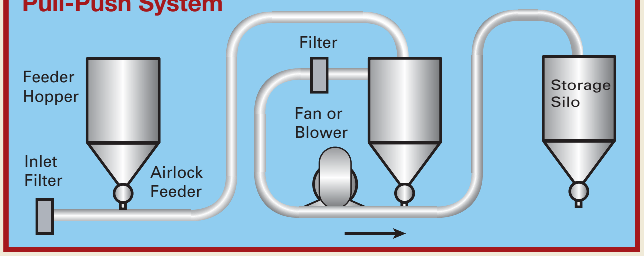
Push System



Pull System



Pull-Push System



Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Bulk materials conveying calculations

Bulk materials, such as those shown in Table 47-1, can be conveyed pneumatically using a Radial Blade or Material Transfer Blower. ***You can calculate your system's fan or blower requirements by following the steps in Figure 48-1.*** In the following example, we will assume a requirement to convey 2,400 lbs/hr of "Wood Shavings, Heavy" through 200' of horizontal straight pipe. The steps in this example correspond to the steps in Figure 48-1.

Terms and Definitions

System: **The path through which air is pushed or pulled. This normally includes ducts, coils, filter, plenum changer, etc., through which air flows. A system can be as simple as inducing air motion into space or a network of ducts providing air for multiple locations.**

Standard Air is air which weighs .075 pounds per cubic foot, which is dry air at 70°F dry bulb with a barometric pressure of 29.92 inches of mercury.

BHP (Brake Horsepower) is the horsepower absorbed by the fan.

CFM (Cubic Feet per Minute) is the volume of air moved per minute.

Capture Velocity is the air velocity at any point in front of a hood or at the hood opening necessary to overcome opposing air currents and capture the contaminated air by causing it to flow into the hood.

Conveying Velocity is the minimum air velocity required to move or transport particles within a duct system. Measured in feet per minute.

FPM (Feet per Minute) is the velocity of the airstream.

FL (Friction Loss) in inches water column (˝wg).

˝wg (Inches of water gage) is a unit of pressure equal to the pressure exerted by a column of water at standard temperature.

SP (Static Pressure) is the pressure in the duct that tends to burst or collapse the duct and is expressed in inches of water gage (˝wg).

V (Velocity) is equal to the flow rate (CFM) divided by the cross-sectional area of the air flow. V = CFM/Area (ft^2).

Step 1: Determine your **materials conveying requirements** in lbs/hr from experience and future projections. *Assumed to be 2,400 lbs/hr.*

Step 2: Convert pounds per hour to pounds per minute: *2,400 lbs/hr ÷ 60 = 40lbs/minute.*

Step 3: Find your **material type** in column A, Table 47-1. *We chose Wood Shavings, Heavy.*

Step 4: Reading across the row, determine your **material weight per cubic foot** (lbs/ft^3) from column B in Table 47-1. *We will use 15 lbs/ft^3.*

Step 5: Determine the **CFM required** to move 1 lb. of your material from column C, Table 47-1. *This equals 80 CFM.*

Step 6: Determine the **minimum conveying velocity** from column D, Table 47-1. *This equals 5600 FPM.*

Step 7: Determine the **suction pickup** from column E, Table 47-1. *This equals 3.0 ˝wg.*

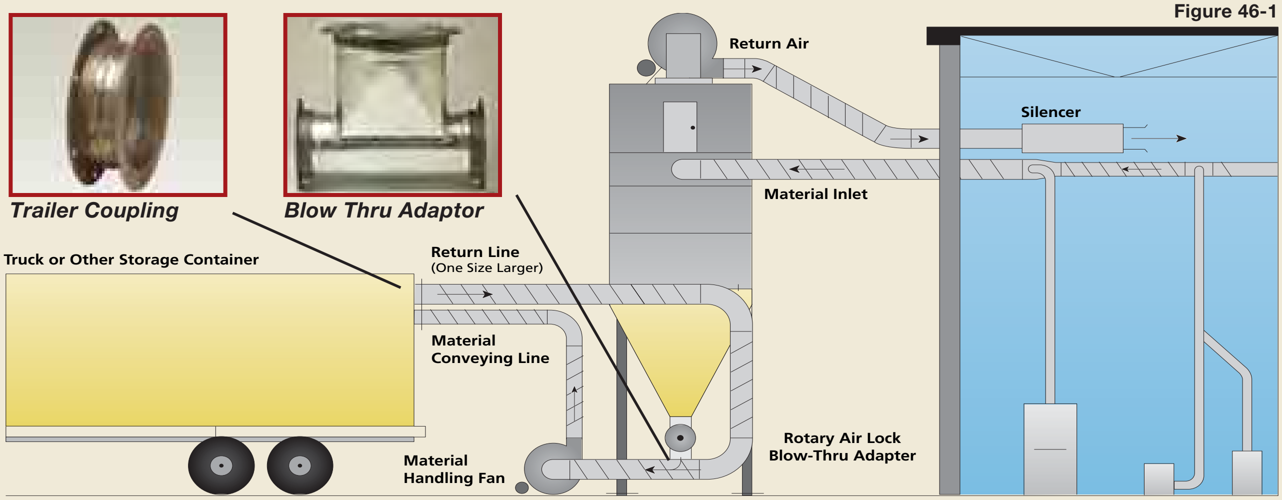
Step 8: Calculate the **total minimum CFM** requirement: Take (step 2) times (step 5). *Our example equals 80 CFM/lb. of material x 40 lbs/minute, which equals 3200 CFM minimum.*

Steps 9 thru 11 can be completed in one operation as follows: To determine the **system static pressure** requirements and **duct size**, find your **minimum conveying velocity** (FPM) from step 6. In the first column of table 47-2, find this velocity and read across the row to the first CFM greater than or equal to (step 8). This yields the **new actual CFM** for step 9. The **friction loss** for step 10 is located in the same column. Now move up to the top of the column to get your **duct size** for step 11.

In our example, reading across Table 47-2 from 5600 FPM to the first CFM greater than or equal to 3200 CFM yields a new actual CFM of 3696, a friction loss of 3.88 per 100 feet of duct, and a duct size of 11˝.

Step 12: Determine the **equivalent feet of straight duct** for horizontal and vertical pipe. We know 1' of horizontal

Figure 46-1



Trailer Loading

Bulk materials conveying calculations

pipe equals 1’ of equivalent straight duct, and 1’ of vertical pipe equals 2’ of equivalent straight duct. *In our example, we have 200’ of equivalent straight duct (there is no vertical duct in our example).*

Step 13: Determine the **equivalent feet of straight duct for all elbows**. *This equals 0 since there are no elbows in this example.*

Step 14: Determine the ***total* equivalent feet of straight duct** by adding steps 12 and 13. *This equals 200’.*

Step 15: Determine the **system friction loss**: divide step 14 by 100, then *times* step 11. *Our example as such: (200 ÷100) x 3.88 = 7.76*
Step 16: Enter the **suction pickup** from step 7.

Step 17: Calculate the **total SP system loss** by adding steps 15 and 16. *Our total is 10.76*.

Step 18 Add a 10% **safety factor** (1.1 times step 17). ***Our System fan minimum requirements equal: an 11” Fan inlet diameter with 11.84 “wg minimum at 3,696 CFM***

Note: If the material being conveyed will be passing through the fan, as in our drawing (Figure 46-1), the fan BHP will be significantly increased. Consult your fan representative.

Table 47-1

Materials	Approx. weight lbs/ft³	CFM per lb of material	Minimum conveying velocity (FPM)	Suction pickup “wg
A	B	C	D	E
Barley	38	38	5000	3.5
Beans, Soy	47	36	5200	4
Bran	16	56	3500	2
Cement, Portland	100	35	7000	5
Coal, Ashes	40	42	4500	3
Coal, Cinders	45	36	6000	4
Coal, Powdered	30	42	4000	3
Coffee beans	48	36	3500	3
Cork, Ground	15	59	3500	1.5
Corn, Cobs	25	44	5000	2.5
Corn, Meal	40	38	5500	3.5
Corn, Shelled	45	36	5500	3.5
Cotton, Dry	30	94	4000	2
Dust, Grinding	165	42	5000	3
Fruit, Dried	30	42	4000	3
Hair or Feathers, Dry	5	94	3000	1.5
Lime, Hydrated	55	42	5000	3
Malt, Dry	35	39	4800	3
Oats	26	44	4500	3
Wood Shavings Heavy	15	80	5600	3
Wood Shavings Light	7	73	4500	2

Table 47-2 Quantity of Air Flowing in CFM and Friction Loss (FL) per 100 feet

Duct Size	6”		7”		8”		9”		10”		11”		12”		14”		16”		18”		20”	
ft²	0.196		0.267		0.349		0.442		0.545		0.660		0.785		1.069		1.396		1.767		2.182	
Velocity FPM	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL	CFM	FL
2800	550	2.18	748	1.80	977	1.53	1237	1.33	1527	1.17	1848	1.04	2199	0.93	2993	0.77	3910	0.66	4948	0.57	6109	0.50
3000	589	2.48	802	2.06	1047	1.75	1325	1.51	1636	1.33	1980	1.19	2356	1.07	3207	0.88	4189	0.75	5301	0.65	6545	0.57
3200	628	2.81	855	2.33	1117	1.98	1414	1.71	1745	1.50	2112	1.34	2513	1.20	3421	1.00	4468	0.85	5655	0.73	6981	0.65
3400	668	3.15	909	2.61	1187	2.22	1502	1.92	1854	1.69	2244	1.50	2670	1.35	3635	1.12	4747	0.95	6008	0.82	7418	0.72
3500	687	3.33	935	2.76	1222	2.34	1546	2.03	1909	1.78	2310	1.59	2749	1.43	3742	1.18	4887	1.01	6185	0.87	7636	0.77
3600	707	3.51	962	2.91	1257	2.47	1590	2.14	1964	1.88	2376	1.68	2827	1.51	3848	1.25	5027	1.06	6362	0.92	7854	0.81
3700	726	3.70	989	3.06	1292	2.60	1635	2.26	2018	1.98	2442	1.77	2906	1.59	3955	1.32	5166	1.12	6538	0.97	8072	0.85
3800	746	3.89	1016	3.22	1326	2.74	1679	2.37	2073	2.09	2508	1.86	2985	1.67	4062	1.38	5306	1.18	6715	1.02	8290	0.90
4000	785	4.29	1069	3.55	1396	3.02	1767	2.62	2182	2.30	2640	2.05	3142	1.84	4276	1.53	5585	1.30	7069	1.12	8727	0.99
4200	825	4.71	1122	3.90	1466	3.31	1856	2.87	2291	2.52	2772	2.25	3299	2.02	4490	1.67	5864	1.42	7422	1.23	9163	1.08
4400	864	5.14	1176	4.26	1536	3.62	1944	3.13	2400	2.76	2904	2.45	3456	2.21	4704	1.83	6144	1.55	7775	1.35	9599	1.18
4500	884	5.36	1203	4.44	1571	3.78	1988	3.27	2454	2.88	2970	2.56	3534	2.30	4811	1.91	6283	1.62	7952	1.40	9818	1.23
4600	903	5.59	1229	4.63	1606	3.94	2032	3.41	2509	3.00	3036	2.67	3613	2.40	4917	1.99	6423	1.69	8129	1.46	10036	1.29
4800	942	6.06	1283	5.02	1676	4.27	2121	3.70	2618	3.25	3168	2.89	3770	2.60	5131	2.16	6702	1.83	8482	1.59	10472	1.40
5000	982	6.55	1336	5.43	1745	4.61	2209	4.00	2727	3.51	3300	3.13	3927	2.81	5345	2.33	6981	1.98	8836	1.72	10908	1.51
5200	1021	7.06	1390	5.85	1815	4.97	2297	4.31	2836	3.79	3432	3.37	4084	3.03	5559	2.51	7261	2.13	9189	1.85	11345	1.63
5400	1060	7.58	1443	6.28	1885	5.34	2386	4.63	2945	4.07	3564	3.62	4241	3.26	5773	2.70	7540	2.29	9543	1.99	11781	1.75
5600	1100	8.13	1497	6.73	1955	5.72	2474	4.96	3054	4.36	3696	3.88	4398	3.49	5986	2.89	7819	2.46	9896	2.13	12217	1.87
5800	1139	8.69	1550	7.20	2025	6.12	2562	5.30	3163	4.66	3828	4.15	4555	3.73	6200	3.09	8098	2.63	10249	2.27	12654	2.00
6000	1178	9.27	1604	7.68	2094	6.52	2651	5.65	3273	4.97	3960	4.42	4712	3.98	6414	3.30	8378	2.80	10603	2.43	13090	2.13
7000	1374	12.42	1871	10.29	2443	8.74	3093	7.57	3818	6.66	4620	5.93	5498	5.33	7483	4.42	9774	3.75	12370	3.25	15272	2.86

Spiral Manufacturing Co., Inc.
11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184

Material Conveying Calculations

Figure 48-1

1) Material pounds conveyed per hour	1)	
2) Material pounds per minute	2)	(step 1 divided by 60)
3) Material being conveyed	3)	(column A, Table 47-1)
4) Material weight, lbs/ft³ (should be your actual)	4)	(column B, Table 47-1)
5) CFM per lb of material	5)	(column C, Table 47-1)
6) Minimum conveying velocity in FPM	6)	(column D, Table 47-1)
7) Suction pick-up, "wg	7)	(column E, Table 47-1)
8) Total minimum CFM required	8)	(step 2 times step 5)
9) Actual CFM for duct (see box to right)	9)	
10) Friction loss (FL) per 100 feet (see box to right)	10)	
11) Duct size (see box to right)	11)	

Go to table 47-2. Read across FPM line to the first CFM greater than the required CFM in step 8. This identifies step 9 & 10. Read the duct size at top of the column to get the **duct size** (step 10).

12) Feet of (supply) straight duct

Horizontal pipe	12a)	
Vertical pipe x 2 =	12b)	+
	12)	= (total equivalent straight duct)

13) Number of Elbows

	Qty.				
=		90° Elbows	X	=	
=		60° Elbows	X	=	+
=		45° Elbows	X	=	+
=		30° Elbows	X	=	+
				13)	= (total equivalent straight duct)

See Table 48-1 for elbow equivalent resistance.

14) Total equivalent feet of duct	14)	(step 12 plus step 13)
15) Friction loss	15)	(divide step 14 by 100 x step 11)
16) Suction pick-up	16)	(from step 7)
17) Total SP system loss	17)	(step 15 plus step 16)
18) Add 10% safety factor (1.1 times step 17)	18)	

SYSTEM FAN MINIMUM REQUIREMENTS

Minimum CFM requirement from step 10 | Min. "wg, step 18 | Fan inlet from step 9

Supplemantal Information:

1. To calculate for elbows in your system, see Table 48-1 or 55-1. Find your duct size in the first column. Read across the row to the elbow turn ratio you will be using. This is the equivalent resistance in feet of duct. Insert this into your calculation at step 13.

2. Make sure you use correct air density for location of fan. Standard Air Density is .075 at sea level.

WARNING:

Whereas fans are used in thousands of material conveying applications around the world, care must be used in their selection and location within each material conveying system.

The material should be crushed, shredded or pulverized before it passes through the fan to eliminate premature fan housing, fan wheel and/or bearing failure which could cause severe personal injury and/or complete system failure.

Please contact a sales engineer in your area for correct, safe selection for your specific application.

Table 48-1
Elbow Equivalent Resistance in Feet of Straight Pipe by Centerline Radius (CLR)

Duct Dia.	1.5 CLR Elbows				2.0 CLR Elbows				2.5 CLR Elbows			
	90°	60°	45°	30°	90°	60°	45°	30°	90°	60°	45°	30°
6"	12	8	6	4	7	5	4	2	6	4	3	2
7"	12	8	6	4	8	5	4	3	7	5	4	2
8"	13	9	7	4	9	6	5	3	7	5	4	2
9"	14	9	7	5	10	7	5	3	8	5	4	3
10"	15	10	8	5	10	7	5	3	8	5	4	3
11"	18	12	9	6	12	8	6	4	10	7	5	3
12"	20	13	10	7	14	9	7	5	11	7	6	4
14"	25	17	13	8	17	11	9	6	14	9	7	5
16"	30	20	15	10	21	14	11	7	17	11	9	6
18"	36	24	18	12	24	16	12	8	20	13	10	7
20"	41	27	21	14	28	19	14	9	23	15	12	8

Materials Transfer

Pneumatic conveying & trailer /container loading components

Trailer Flange and Quick Disconnect

Silencer

Heavy Duty (HD) Flexible Hose (Black)

Diverter Valves

Ball Joint

Pneumatic Air-Actuated Blast Gate

Flange Clamp

Blow Thru Adapter

Spiral Manufacturing Co., Inc.

11419 Yellowpine Street N.W. • Minneapolis, MN 55448-3158
Phone: 763-755-7677 • 800-426-3643 • Fax: 763-755-6184