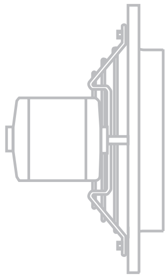
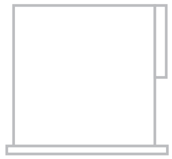
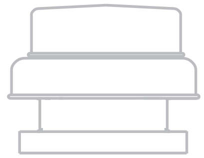
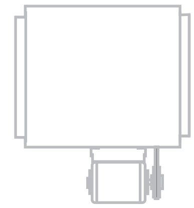
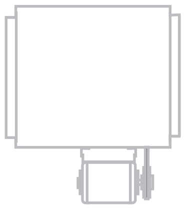
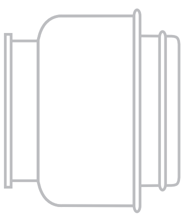
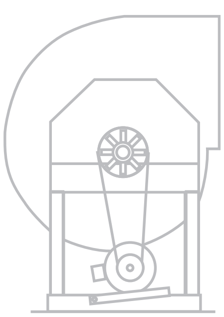
FAN FUNDAMENTALS

Fan Selection
Application-Based Selection
Performance Theory

GREENHECK

SELECTING THE RIGHT FAN FOR THE JOB

This book is designed to help you select the fan that will best fit the application for which it is intended. With the large number of different fan types and sizes available it's necessary to know which fan model does the best job in certain applications and then be able to select the most economical fan size for the job.

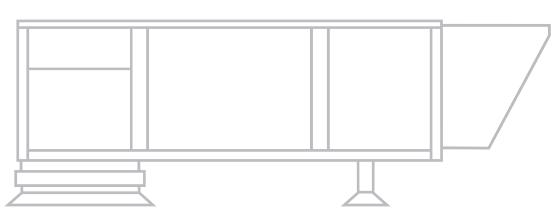
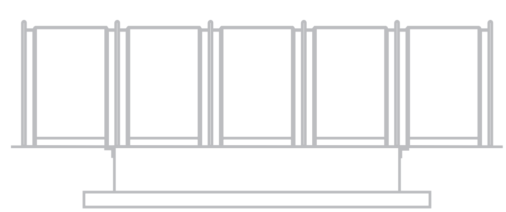
With that in mind, this guide is constructed in three sections.

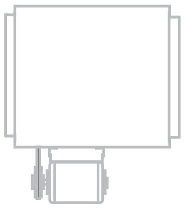
Section One describes how to select a fan using catalog performance tables with a given air volume and static pressure. This section also interprets Greenheck model numbers and illustrates the relationship between fan speed and airflow.

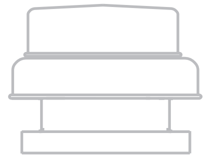
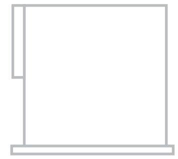
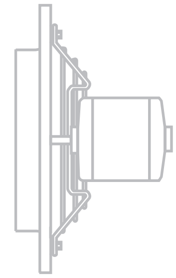
Section Two covers the basics of fan selection—determining the proper fan model, air volume, static pressure and loudness appropriate for a given application. This is important when your customer does not know the amount of air to be moved or the resistance to airflow that will be encountered. This section also illustrates proper fan installation and proper wheel rotation.

Section Three goes beyond fan selection with information of a more comprehensive and technical nature about air movement and air systems.

GREENHECK®
Building Value in Air.



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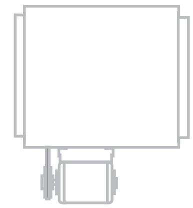
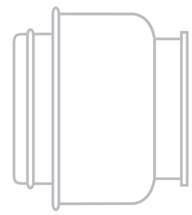
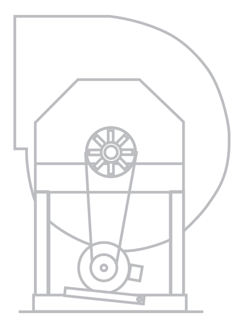
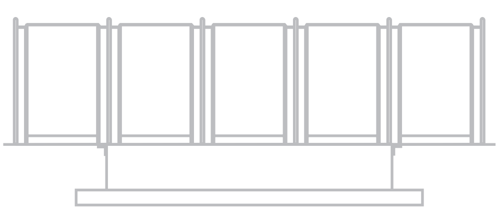
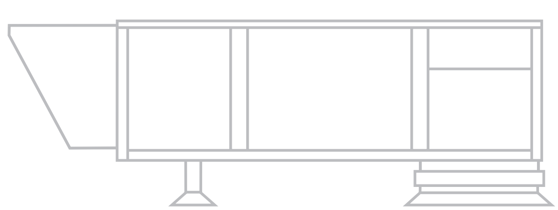




INTRODUCTION TO FAN SELECTION

This is the first and most basic of this manual's three sections, all of which are designed to enable you to select the right fan for the job. Look at this first section as a "user's manual" for Greenheck literature. It will answer the following questions (and more): What is a SONE? How are model numbers and performance tables used to select a fan? How are direct drive and belt driven fans different? What types of motors and accessories are used with these fans? Are there Greenheck fans that will match the size and performance of fans from other manufacturers? The goal is to understand and use the Greenheck literature as an important tool in filling a customer's fan order.

Terms

- **cfm -** Cubic Feet Per Minute. A measure of airflow.
- **Ps -** Static Pressure. Resistance to airflow measured in inches of water gauge.
- **sone -** A measure of loudness. One sone can be approximated as the loudness of a quiet refrigerator at a distance of 5 feet. Sones follow a linear scale, that is, 10 sones are twice as loud as 5 sones.
- **Bhp -** Brake Horsepower. A measure of power consumption. Used to determine the proper motor horsepower and wiring.
- **hp -** Horsepower. Used to indicate a fan's motor size.
- **rpm -** Revolutions Per Minute. Measure of fan speed.
- **TS -** Tip Speed. The speed of the tip of a fan wheel or prop measured in feet per minute.
- **AMCA -** Air Movement and Control Association. A nationally recognized association which establishes standards for fan testing and performance ratings. AMCA also licenses air volume and sound certified ratings.

Model Designation

For Greenheck belt drive models, the model designation tells the model type, size and the motor hp.

EXAMPLE: GB-090-6

- Model is GB
- Nominal Wheel Dia. 9 in.
- hp is 1/6

For direct drive units, the model designation tells the model type, the size and the motor/fan rpm.

EXAMPLE: G-121-B

- Model is G
- Nominal Wheel Dia. 12 in.
- rpm is 1140

The table below lists model designation suffixes for motor horsepower and fan rpm.

Belt Drive		Direct Drive	
Suffix	Motor hp	Suffix	Fan rpm
6	1/6	A	1725
4	1/4	B	1140
3	1/3	C	860
5	1/2	D	1550
7	3/4	G	1300
10	1	E	1050
15	1 1/2	F	680
20	2	P	1625
30	3		
50	5		
75	7 1/2		

Reading Performance Charts

The most important part of selecting a fan is the ability to read the performance charts. Most of the performance charts in the catalog are similar and are read in the same manner. Models RSF and BCF are exceptions to this rule. The selection procedure for these models is handled separately. Direct drive and belt drive fans are also addressed separately.

Belt Drive Selection

Assume that a job requires a belt drive roof exhauster to move 1000 cfm against 0.25 in. Ps. Refer to the performance model at the bottom of this page. Start at the top of the chart with the 0.25 in. Ps column. (All numbers in this column correspond to .25 in. Ps.) Now follow the column downward until a value is found that slightly exceeds 1000 cfm. In this case, 1012 cfm is the first box that meets the requirements.

Note: Notice that each performance box is divided into 3 smaller boxes. The numbers refer to cfm, Sones and Bhp.

Example:

CFM	
Sone	Bhp

1012	
11.1	0.16

At this performance point, the sone value is 11.1 and the fan Bhp required is 0.16. Now by following the row to the left, we can determine fan rpm and fan model. In this case, the fan rpm is 1510 and the model is GB-090-4 which has a 1/4 hp motor.

Notice that the GB-090-4 is not the only model to choose from. If we follow the 0.250 in. Ps column down further, we find a performance point at 1010 cfm. At this point, the sone value is 7.9 and the Bhp is 0.14. Following across to the left we find the rpm to be 1355. The model is GB-101-4-R1, which also has a 1/4 hp motor.

Both the GB-090-4 and the GB-101-4-R1 will perform the air movement task equally as well. However, the sound generated by the fan may have to be considered. Compare the sone values: 7.9 sones for the GB-101 and 11.1 for the GB-090. The GB-101 is about 30% quieter. Where a low sound fan is required, the GB-101 would be a better selection. If loudness is not a factor, the GB-090 would be a better selection because it is less expensive.

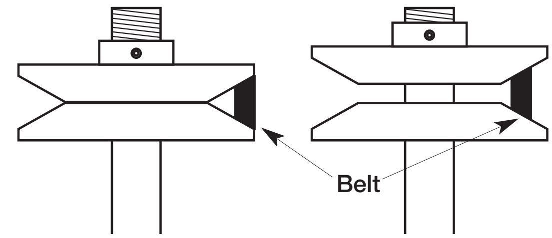
Another possibility for this particular selection is a GB-100-4-R2. Even though there is no performance box showing close to 1000 cfm, there are two performance boxes that bracket 1000 cfm. At 921 cfm the fan will be running at 1260 rpm. At 1269 cfm the fan will be running at 1635 rpm. Therefore, there is an rpm for this model that will correspond to 1000 cfm (obviously somewhere within the 1260-1635 rpm range). As with all Greenheck belt drive fans, intermediate cfm values are easily achieved by adjusting the motor pulley (see illustration on next page).

Table 2

MODEL (rpm RANGE)	hp	RPM	TS	STATIC PRESSURE / CAPACITY																	
				0.000		0.125		0.250		0.375		0.500		0.625		0.750		0.875		1.000	
				Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp
GB-090-4 (1290-1710)	1/4	1360	3983	1030		957		884		807		725		632							
				10.1	0.11	9.9	0.12	9.6	0.12	9.3	0.12	8.8	0.13	8.5	0.13						
		1510	4422	1144		1078		1012		946		875		800		720		607			
				11.4	0.15	11.2	0.16	11.1	0.16	10.7	0.17	10.4	0.17	10.0	0.17	9.8	0.17	9.5	0.17		
		1710	5008	1295		1237		1179		1121		1061		999		934		866		785	
				13.4	0.22	13.3	0.23	13.2	0.23	13.0	0.24	12.7	0.24	12.4	0.25	12.1	0.25	11.8	0.25	11.6	0.25
GB-101-4-R1 (1020-1400)	1/4	1070	3116	906		818		731		607											
				6.0	0.060	5.4	0.065	5.0	0.070	4.3	0.070										
		1355	3946	1148		1077		1010		943		856		739							
				8.5	0.12	8.1	0.13	7.9	0.14	7.8	0.14	7.2	0.14	6.8	0.14						
GB-101-4-R2 (1260-1635)	1/4	1260	3669	1067		991		921		840		735		385							
				7.6	0.099	7.1	0.104	6.8	0.112	6.5	0.115	5.9	0.115	4.4	0.083						
		1635	4761	1385		1325		1269		1214		1161		1094		1019		928		792	
				11.1	0.22	10.8	0.22	10.4	0.23	10.2	0.24	9.8	0.25	9.3	0.25	8.9	0.25	8.4	0.25	7.8	0.24
GB-101-3	1/3	1800	5242	1525		1471		1418		1367		1320		1270		1208		1141		1064	
				13.2	0.29	12.8	0.30	12.5	0.30	12.3	0.31	12.2	0.33	11.3	0.33	10.8	0.33	10.6	0.33	10.1	0.33

One advantage of choosing the GB-101-4-R2 over the GB-101-4-R1 is that it is capable of running at higher rpm's, which enables the fan to move more air if necessary.

Motor pulleys are adjusted by loosening the set screw and turning the top half of the pulley (see illustrations at right). This causes the pulley diameter to change, which results in changing the fan rpm.



Opening the pulley decreases fan rpm.
Closing the pulley increases fan rpm.

Direct Drive Selection

Selection of direct drive fans (those with the motor shaft connected to the fan wheel or propeller) is nearly the same as belt drive selection. However, there are two differences worth noting. Where belt drive fan speed can be altered by adjusting the motor pulley, direct drive fans (since they have no pulleys) must use a different method.

1. To adjust a direct drive fan's speed (also motor speed) or to provide a means of meeting an exact performance requirement, a speed control can be furnished. Speed controls vary the voltage supplied to the fan and slows it down; a principle similar to the way dimmer light switches work.
2. Models CUE and CW, sizes 060-095 and Model SQ, sizes 60-95, are provided with 115 volt, 60 cycle motors. The three speeds are 1550 rpm (D), 1300 rpm (G) and 1050 rpm (E). Changing a motor lead is all that is necessary to change speeds. When selecting a model with 3 speed motors, it is recommended that the G speed be chosen whenever possible. This is the middle speed, which gives the greatest flexibility in air volume because airflow can be increased or decreased simply by changing a motor lead.

Typical Motor Tag

Electrical Instructions		
Suffix Letter	Motor Speed	Wiring Connections
D	1550 rpm	White to L1 Black to L2
G	1300 rpm	White to L1 Blue to L2
E	1050 rpm	White to L1 Red to L2

Motor Information (Belt Drive Only)

When specifying a belt drive fan, the model designation does not completely describe the unit. Additional information about the motor is necessary. These items are listed below:

Motor Enclosure
This will be either "Open" (open, drip proof), "TE" (totally enclosed) or "EXP" (explosion resistant). Open is the most common and will be supplied unless otherwise specified.

Speeds
Motors are available in either single speed or two speed. Single speed motors are 1725 rpm. Two speed motors will be 1725/1140 rpm. Single speed will be supplied unless otherwise specified.

Electrical Characteristics
Voltage and phase. Voltage can be 115, 208, 230 or 460. Phase is either single or 3 phase. A 115 volt, single phase motor is shown as 115/1. Typically, motors of 1/2 hp and less are single phase. Motors of 3/4 hp and greater are 3 phase.

Accessories

Most fans are ordered with accessories. Here are some common accessories for selected models:

Model	Common Accessories
G & GB	Roof Curb Backdraft Damper
CUBE	Roof Curb Grease Trap
SB	Wall Mount Housing or Wall Mount Collar
SP & CSP	Speed Control Discharge Vents
SQ & BSQ	Backdraft Damper Vibration Isolators

Matching a Specification

There will be times when a Greenheck model will have to be matched to a competing manufacturer's unit. To aid in these circumstances, we have provided a cross reference chart which includes our nine most common competitors. If the manufacturer you need is not on this chart, contact Greenheck for assistance.

To use the cross reference chart, on next page, start with the manufacturer at the top. Then follow down until the model in question is found. Follow across to the left to determine which Greenheck model is equivalent. Once this is determined, refer to the Greenheck catalog to find the best size to meet the specified performance.

Hint: Typically, when matching a Greenheck fan to a competitive model, the size should also be matched. If you are unsure of the size of the competitive unit, compare fan rpm. Fans of equal size should move approximately the same amount of air.

Model RSF and BCF Selection

The RSF and BCF selection charts are different from all other selection charts. For these models, the cfm values are at the left side of the chart in a single column and the rpms are in the performance boxes. It is just the opposite for other models. The reason for this is that the RSF and BCF models are forward curved, and the fan industry historically catalogs forward curved fans in this fashion.

Sample problem:

Choose the fan size and appropriate motor horsepower to move 980 cfm against 0.625 in. Ps.

Solution: (Refer to table below)

The first row in the chart corresponds to 980 cfm. Follow across to the right to the 0.625 in. Ps column. The performance box reveals that size 90 will meet this performance at 893 rpm and will require 0.20 Bhp.

Motor hp selection for forward curved fans is more complicated. The Bhp is only 0.20, which suggests that a 1/4 hp motor is adequate. However, forward curved fans draw more horsepower at low Ps than at high Ps. Assume this fan was running at about 893 rpm, but instead of 0.625 in. Ps, it was operating at only 0.25 in. Ps. The new performance box in the 0.25 in. Ps column reveals 894 rpm at 0.45 Bhp. The airflow would then be 1860 cfm.

Notice that as the Ps was reduced from 0.625 in. to 0.25 in., the Bhp increased from 0.20 to 0.45. This would burn out the 1/4 hp motor quickly. With this in mind, it is good practice to size RSF and BCF motors at least one size larger than necessary based on the Bhp value in the performance box, especially if the estimated Ps is questionable.

For this case, an RSF-90-3 (1/3 hp motor) would be a good selection if we had confidence in the estimated Ps. Otherwise, use an RSF-90-5 (1/2 hp motor).

RSF-90-4 (1/4 hp motor) is not recommended for this job.

MODEL	CFM	OV		STATIC PRESSURE / CAPACITY									
				0.125	0.250	0.375	0.500	0.625	0.750	1.000	1.250	1.500	1.750
RSF-90	980	1065	rpm	521	630	725	812	893	967				
			Bhp	0.08	0.11	0.13	0.16	0.20	0.23				
	1200	1304	rpm	593	685	771	849	925	994	1125			
			Bhp	0.13	0.16	0.19	0.23	0.26	0.30	0.38			
	1420	1543	rpm	668	747	825	898	966	1031	1153	1267	1371	
			Bhp	0.19	0.23	0.27	0.31	0.35	0.39	0.48	0.57	0.67	
	1640	1783	rpm	746	819	887	953	1016	1077	1191	1298		
			Bhp	0.28	0.33	0.37	0.42	0.46	0.51	0.61	0.71		
	1860	2022	rpm	828	894	954	1014	1073	1128	1236			
			Bhp	0.40	0.45	0.50	0.55	0.60	0.65	0.76			
	2080	2261	rpm	910	970	1027	1080	1134					
			Bhp	0.54	0.60	0.66	0.71	0.77					
RSF-100	1240	1097	rpm	476	572	656	733	807	876				
			Bhp	0.10	0.13	0.16	0.19	0.23	0.27				
	1780	1575	rpm	605	679	748	813	873	931	1040	1143	1240	
			Bhp	0.24	0.29	0.33	0.38	0.42	0.47	0.56	0.66	0.77	
	2140	1894	rpm	699	763	823	880	935	989	1086	1181	1269	1354
			Bhp	0.40	0.45	0.50	0.56	0.61	0.67	0.78	0.89	1.00	1.12

Cross Reference Chart

(Models in *italics* refer to older models)

Greenheck	Cook Updated 12-7-2004	Penn	Acme	Jenn (Breidert) (Stanley)	Carnes	COOLAIR (ILG)	AirMaster (Chelsea)	Captive Aire (Flow Air)
G *CE,CX,CH*	ACED *C-D,CVD,TCD*	Domex DX *XQ,XR,AT,AW*	PRN	CRD	VEDK *VEDB,VEDC*	CRD	CDD *RDD*	DR
GB *CDE, CBX*	ACEB *C-B,TCB,UCB*	Domex DXB KB,JB,MB,*AB,LB*	PN,PNN,PV	NBCR *BCR*	VEBK *VEBC*	CRB LSB	CBD *RDB*	DD
CUE	ACRUD, VCRD	Fumex FX	PDU	n/a	VUDK	CUD, UBD	n/a	DU
CUBE *UCBE,UCBH*	ACRUB,VCR *URB,R-B,BTD*	Fumex FXB FMXB	PNU PUB,*PU,PUH*	NBTD NBRTD	VUBK,VRBK *VUBB,URBA*	UBC,CUB *CVB*	CBU *CUBA*	NCA
CW *SW,GW*	ACWD *CW*	Fumex WFX Domex WX,WA,WB	PDU-W *PW*	CWD	VWDK *VWDB*	CWD *CWF*	CDU *WDC*	DU
CWB *GWB*	ACWB *CWB,TWB*	Fumex WFXB Domex WCB,WLB	PNU-W *PWB*	NBTD NBRTD (UL 762)	VWBK *VWBB*	CWB	CBU *WBC*	*NCA*
SP	Gemini GC	Zephyr Z, (RA,TD)	VQ/VQL	J,EC,L	VCDB,VCDC, VCDD	CF	NCF *CF*	CFA
CSP	Gemini Inline GN	Zephyr Z, (TDA)	VQ/VQL	n/a	VCDB	IL	DCF	n/a
SQ *DSQ,SQD*	SQID,SQND *CV-D*	Centrex SX	XD	ISD *ILD*	VIDK *VIDB,AMDA*	SQDA *CLD*	n/a	CVIDK
BSQ	SQIB,SQNB, SQN-HP	Centrex SX-BC	XB	ILB	VIBK *VIBA*	SQBA	SBCL	CVIBK
SE/SS *SDE*	SWD *SD*	P	FQ	GDW HDW,FDW	LYDK,LZDK *LWDA*	UDU/UDF *PV*	EPR WFA	C-EPR
SCE/SCS	AWD	BC	FN	n/a	LRDA,LNDA	CDC	HV, HVE *PLFA*	n/a
SBE/SBS *SPFE/SPFS*	XLW,XMW SWB *SPB*	BBK,BFL	DC	TBW	LWBK,LMBK TYPE T	CBL,CBH *PF*	HA *IND, FHA*	CPB
SBE/SBS-3 *SPNE/SPNS*	XLWH,XMWH	BF	DCH	LBW	LJDB, LKDB, LRDA, LNDA	CBHX	n/a	n/a
SBCE/SBCS	AWB	BC,BAT	DCK, K	HBW	LRBA,LNBA	CBC	HA *IND*	n/a
RBS/RBE *RPE,RPS*	HXSL, HXSM, HXEL, HXEM	AF	EC/EC-S	n/a	LTBA,LGBA	PB	n/a	n/a
RBCE/RBCS	HEE,HES	AC	EC, ECH	HBRE,HBRS	n/a	PBC	n/a	n/a
RE/RS	HEE-D/HES-D	AF	n/a	n/a	LTDA,LGDA	PD	n/a	n/a
RBU *PBU,PUB*	LEU, LXUL, LXUM *AVB,VB*	HF,HS,HZ (cast)	UBG	BRU	LUBA	JBH,JBC (cast)	UPB *RUBA*	CUPB
RBUMO	SUBH, SUB	HX	UBH	available	LUKA	n/a	RUBDX (cast)	n/a
RDU	AUD	HZ,HC	UD	DRU	LUDA	JDC	UP *RUDA*	CUPD
RSF	ASP *CFS*	Muffan MU	AFSN *PLS*	BCFS	VSBB *VSBA*	CFS	CAS	n/a
RSFP	ASP-T	n/a	AFSL	n/a	VHBB	n/a	n/a	n/a
SFD	CPF-D	n/a	FCE	FCD	n/a	n/a	UDF	n/a
SFB	CPF-B	n/a	FCF, FCD, FCA	FCB	VFBA	VSFC	UXF	n/a
SWB	CPV,CPS	Dynamo D,QX *GWB*	QBR	JVS	VBBA	VSBC	UXB	BI

Competitor Model Number Deciphering Hints

Cook-

Direct Drive

120 W 10 D
- D — Direct Drive
- 10 — rpm x 100
- W — Model ACW
- 120 — Wheel Size

Belt Drive

150 V 6 B
- B — Belt Drive
- 6 — 3/4 hp
- V — Model VCR
- 150 — Wheel Size = 15 in.

Letter Designations
C=ACE (G,GB)
R=ACRU (CUBE)
W=ACW (CW,CWB)
V=VCR (CUBE)

Horsepower Designations

2=1/6 hp	6=3/4	10=3
3=1/4	7=1	11=5
4=1/3	8=1$^1/_2$	12=7$^1/_2$
5=1/2	9=2	

Acme -

Direct Drive

PW 135 A 8
- 8 — 860 rpm
- A — 1/20 hp
- 135 — Wheel Size =13.5 in.
- PW — Model PW

Belt Drive

PNN 163 G
- G — 1/2 hp
- 163 — Wheel Size = 16.3 in.
- PNN — Model PNN

Direct Drive rpm Designation
8 = 860 rpm
6 = 1160 rpm
4 = 1725 rpm

Horsepower Designation

A=1/20 hp	F=1/3	L=2
B=1/12	G=1/2	M=3
C=1/8	H=3/4	N=5
D=1/6	J= 1	P=7$^1/_2$
E=1/4	K=1$^1/_2$	R=10

GREENHECK
Building Value in Air.

FAN SELECTION BASED ON FAN APPLICATION

Basic Overview

Ventilating a building simply replaces stale or foul air with clean, fresh air. Although the ventilation process is required for many different applications, the airflow fundamentals never change:

Undesired air out, fresh air in

The key variables that do change depending on applications are the fan model and the air volume flow rate (cfm). Other considerations include the resistance to airflow (static pressure or Ps) and sound produced by the fan (Sones).

Occasionally, a customer will require a fan to perform a particular function, yet does not know which model to use or even what cfm is necessary. In this case, some fan specification work must be done.

Fan specification is usually not a precise science and can be done confidently when the fan application is understood.

Based on the application, four parameters need to be determined. They are:

1. Fan Model
2. cfm
3. Static Pressure (Ps)
4. Loudness limit (sones)

The information that follows will help walk you through this type of problem and enable you to select the right fan for the job.

Fan Model

Fans all perform the basic function of moving air from one space to another. But the great diversity of fan applications creates the need for manufacturers to develop many different models. Each model has benefits for certain applications, providing the most economical means of performing the air movement function. The trick for most users is sorting through all of the models available to find one that is suitable for their needs. Here are some guidelines.

Propeller vs. Centrifugal Wheel

Propeller fans provide an economical method to move large air volumes (5,000+ cfm) at low static pressures (0.50 in. or less). Motors are typically mounted in the airstream which limits applications to relatively clean air at maximum temperatures of 110°F.

Centrifugal fans are more efficient at higher static pressures and are quieter than propeller fans. Many centrifugal fan models are designed with motors mounted out of the airstream to ventilate contaminated and high temperature air.

Direct Drive vs Belt Drive

Direct drive fans are economical for low volume (2000 cfm or less) and low static pressure (0.50 in. or less). They require little maintenance and most direct drive motors can be used with a speed control to adjust the cfm.

Belt drive fans are better suited for air volumes above 2000 cfm or static pressures above 0.50 in..Adjustable pulleys allow fan speed and cfm to be adjusted by about 25%. High temperature fans (above 120°F) are almost always belt driven.

Fan Location

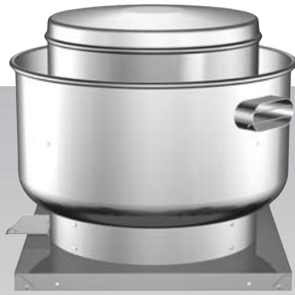
Fan models are designed to be mounted in three common locations: on a roof, in a wall, or in a duct. Whatever the location, the basic fan components do not change. Only the fan housing changes to make installation as easy as possible.

Determining the best location for a fan depends on the airflow pattern desired and the physical characteristics of the building. By surveying the building structure and visualizing how the air should flow, the place to locate the fan usually becomes evident.

Examples of fans installed in common applications are illustrated on the following 6 pages. Even if you come across an application that is not shown in this manual, the concepts remain the same.

Commercial Kitchen Ventilation

Recommended Exhaust Fans

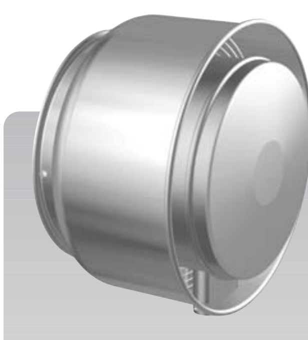


Model CUBE

Belt Drive
Upblast Roof Exhaust
300-30,000 cfm
Up to 5.0 in. wg

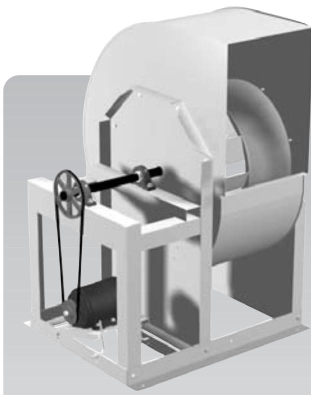
Model USGF

Belt Drive
Upblast Roof Exhaust
300-7,000 cfm
Up to 3 in. wg



Model CWB

Belt Drive
Sidewall Exhaust
300-12,000 cfm
Up to 2.75 in. wg



Model SWB

Belt Drive
Utility Blower
500-30,000 cfm
Up to 5.0 in. wg

The above models are designed for exhausting dirty or grease laden air up and away from the roof line or away from the wall in commercial restaurant applications. All three models are UL 762 listed for restaurant applications and for operation with air temperatures up to 300°F.

Recommended Supply Fans

Model DG

Direct Gas-Fired
Make-Up Air
800-15,000 cfm
Up to 2.0 in. wg

Model IG

Indirect Gas-Fired
Make-Up Air
800-7,000 cfm
Up to 2.0 in. wg

Model RSF

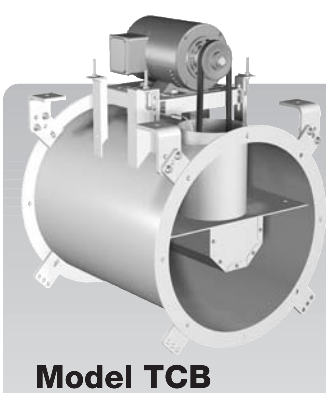
Filtered Roof Supply
650-14,300 cfm
Up to 2.0 in. wg

Model BSQ

Belt Drive Inline
150-28,000 cfm
Up to 4.0 in. wg

Model SQ

Direct Drive Inline
120-5,000 cfm
Up to 1.75 in. wg

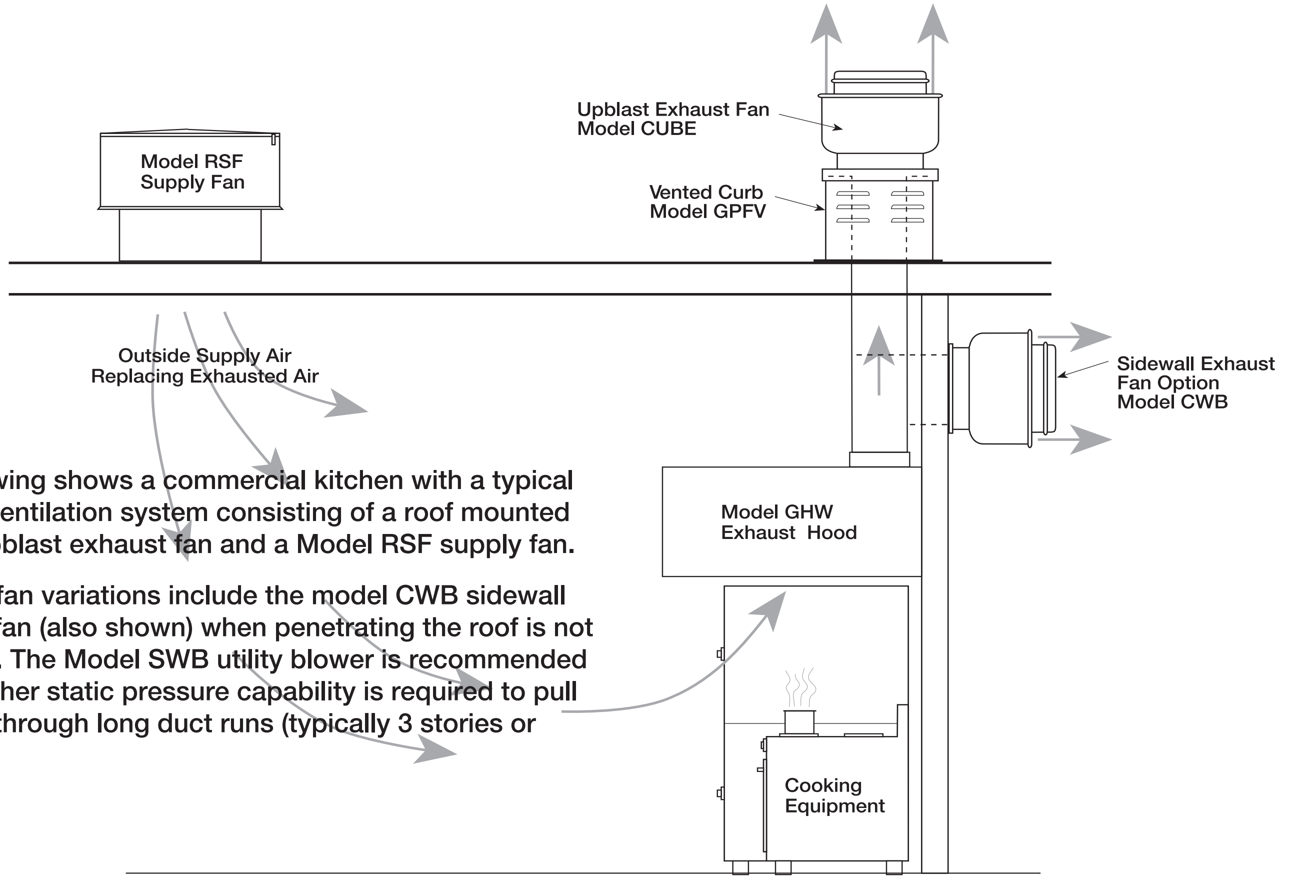


Model TCB

Belt Drive Inline Fan
Roof Upblast, Supply
360-24,000 cfm
Up to 4.5 in. wg

The above models are designed to provide efficient economical make-up air to replenish the air exhausted through the kitchen hood. Provisions for make-up air must be considered for proper kitchen ventilation.

Commercial Kitchen Ventilation



This drawing shows a commercial kitchen with a typical kitchen ventilation system consisting of a roof mounted CUBE upblast exhaust fan and a Model RSF supply fan.

Exhaust fan variations include the model CWB sidewall exhaust fan (also shown) when penetrating the roof is not practical. The Model SWB utility blower is recommended when higher static pressure capability is required to pull exhaust through long duct runs (typically 3 stories or more).

Fan Sizing

Exhaust

When not specified by local codes, the following guidelines may be used to determine the minimum kitchen hood exhaust cfm. Some local codes require 100 cfm/ft.^{2} of hood area for wall style hoods.

Supply

Recommended supply airflow is 90% of exhaust cfm. The remaining 10% of supply air will be drawn from areas adjacent to the kitchen, which helps prevent undesirable kitchen odors from drifting into areas such as the dining room.

	Type of Cooking Equipment	cfm/ft.^{2} of Hood
Light Duty	Oven, Range, Kettle	50
Medium Duty	Fryer, Griddle	75
Heavy Duty	Charbroiler, Electric Broiler	100

Static pressure typically ranges from .625 in. to 1.0 in. for 1 story buildings.

NFPA Considerations

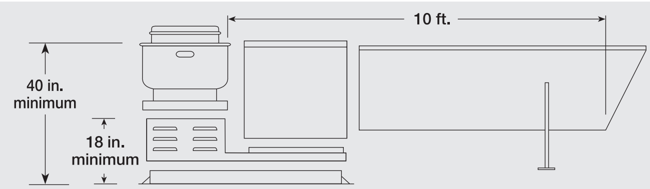
The National Fire Protection Association specifies minimum distance criteria for restaurant exhaust and supply fans as shown below:

10 ft. Horizontal Separation

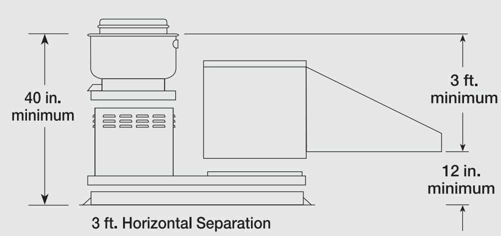
1. Roof deck to top of exhaust fan windband - 40 in. min.
2. Roof deck to top of curb - 18 in. min.
3. Supply fan intake - 10 ft. min. from all exhaust fans.

3 ft. Horizontal Separation

For applications where the 10 ft. horizontal distance cannot be met, vertical separation between exhaust and supply must be at least 3 feet.



10 ft. Horizontal Separation



3 ft. Horizontal Separation

General Commercial Ventilation

Model G

Direct Drive Roof Exhaust
90-3,200 cfm
Up to 1.0 in. wg

Model GB

Belt Drive Roof Exhaust
80-44,700 cfm
Up to 3.25 in. wg

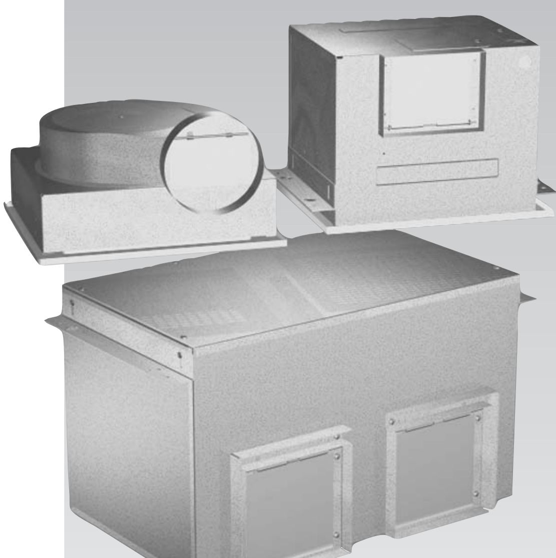
Model CW

Direct Drive Wall Exhaust
80-6,000 cfm
Up to 2.25 in. wg

Model CWB

Belt Drive Wall Exhaust
300-12,000 cfm
Up to 2.75 in. wg

The above models are designed for exhausting relatively clean air at temperatures up to 130°F. Motors are out of the airstream. Direct drive sizes 60-95 are equipped with 3-speed motors for maximum airflow flexibility. All direct drive units except 1725 rpm (A speed) can be used with a speed control.

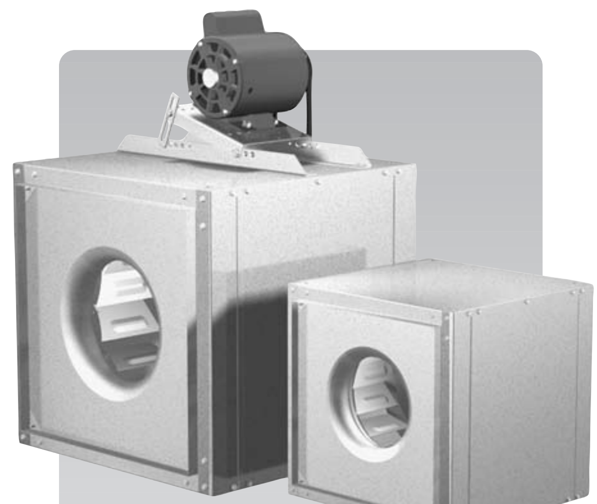


Model SP

Ceiling Exhaust Fan
50-1,600 cfm
Up to 1.0 in. wg

Model CSP

Inline Cabinet Fan
100-3,800 cfm
Up to 1.0 in. wg



Model BSQ

Belt Drive Inline Fan
150-28,000 cfm
Up to 4.0 in. wg

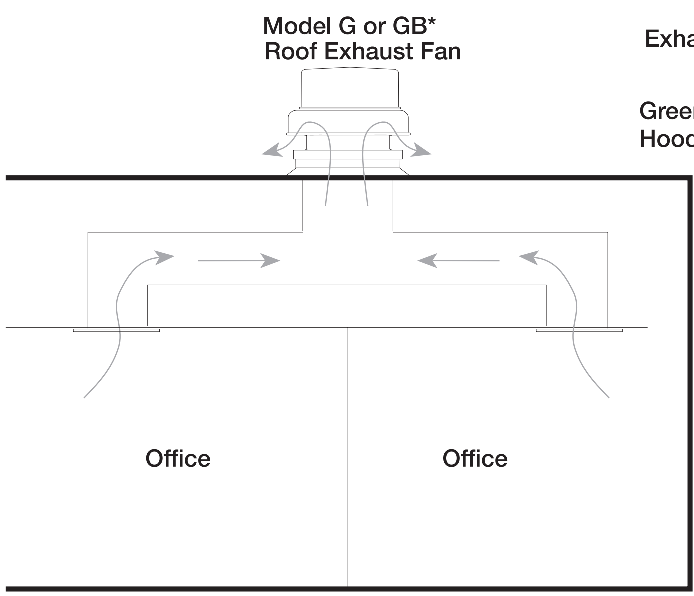
Model SQ

Direct Drive Inline Fan
120-5,000 cfm
Up to 1.75 in. wg

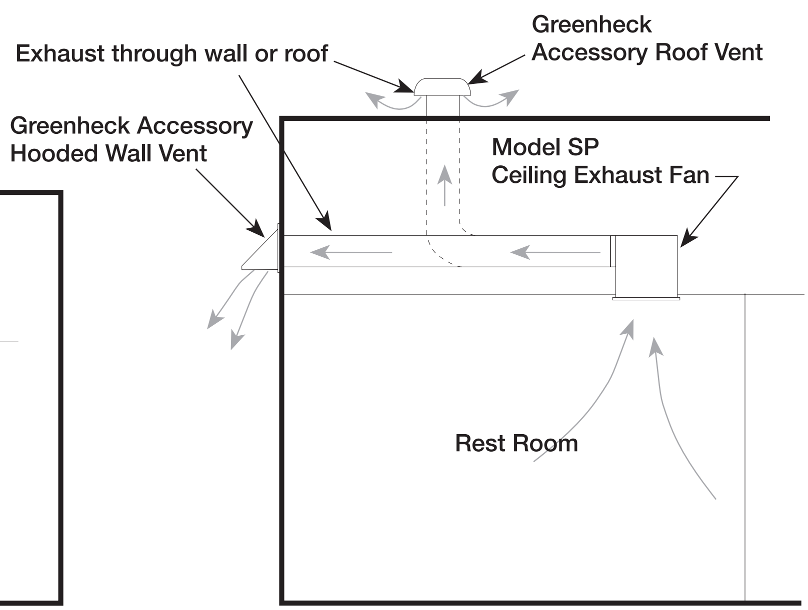
Models SP and CSP are designed for exhausting relatively clean air at temperatures up to 110°F. Motors are in the airstream. All models are direct drive and can be used with a speed control.

Models SQ and BSQ are versatile fans that can be used for exhaust or supply and can be mounted in any position. Two removable side panels provide access for service.

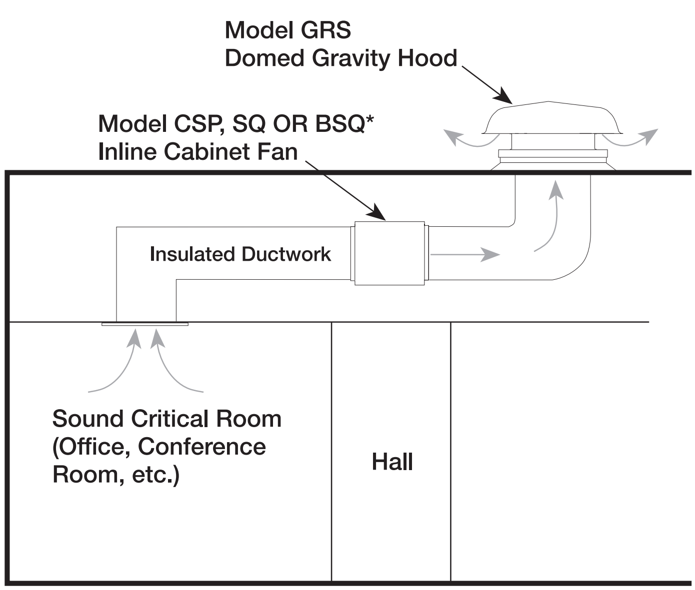
Typical Commercial Ventilation Installations



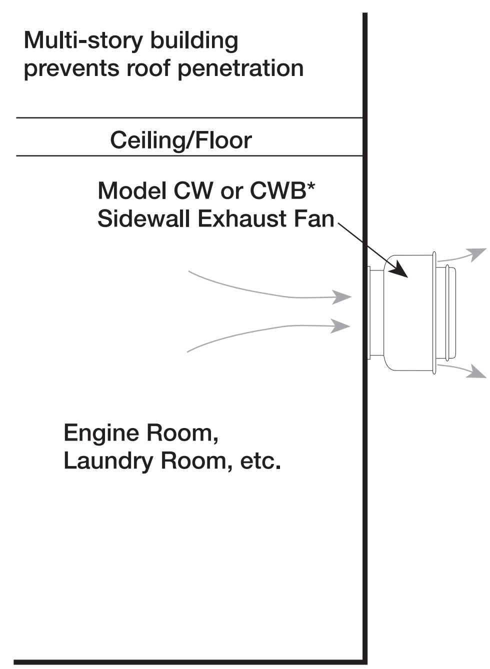
This drawing demonstrates how to ventilate more than one area with a single fan.



Typical restroom exhaust system



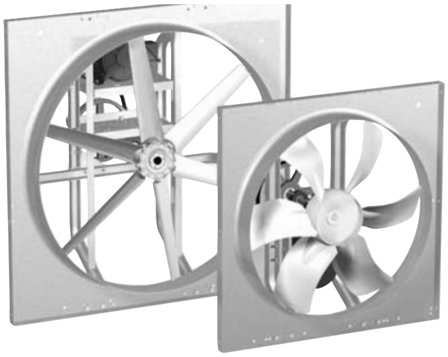
For ultra-quiet applications, insulate ductwork and mount fan over a less sound critical area.



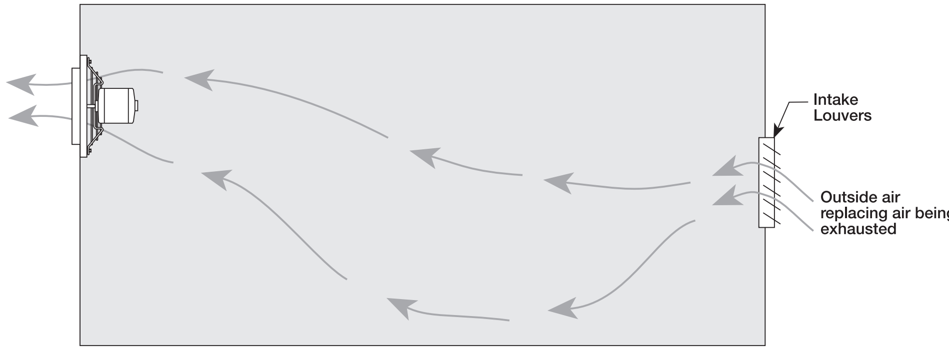
Exhausting through an outside wall is often the best solution when penetrating the roof is not practical.

*Illustrations show fan types typically used in these applications. The specific fan model required depends on the conditions of each individual application.

General Industrial Ventilation

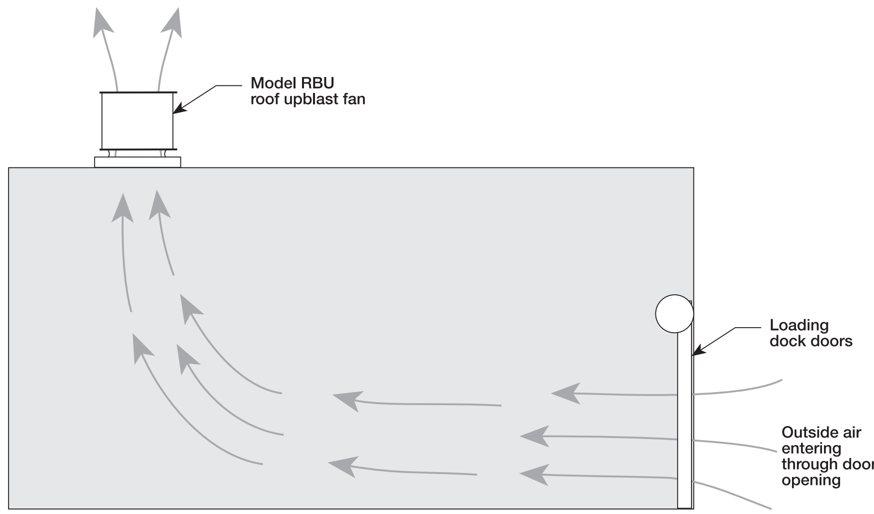


Model SB
Belt Drive
Propeller Sidewall
3,600-85,000 cfm
Up to 1.0 in. wg

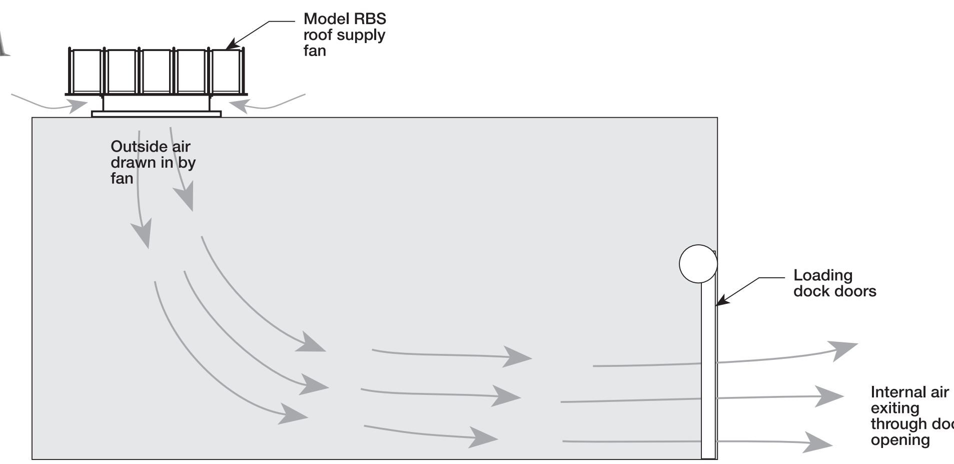


Model RBU
Belt Drive
Propeller Upblast
4,000-65,000 cfm
Up to 1.0 in. wg

Model RBUMO
Belt Drive
Propeller Upblast
3,000-60,000
Up to 1.0 in. wg

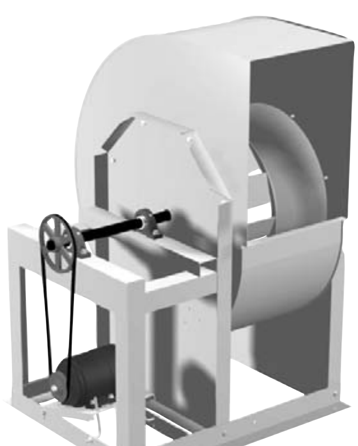


Model RB
RBS-Supply
RBE-Exhaust
RBF-Filtered
Belt Drive Propeller Roof
2,000-86,500 cfm
Up to 1.5 in. wg

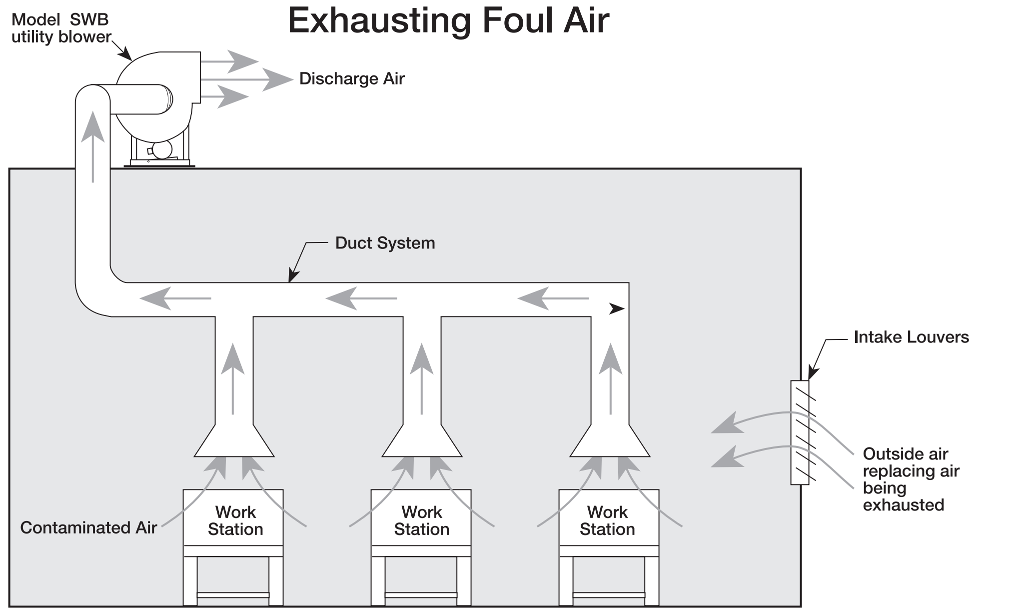


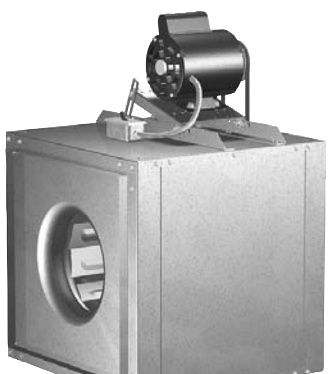
Typical Applications
Propeller fans are ideal for ventilating high air volumes at low static pressures (0.50 in. or less). Industrial applications often include factories and warehouses. A variety of fan models offer flexibility for roof or wall mount as well as exhaust or supply. However, because the motors are mounted in the airstream, these models are not recommended for temperatures above 110°F.

High Static Pressure Ventilation

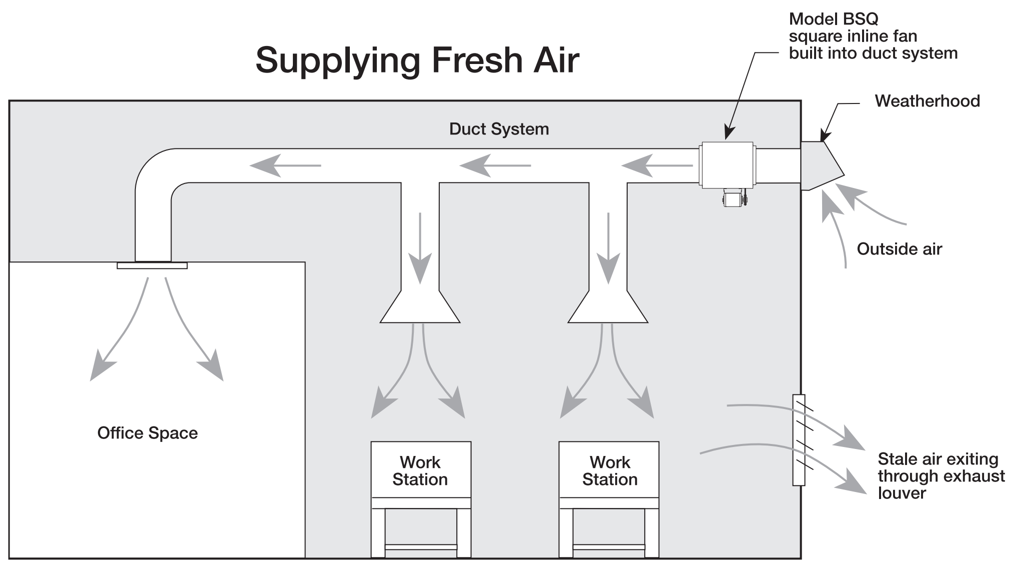


Model SWB
Belt Drive Utility Blower
500-30,000 cfm
Temperatures up to 400°F
Up to 5.0 in. wg





Model BSQ
Belt Drive Inline Fan
150-28,000 cfm
Temperatures up to 180°F
Up to 4.0 in. wg



Typical Applications
Models SWB and BSQ are general, all-purpose fans that are capable of moving high air volumes against high static pressures (up to 5.0 in wg). High static pressures are generated by long or complex duct systems, especially when capture hoods are present. Both models can be used for either exhaust or supply. Model SWB is designed to be mounted indoors or outdoors, while model BSQ can be used indoors only.

Determining CFM (cfm)

After the model is known, the cfm must be determined. Consult local code requirements or the table below for suggested air changes for proper ventilation.

The ranges specified will adequately ventilate the corresponding areas in most cases. However, extreme conditions may require “Minutes per Change” outside of the specified range. To determine the actual number needed within a range, consider the geographic location and average duty level of the area. For hot climates and heavier than normal area usage, select a lower number in the range to change the air more quickly. For moderate climates with lighter usages, select a higher number in the range.

To determine the cfm required to adequately ventilate an area, divide the room volume by the appropriate “Minutes per Change” value.

Suggested Air Changes for Proper Ventilation

$$\text{cfm} = \frac{\text{Room Volume}}{\text{Min./Chg.}} \qquad \text{Room Volume} = L \times W \times H \text{ (of room)}$$

Area	Min./Chg.	Area	Min./Chg.	Area	Min./Chg.
Assembly Hall	3-10	Dance Hall	3-7	Machine Shop	3-6
Attic	2-4	Dining Room	4-8	Mill	3-8
Auditorium	3-10	Dry Cleaner	2-5	Office	2-8
Bakery	2-3	Engine Room	1-3	Packing House	2-5
Bar	2-4	Factory	2-7	Projection Room	1-2
Barn	12-18	Foundry	1-5	Recreation Room	2-8
Boiler Room	1-3	Garage	2-10	Residence	2-6
Bowling Alley	3-7	Generator Room	2-5	Restaurant	5-10
Cafeteria	3-5	Gymnasium	3-8	Rest Room	5-7
Church	4-10	Kitchen	1-5	Store	3-7
Classroom	4-6	Laboratory	2-5	Transfer Room	1-5
Club Room	3-7	Laundry	2-4	Warehouse	3-10

Sample problem:

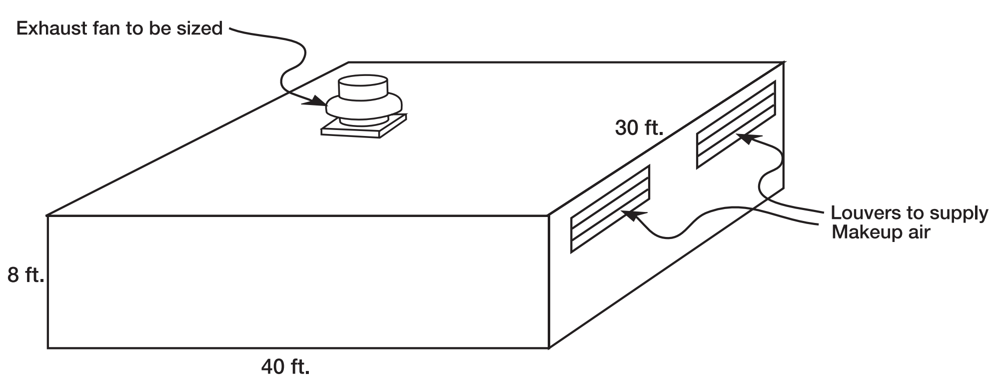
A building requires an exhaust fan to ventilate a general office (see diagram below) which measures 30 ft. x 40 ft. x 8 ft. The office is often crowded.

Solution:
The total room volume is 30 ft. x 40 ft. x 8 ft. = 9600 cubic feet. From the chart, the range for general offices is 2-8 minutes per change. Since the office has heavier than normal usage, 4 minutes per change is recommended. Therefore, the required exhaust is:

$$\frac{9600 \text{ ft}^3}{4 \text{ min.}} = 2400 \text{ cfm}$$

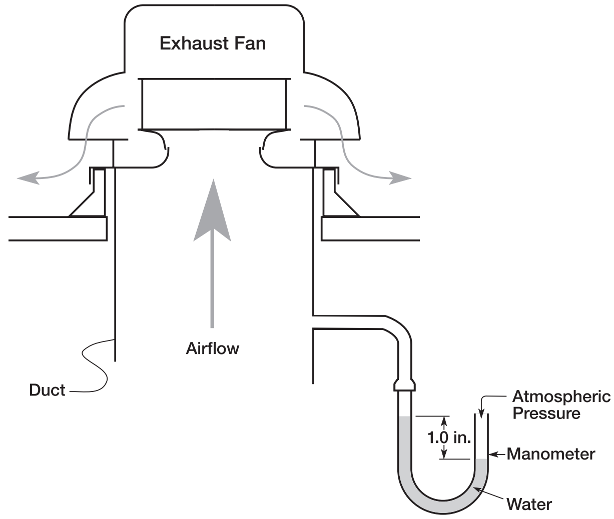
Since the air to be exhausted is relatively clean, this is an ideal application for a model GB fan.

Note: In this example, make-up air was provided through a set of louvers at the wall farthest from the exhaust fan. If there were no provisions for make-up air in this room, a supply fan would also have to be sized. The supply cfm should equal the exhaust cfm. Supply fan location should be as far as possible from the exhaust fan.



Determining Static Pressure (Ps)

The pressures generated by fans in ductwork are very small. Yet, accurately estimating the static pressure is critical to proper fan selection.



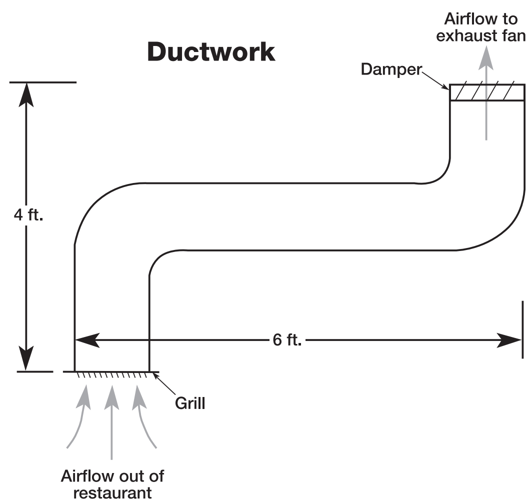
Fan static pressure is measured in inches of water gauge. One pound per square inch is equivalent to 27.7 in. of water gauge. Static pressures in fan systems are typically less than 2 in. of water gauge, or 0.072 Psi. The drawing to the right illustrates how static pressures are measured in ductwork with a manometer.

A pressure differential between the duct and the atmosphere will cause the water level in the manometer legs to rest at different levels. This difference is the static pressure measured in inches of water gauge.

In the case of the exhaust fan at right, the air is being drawn upward through the ductwork because the fan is producing a low pressure region at the top of the duct. This is the same principle that enables beverages to be sipped through a straw.

The amount of static pressure that the fan must overcome depends on the air velocity in the ductwork, the number of duct turns (and other resistive elements), and the duct length. For properly designed systems with sufficient make-up air, the guide lines in the table below can be used for estimating static pressure:

STATIC PRESSURE GUIDELINES	
Non-Ducted	0.05 in. to 0.20 in.
Ducted	0.2 in. to 0.40 in. per 100 feet of duct (assuming duct air velocity falls within 1000-1800 feet per minute)
Fittings	0.08 in. per fitting (elbow, register, grill, damper, etc.)
Kitchen Hood Exhaust	0.625 in. to 1.50 in.
Important: Static pressure requirements are significantly affected by the amount of make-up air supplied to an area. Insufficient make-up air will increase static pressure and reduce the amount of air that will be exhausted. Remember, for each cubic foot of air exhausted, one cubic foot of air must be supplied.	



To calculate the system losses, one must know the ductwork system configuration (see Ductwork figure).

This duct is sized for air velocities of 1400 feet per minute. Referring to the static pressure chart, that will result in about 0.3 in. per 100 feet. Since we have 10 feet of total ductwork, our pressure drop due to the duct is:

$$\frac{.3\text{ in.}}{100\text{ ft.}} \times 10\text{ ft.} = .03\text{ in.}$$

There is also a 0.08 in. pressure drop for each resistive element or fitting. For this example, there are 5 fittings: one grill, two duct turns, one damper and louvers in the wall of the office. The total pressure drop for fittings is:

$$5 \times 0.08\text{ in.} = 0.4\text{ in.}$$

Therefore, the total pressure drop is:

$$0.03\text{ in.} + 0.40\text{ in.} = 0.43\text{ in.}$$

For convenience in using selection charts, round this value up to the nearest 1/8 in., which would be 0.50 Ps.

Preliminary Selections

At this point we know the model, cfm and Ps. With this information we can refer to the GB performance charts to determine the sizes available to move 2400 cfm against 0.50 in. Ps.

In our case, all of the criteria can be met by more than one size of a particular model. When this occurs, choose the size that provides the greatest airflow range about the desired cfm. For example, many direct drive fans have three speeds. If possible, choose a size that uses the middle rpm. This will allow some final system adjustment if the actual cfm the job requires is somewhat higher or lower once the fan is installed. Belt driven fans have adjustable motor pulleys which allow the fan speed to be varied. With belt drive units, avoid selecting near the maximum rpm of a size to allow for final adjustments if necessary.

There are four GB sizes to choose from in the QD catalog. These sizes along with their performance data are in the table below.

Model and Size	Performance Box Data			RPM
	CFM	Sones	Bhp	
GB-141	2556	16.8	.76	1545
GB-161	2614	13.5	.53	1100
GB-180	2375	8.6	.35	810
GB-200	2493	7.8	.40	700

Stability Considerations

Whenever there is more than one size to choose from, it is not recommended to select from the performance box in the far right column for any given rpm unless the Ps is known to be accurate. For example, the GB-200 selection (see table below) of 2493 cfm at 0.50 in. Ps is the far right selection at 700 rpm.

The next box to the right (0.625 in. Ps) is empty because the performance at that point is unstable. This means that 2494 cfm at 0.50 in. is marginally stable.

For more information on fan stability, contact Greenheck.

MODEL (rpm RANGE)	hp	RPM	Tip Speed	STATIC PRESSURE / CAPACITY																	
				0.000		0.125		0.250		0.375		0.500		0.625		0.750		0.875		1.000	
				Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp	Sone	Bhp
GB-141-5 (1125-1360)	1/2	1360	5207	2522		2433		2346		2258		2166		2062		1942		1792		1602	
				14.6	0.48	14.3	0.50	13.9	0.51	13.5	0.52	13.1	0.52	12.7	0.52	12.2	0.53	11.6	0.52	11.0	0.51
GB-141	3/4	1545	5915	2866		2787		2709		2634		2556		2475		2384		2286		2176	
				17.6	0.71	18.0	0.72	17.4	0.74	17.1	0.75	16.8	0.76	15.9	0.77	14.9	0.77	14.8	0.77	14.7	0.78
GB-161-4 (634-865)	1/4	785	3416	2318		2104		1875		1587											
				8.9	0.18	8.5	0.19	8.3	0.19	7.8	0.19										
		865	3764	2555		2359		2162		1932		1624									
				10.6	0.24	10.1	0.25	9.7	0.26	9.4	0.26	8.8	0.25								
GB-161-5 (852-1100)	1/2	985	4287	2909		2737		2567		2382		2176		1914		1550					
				13.4	0.35	12.7	0.36	12.3	0.37	11.9	0.38	11.5	0.38	10.9	0.37	10.2	0.35				
		1100	4787	3249		3094		2943		2786		2614		2428		2197		1899			
				15.3	0.48	14.7	0.50	14.1	0.52	13.8	0.53	13.5	0.53	13.0	0.53	12.5	0.52	12.0	0.50		
GB-180-3 (618-810)	1/3	770	3729	2994		2833		2651		2427		2139		1700							
				8.1	0.25	9.2	0.26	9.1	0.29	8.5	0.30	7.8	0.30	7.4	0.28						
		810	3923	3150		2997		2832		2624		2375		2053							
				10.6	0.29	10.3	0.31	10.0	0.33	9.3	0.35	8.6	0.35	8.2	0.34						
GB-180-5 (700-940)	1/2	900	4359	3500		3364		3219		3052		2858		2624		2347		1821			
				12.7	0.40	12.4	0.42	12.1	0.44	11.3	0.46	10.5	0.48	10.2	0.48	9.8	0.47	9.2	0.43		
		940	4553	3655		3527		3388		3234		3052		2844		2601		2272			
				13.6	0.46	13.4	0.47	13.1	0.49	12.3	0.52	11.4	0.54	11.0	0.55	10.6	0.54	10.1	0.52		
GB-180-7 (764-1055)	3/4	1000	4843	3888		3768		3638		3504		3339		3164		2952		2712		2387	
				15.2	0.55	14.7	0.57	13.7	0.58	13.3	0.62	13.0	0.64	12.4	0.66	11.9	0.66	11.6	0.65	11.1	0.63
		1055	5109	4102		3989		3866		3741		3596		3432		3251		3050		2811	
				16.2	0.65	15.7	0.67	14.9	0.68	14.4	0.72	14.0	0.74	13.5	0.76	12.9	0.77	12.7	0.77	12.4	0.77
GB-180	1	1185	5739	4607		4507		4400		4290		4179		4045		3900		3753		3575	
				19.0	0.91	18.4	0.94	17.8	0.96	17.4	0.98	17.1	1.03	16.7	1.05	16.2	1.07	15.8	1.10	15.4	1.10
	1½	1335	6465	5191		5102		5010		4912		4814		4715		4599		4474		4343	
				22.0	1.31	22.0	1.33	21.0	1.36	21.0	1.37	21.0	1.41	20.0	1.47	19.9	1.49	19.5	1.51	19.2	1.54
	2	1460	7071	5677		5595		5514		5424		5335		5245		5155		5049		4938	
				26.0	1.71	25.0	1.74	24.0	1.77	24.0	1.79	24.0	1.81	24.0	1.86	23.0	1.93	23.0	1.95	23.0	1.97
GB-200-5 (512-770)	1/2	700	3917	3873		3591		3307		2973		2493									
				10.3	0.39	9.6	0.40	9.2	0.41	8.6	0.41	7.8	0.40								
		770	4308	4260		4013		3744		3477		3140		2643							
				12.1	0.52	11.0	0.53	10.7	0.55	10.2	0.55	9.8	0.55	9.3	0.52						

Sound Levels

In many cases, the sound generated by a fan must be considered. For the fan industry, a common unit for expressing sound pressure level is the sone. In practical terms, the loudness of one sone is equivalent to the sound of a quiet refrigerator heard from five feet away in an acoustically average room.

Sones are a linear measurement of sound pressure levels. For example, a sound level of 10 sones is twice as loud as 5 sones.

Refer to the Suggested Limits for Room Loudness chart to determine the acceptable sone range for the application. As a general guideline, choose a fan that has a sone value within the range specified.

Note: Rooms with a hard construction (concrete block, tile floors, etc.) reflect sound. For these rooms, select fans on the lower end of the range. Rooms with soft construction or those with carpeting and drapes, etc., absorb sound. For these rooms, fans near the higher end of the range may be selected.

Our example describes an exhaust fan for an office. Referring to the “Suggested limits for Room Loudness” chart, offices should have a loudness range from 4 to 12 sones. Of our remaining three selections, only the GB-180 has a sone value of less than 12. Therefore, the GB-180 is the best selection for this application.

Suggested Limits for Room Loudness

Sones	DBA	
1.3-4	32-48	Private homes (rural and suburban)
1.7-5	36-51	Conference rooms
2-6	38-54	Hotel rooms, libraries, movie theatres, executive offices
2.5-8	41-58	Schools and classrooms, hospital wards, and operating rooms
3-9	44-60	Court rooms, museums, apartments, private homes urban)
4-12	48-64	Restaurants, lobbies, general open offices, banks
5-15	51-67	Corridors and halls, cocktail lounges, washrooms and toilets
7-21	56-72	Hotel kitchens and laundries, supermarkets
12-36	64-80	Light machinery, assembly lines
15-50	67-84	Machine shops
25-60	74-87	Heavy machinery

From AMCA Publication 302 (Application of Sone Ratings for Non Ducted Air Moving Devices with Room-Sone-dBA correlations).

Motor Horsepower

The motor horsepower for direct drive fans is always sized by Greenheck and does not require further consideration. For belt drive models, the catalog identifies which horsepower is recommended. However, there are times when it is wise to bump the horsepower one size. For example, the hp recommended for the GB-180 at 810 rpm is 1/3 hp.

Although a 1/3 hp motor is recommended, it is not necessarily a good motor selection for this application. Our static pressure of 0.5 in. was only an estimate. It may actually turn out to be .625 in.

If this is the case, we will need a 1/2 hp motor because our fan will have to run at almost 900 rpm (refer to performance box - 2624 cfm at 0.625 in.Ps). Therefore, choosing a 1/2 hp motor in this case is exercising good judgement.

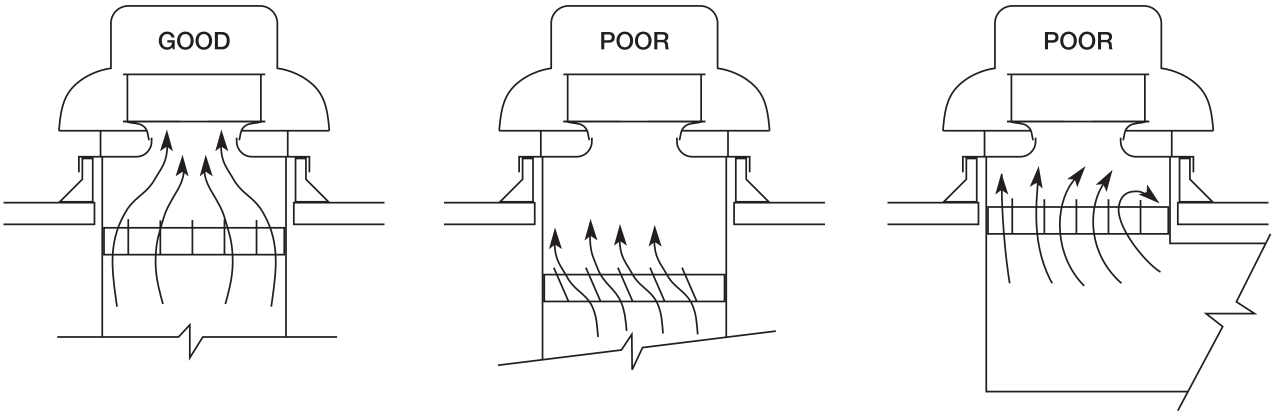
The complete model designation for this application is GB-180-5.

Note: The GB-180-5 has an rpm range of 700-940

(refer to model column in catalog). This means that if the static pressure is less than estimated, say 0.25 in. Ps, the fan can be slowed down to accommodate this condition.

Installation

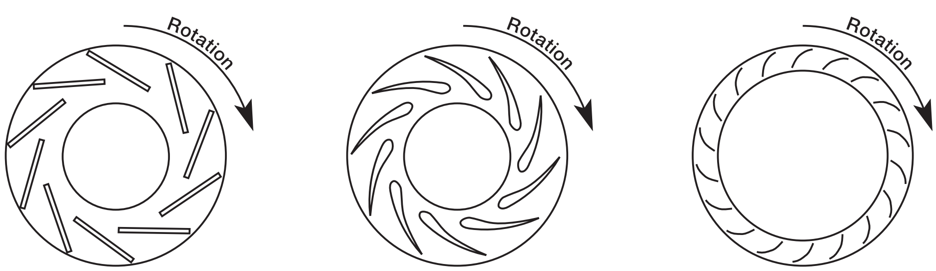
To ensure proper fan performance as cataloged, caution must be exercised in fan placement and connection to the ventilation system. Obstructions, transitions, poorly designed elbows, improperly selected dampers, etc., can cause reduced performance, excessive noise, and increased mechanical stressing. For the fan to perform as published, the system must provide uniform and stable airflow into the fan.



Uniform Flow | **Improperly sized or obstructed damper** | **Elbow too close to fan inlet**

Wheel Rotation

A common problem is wheel rotation in the wrong direction. For centrifugal fans, incorrect wheel rotation will provide some airflow. However, the airflow will be far below the cataloged value. Rotation should be checked while the fan is coasting to a stop. Proper rotation for the most common wheels are shown below. When connecting a 3 phase motor, there is a 50% chance that the fan will run backwards. Changing any two supply power connections will reverse the direction of rotation.



Backward Inclined | Airfoil | Forward Curved

FAN PERFORMANCE

The first two sections of this guide contain information needed to select the right fan for the particular application. The information in this section is useful once the fan has been selected and installed on the job.

The fan curves and system resistance curves below will help to solve fan performance problems that may be encountered in a variety of applications.

Fan Dynamics

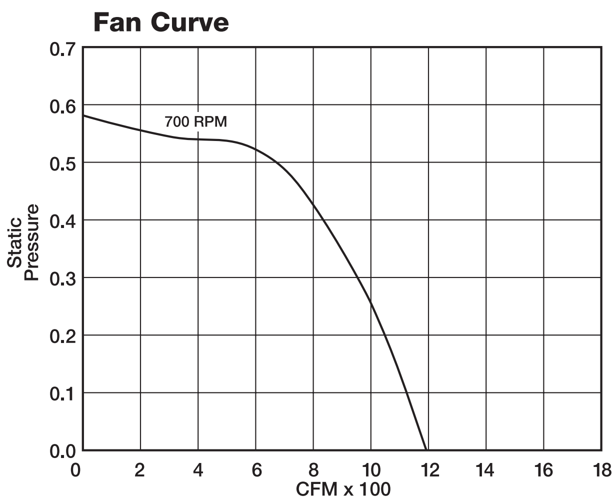
A fan is simply an air pump. The rate at which a fan can “pump” air depends on the pressure the fan must overcome. This principle also relates to water pumps. A water pump is able to deliver more water through a 2 in. diameter hose than a 1 in. diameter hose because the 1 in. hose creates more resistance to flow.

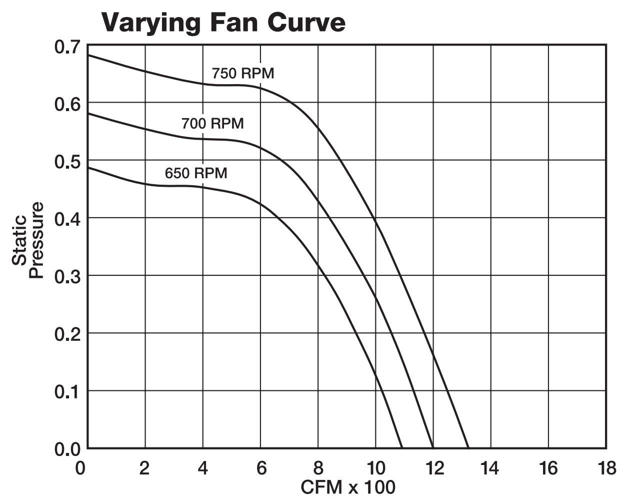
For a fan, every flow rate (CFM-Cubic Feet per Minute) corresponds to a specific resistance to flow (Ps-Static Pressure). The series of cfm, Ps points for a fan at a constant rpm is called a fan curve. A fan curve at 700 rpm is shown below.

At 0.25 in. Ps, this fan will deliver 1000 cfm. If the pressure increases, cfm decreases. If the pressure decreases, cfm will increase.

At 700 rpm, the operating point will slide along the fan curve as static pressure changes, but it will never lie off the curve. In order for a fan to perform at a point off the curve, the rpm must be changed.

The figure below illustrates how rpm affects the fan curve. Notice that the general shape of the curves are the same. Changing rpm simply moves the curve outward or inward.





System Dynamics

For a given flow rate (cfm), an air distribution system produces a resistance to airflow (Ps). This resistance is the sum of all static pressure losses as the air flows through the system. Resistance producing elements include ductwork, dampers, grills, coils, etc.

A fan is simply the device that creates the pressure differential to move air through the system.

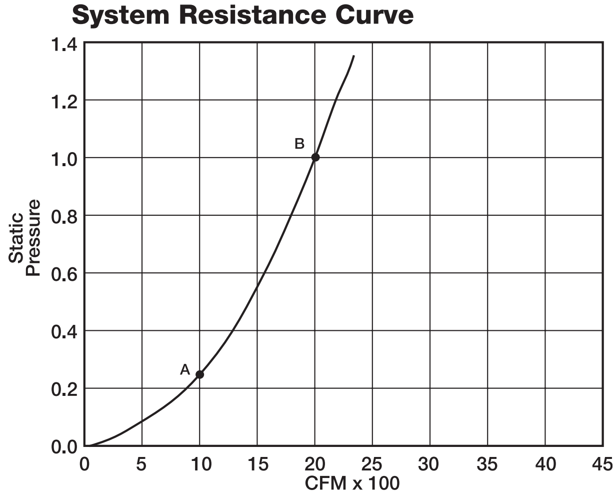
The greater the pressure differential created by the fan, the greater the volume of air moved through the system. Again, this is the same principle that relates to water pumps. The main difference in our case is that the fan is pumping air.

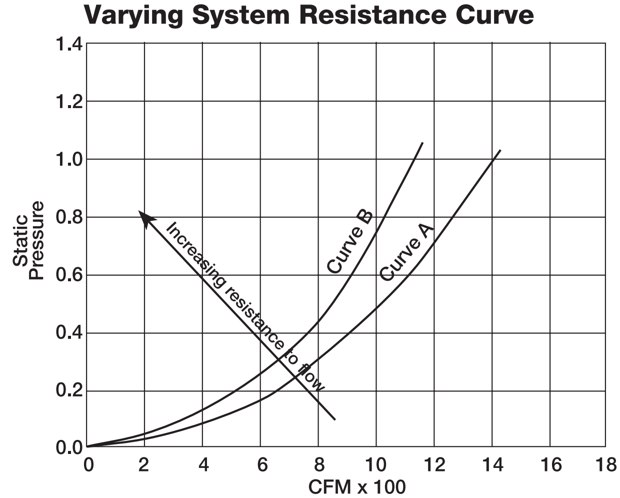
Tests have established a relationship between cfm and Ps. This relationship is parabolic and takes the form of the following equation:

$$Ps = K \times (cfm)^2$$

Where K is the constant that reflects the “steepness” of the parabola. This equation literally states that Ps varies as the square of the cfm.

For example, whenever the cfm doubles, the Ps will increase 4 times. The figures on the next page graphically illustrate this concept.





Sample problem:

If a system is designed to move 1000 cfm at a resistance of 0.25 in. Ps, what static pressure would the fan have to overcome to produce 2000 cfm of airflow?

Solution:

Since static pressure varies as the square of cfm, we can solve for the new Ps (Ps_2) with the following equation:

$$Ps_2 = Ps_1 \times \left(\frac{cfm_2}{cfm_1}\right)^2 = 0.25 \text{ in.} \times \left(\frac{2000\,cfm}{1000\text{ cfm}}\right)^2 = 1.0 \text{ in.}$$

Referring to the figure above, this results in sliding up the system resistance curve from Point A to Point B.

For this system, it is impossible to move 2000 cfm at only 0.25 in. Ps. For any given system, every cfm requires a unique Ps. This series of cfm/Ps points forms a system resistance curve such as the one above. Once the system resistance curve is defined, changing the fan rpm will change the cfm and Ps simultaneously, which results in sliding along the system resistance curve.

Note: Physically changing the system will alter the system resistance. For example, closing a damper from 100% open to only 50% open will add resistance and increase the "steepness" of the system resistance curve. The same effect occurs as filters become dirty. The figure above illustrates this point.

Curve A defines a system that requires 0.5 in. Ps to move 1000 cfm. Curve B requires 0.75 in. Ps to move the same amount of air. This is typical of how a system reacts to increased resistance.

In this section, there are three key points to emphasize:

1. As airflow through a system changes, so does the static pressure.
2. For a steady-state system, operating points must lie on the curve defining that system's cfm/Ps characteristics.
3. As the system's resistive elements change, the steepness of the system resistance curve changes.

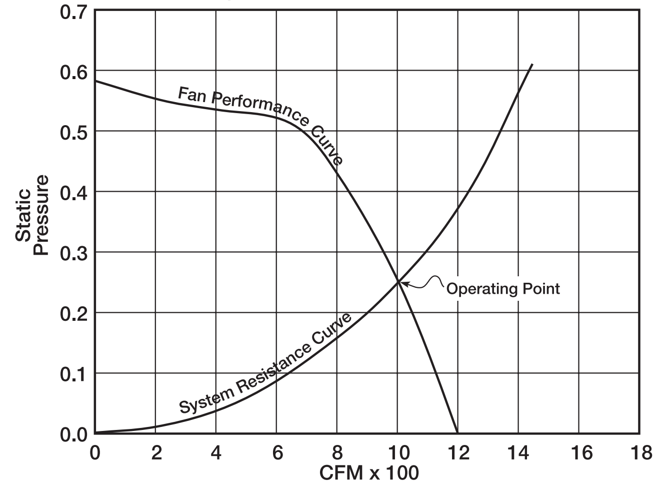
Combining Fan and System Dynamics

The previous two sections introduced fan curves and system resistance curves. This section will show how these relate to each other to provide an understanding of the way the fan-system operates as a complete entity.

Remember that a fan curve is the series of points at which the fan can operate at a constant rpm. Likewise, a system resistance curve is the series of points at which the system can operate. The operating point (cfm, Ps) for the fan-system combination is where these these two curves intersect.

The operating point of the fan and the system is the point where these two curves intersect. This intersection will determine the cfm and Ps delivered.

Operating Point



Adjusting Fan Performance

There is a direct relationship between cfm and rpm within a system. Doubling the fan rpm will double the cfm delivered.

Sample problem:

The figure on page 21 showed a fan curve at 700 rpm which had an operating point of 1000 cfm at 0.25 in. Ps. What rpm is required to move 2000 cfm through the same system?

Solution:

Within a system, cfm is directly related to rpm. Therefore, the new rpm (rpm_2) can be determined from the following equation:

$$rpm_2 = rpm_1 \text{ X } \left(\frac{cfm_2}{cfm_1}\right)$$

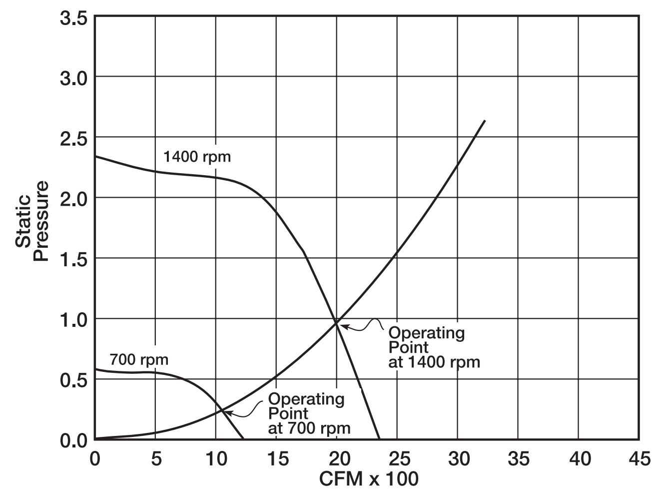
$$= 700 \text{ rpm x } \left(\frac{2000 \text{ cfm}}{1000 \text{ cfm}}\right) = 1400 \text{ rpm}$$

Referring to figure at right, this results in sliding up the system resistance curve from 700 rpm to 1400 rpm.

Notice that as we doubled our airflow from 1000 cfm to 2000 cfm, the Ps went up from 0.25 in. to 1.0 in. It must be kept in mind that we are not changing the system, only increasing fan speed. Therefore, we must remain on the system resistance curve. Within a system, Ps varies as the square of cfm. Since cfm and rpm are directly proportional, an equation relating Ps and rpm can be derived as follows:

$$Ps_2 = Ps_1 \text{ X } \left(\frac{rpm_2}{rpm_1}\right)^2$$

Varying Operating Points



For our example,

$$Ps^2 = 0.25 \text{ in. X } \left(\frac{1400 \text{ rpm}}{700 \text{ rpm}}\right)^2 = 1.0 \text{ in.}$$

This verifies the operating point on the 1400 rpm curve (2000 cfm at 1.0 in. Ps). With this example, it should be clear how cfm, rpm and Ps tie together in a steady-state system.

Fan Laws

In a steady-state system, as the fan rpm changes, cfm, Ps and BHp (horsepower) also change. The equations below, known better as fan laws, show the relationship between these performance parameters.

$$cfm_{New} = \frac{rpm_{New}}{rpm_{Old}} \times cfm_{Old}$$

$$Ps_{New} = \left(\frac{rpm_{New}}{rpm_{Old}}\right)^2 \times Ps_{Old}$$

$$Bhp_{New} = \left(\frac{rpm_{New}}{rpm_{Old}}\right)^3 \times Bhp_{Old}$$

The first two equations have already been covered in the fan and system dynamics section. Refer to the examples in those sections on how to apply these equations.

The third equation relates horsepower to rpm. The change in horsepower can be determined when the rpm is increased by 25%. This is shown below:

$$Bhp_{New} = (1.25)^3 \times Bhp_{Old} = 1.95 \times Bhp_{Old}$$

NOTE: a 25% increase in rpm results in a 95% increase in horsepower. Considering this, initial fan selections should be sized with motor horsepowers greater than necessary if any increase in fan rpm is likely in the future.