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.

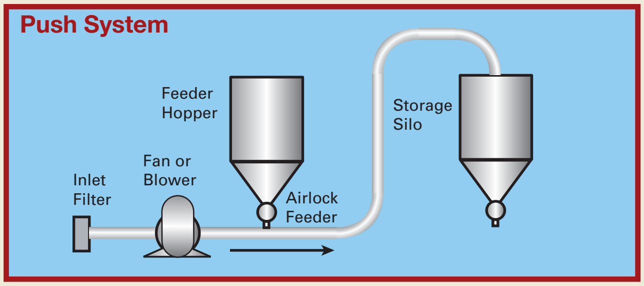
These considerations can be complex and it is recommended that you consult with a qualified and experienced sales engineer to assure that your system is properly designed.

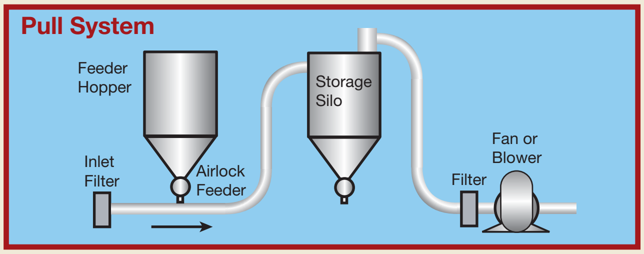
Spiral pipe is specified for dilute phase pneumatic transfer systems due to its strength, durability, and abrasion resistance, **Spiral Manufacturing** offers Spiral pipe in a variety of sizes, gauges, and materials to meet your requirements as, well as a complete line of fittings and specialized components.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

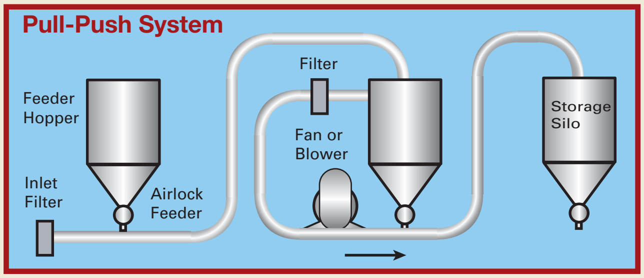
Trailer Loading

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:







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Trailer Loading

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.*

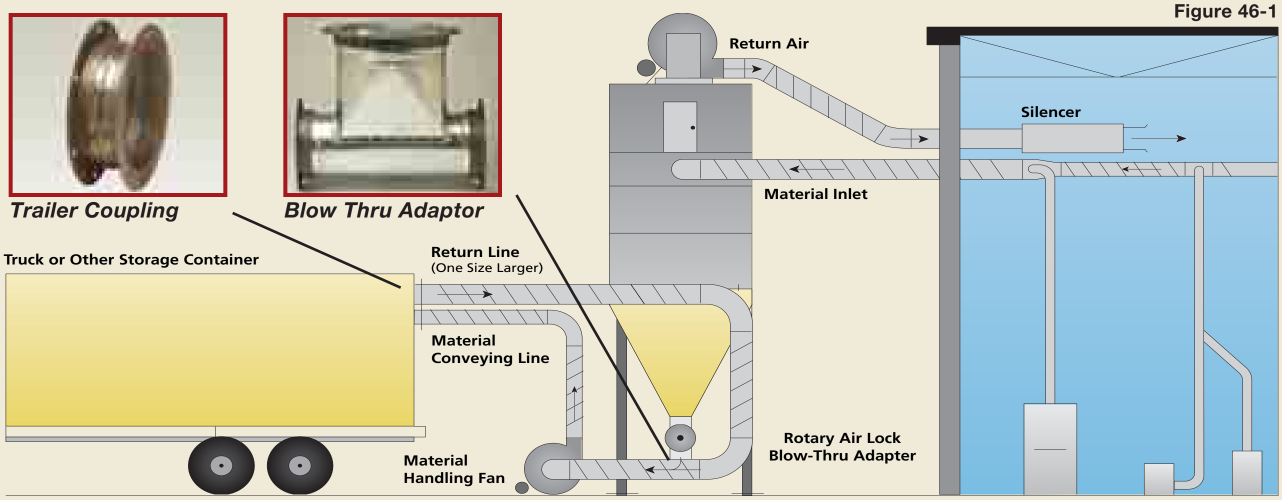
Step 8: Calculate the **total minimum CFM** requirement: Take (step 2) times (step 5). *Our example equals 80 CFM/lb. of material x 40 lbs/minute, which equals 3200 CFM minimum.*

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

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

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).

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

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