

TUBULAR **CENTRIFUGAL FANS**



 **GREENHECK**[®]

MAY 1996

MODEL TCF

Tubular Centrifugal Fans

Greenheck Tubular Centrifugal fans have been designed for commercial and industrial applications that demand quiet, efficient and reliable air movement.


The high efficiency, low sound level, and non-overloading characteristics of Greenheck's airfoil wheels result from a careful matching of the inlet and wheel cones, optimum blade pitch and a well proportioned housing.

Rugged Tubular Centrifugal fan construction includes continuously welded housings and rigid support members for structural strength. Heavy duty bearings have an average life exceeding 200,000 hours. Fan wheels are mounted on accurately turned, ground and polished shafts. Each wheel is statically and dynamically balanced. Prior to shipment each fan is given a final balance test at operating speed to insure smooth, vibration free operation.

Greenheck's Tubular Centrifugal design has been engineered and tested to deliver years of dependable service with minimal maintenance. Extensive testing in Greenheck's modern AMCA registered research and development laboratory assures complete and accurate performance ratings.

Greenheck Tubular Centrifugal fans with airfoil wheels are available with capacities up to 127,000 CFM and static pressures to 8¹/₂". They are offered with wheels from 18¹/₄" to 73" in diameter in both Class I and Class II construction. Arrangement 1 fans are available for horizontal base mount. Arrangement 3 fans are available for horizontal ceiling hung or horizontal base mount. Arrangement 9 fans are available for horizontal base mount, horizontal ceiling hung and vertical mount. In the vertical mount, fans can be positioned for either upblast or downblast discharge. Arrangement 9 vertical mount fans are also available with a wide, quick opening door for ease of access and cleaning.



 <p>amca CERTIFIED RATINGS</p> <p>AIR PERFORMANCE</p> <p>AIR MOVEMENT AND CONTROL ASSOCIATION, INC.</p>	<p>Greenheck certifies that the TCF fans shown herein are licensed to bear the AMCA seal. The ratings shown are based on tests and procedures performed in accordance with AMCA Publication 211 and comply with the requirements of the AMCA Certified Ratings Program.</p>
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ARRANGEMENTS

ARRANGEMENT 1 HORIZONTAL BASE MOUNT

Arrangement 1 fans have the motor mounted on the fan base, either to the left or right of the discharge as specified. This arrangement results in maximum stability and in ease of access for service.

ARRANGEMENT 9 HORIZONTAL BASE MOUNT

Arrangement 9 base mount fans are used in applications where floor space is limited. A rigid welded steel base provides a stable floor mount for the housing. Motors may be mounted in one of five positions on the fan housing. (See drawing below.) Motor positions must be specified.

ARRANGEMENT 9 HORIZONTAL CEILING HUNG

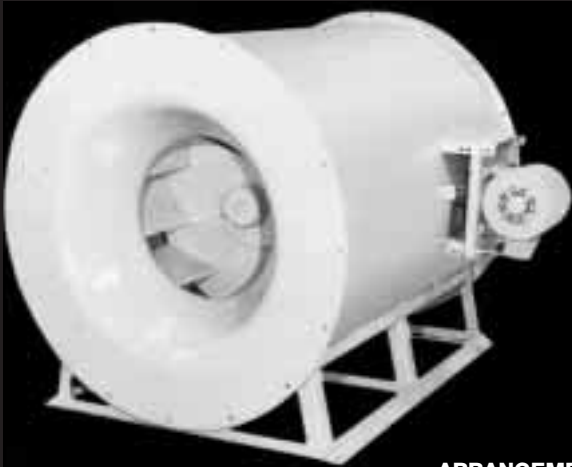
In applications where it is desirable to suspend the fan horizontally from the ceiling, structural steel hanging brackets are welded to the fan housing. Motors may be mounted in one of the locations shown below. Positions B and H must be avoided, because they conflict with hanger bracket locations. See page 27 for hanger bracket locations.

ARRANGEMENT 3 HORIZONTAL BASE MOUNTED OR CEILING HUNG

Arrangement 3 fans are designed for installations where space is limited. Overall length of the housing is considerably shorter than other horizontal arrangements. The fan is constructed with the bearing on the inlet end in the airstream. This construction limits the fan to a maximum air temperature of 180°F and to non-sparking applications. Motor mounting positions are shown below. As with Arr. 9 ceiling hung fans, positions B and H must be avoided. See page 26 for hanger bracket locations.



**ARRANGEMENT 1
HORIZONTAL BASE MOUNT**



**ARRANGEMENT 9
HORIZONTAL BASE MOUNT**

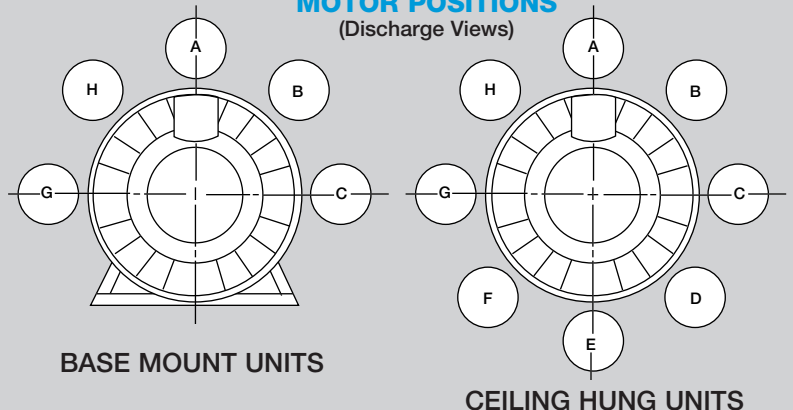


**ARRANGEMENT 9
HORIZONTAL CEILING HUNG**



**ARRANGEMENT 3
HORIZONTAL BASE
MOUNTED OR CEILING HUNG**

MOTOR POSITIONS (Discharge Views)

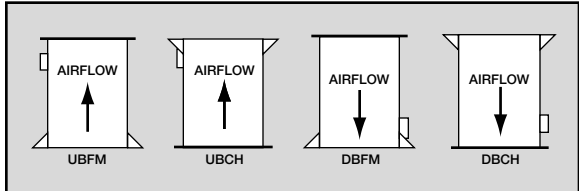


ARRANGEMENT 9 VERTICAL MOUNT



For vertical installation, fans are available with heavy duty steel brackets designed for either floor mounting or ceiling mounting. Both are available with either downblast or upblast discharge. Specify mounting position and discharge.

Arrangement 9 vertical mount fans are available in Class I only.



ARRANGEMENT 9 VERTICAL UPBLAST ROOF MOUNT

Vertical upblast roof fans discharge and disperse exhaust air well above the roofline. Model TCF roof exhausters feature windbands with built-in butterfly dampers, a weatherproof motor cover, and a curb cap with prepunched mounting holes. Arrangement 9 fans are also available without curb caps for stack mounting. TCF roof exhausters are offered in Class I construction only.

MINIMUM CFM TO OPEN STEEL BUTTERFLY DAMPERS

FAN SIZE	MINIMUM CFM
18	5730
20	6010
22	7430
24	9640
27	11700
30	13100
33	14700
36	18600
40	22600
44	25900
49	30000
54	33000

EASY ACCESS VERTICAL MOUNT

Easy Access fans are designed for applications where frequent cleaning and inspection are required. Two quick-open latches allow a wide, hinged section of the housing to swing open for complete accessibility to all fan components. Fans are vertical mount upblast, Class I, sizes 18-54. Easy Access fans are also available for roof mount as shown above.



Optional Curb Cap



Construction Features



- **HOUSING CONSTRUCTION**

Housings are constructed of heavy gauge, continuously welded steel to assure no air leakage. They are rigidly supported to prevent vibration and pulsation. Inlet cones are bolted to the inlet side of the housing and are removable for access to the wheel. A removable drive cover allows access to bearings, shaft and pulleys.

- **STRAIGHTENING VANES**

Welded steel vanes provide positive support for shafts and bearings and straighten the flow of air prior to leaving the fan.

- **FINISH**

All structural steel parts are phosphatized, primed and coated with a baked enamel finish.

- **BEARINGS**

Standard heavy bearings are grease lubricated, self aligning ball or roller type in pillow block mounts. Standard construction includes external lubrication lines. Bearings are selected for a minimum average life in excess of 200,000 hours operation at maximum cataloged conditions for each pressure class.

- **SHAFTS**

Turned, precision ground and polished steel shafts are sized so that the first critical speed is at least 25% over the maximum operating speed. Close tolerances where the shaft makes contact with the bearing result in longer bearing life.

- **ACCESS DOORS**

Bolted access doors provide access to the fan wheel for inspection or cleaning.

- **LIFTING LUGS**

Lifting lugs are provided on the housing for handling and ease of installation.

- **INLET AND OUTLET FLANGES**

Flanged inlets and outlets with mounting holes are provided for duct-work connection. Fan sizes 18 through 27 feature integral flanges. Fan sizes 30 and larger are supplied with hot rolled steel angles stitch welded to the housing.

- **AIRFOIL WHEELS**

Non-overloading airfoil wheels are constructed of heavy gauge steel continuously welded to the wheel cone and to a heavy gauge backplate. The wheel cone and inlet cone are carefully matched for precise running tolerances and maximum efficiency.

- **BALANCING**

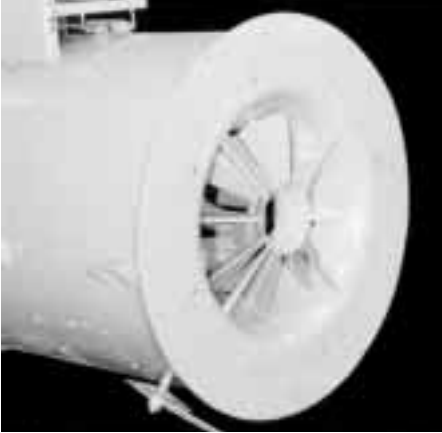
Each fan wheel is statically and dynamically balanced before assembly into the fan. After assembly, each fan is given a final balance test utilizing electronic balance equipment to insure smooth vibration free operation.

- **MOTOR SUPPORTS**

Rigid structural steel motor supports are welded to the fan housing and include heavy duty adjustment screws for belt tensioning.

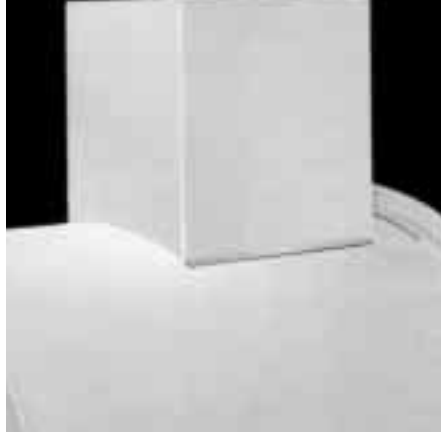


Accessories & Options



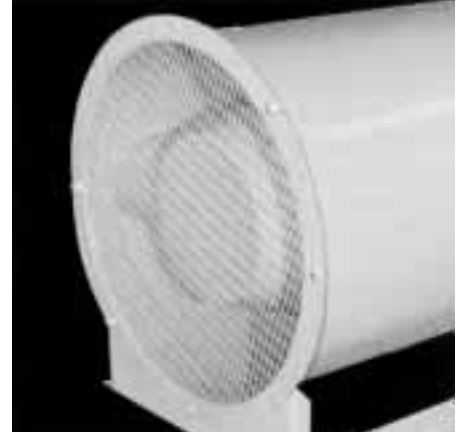
NESTED INLET VANES

Inlet vanes built into the fan inlet cone are available for fan sizes 18-60. Vanes feature steel rods with stainless steel bushings to assure uniform blade movement and positive control. Inlet vanes are suitable for air temperatures up to 200°F. Vanes are suitable for manual or automatic operation (controls furnished by others).



WEATHERPROOF MOTOR COVERS

For outdoor installations, motor covers are recommended to protect motors and drives from moisture and other adverse conditions. Ventilation slots are provided for motor cooling.



INLET AND OUTLET SCREENS

Removable inlet and outlet screens can be furnished to provide protection from rotating parts in non-ducted applications.

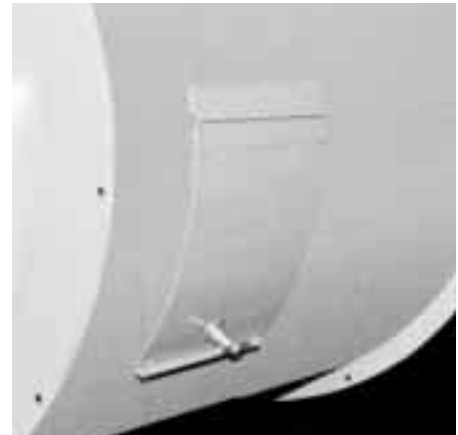


SPARK RESISTANT CONSTRUCTION

Spark resistant construction in accordance with AMCA standards is available.

AMCA Type C -- An aluminum inlet cone and an aluminum rub ring around the shaft opening.

AMCA Type B -- An aluminum backward inclined wheel and an aluminum rub ring around the shaft opening.



HINGED ACCESS DOORS

In addition to the standard bolted access door, hinged doors are also available. Hinged doors open with quick release latches.

BELT GUARDS

Sturdy, fabricated, three sided steel belt guards are available for protection from rotating pulleys and belts. Optional totally enclosed belt guards are also available.

COMPANION FLANGES

Inlet and outlet companion flanges are available for duct connections. See drawings on pages 25, 26 and 27.

SPECIAL COATINGS

A wide selection of protective coatings are available for application to fans exposed to corrosive atmospheres.

SHAFT SEAL

A shaft seal with an aluminum rub ring is available to protect bearings from heat and contaminants. The shaft seal is not gas tight.

DRAIN CONNECTIONS

A 1" threaded drain connection with a plug is available to drain moisture from the bottom of the fan housing.

SPLIT PILLOW BLOCK BEARINGS

Optional split pillow block bearings are selected for a minimum of 400,000 hours average life at the maximum RPM for each pressure class.



ENGINEERING DATA

This catalog contains comprehensive air performance data for Greenheck's tubular centrifugal fans. Air performance is shown in both fan tables and fan curves. This engineering data section will assist the system designer in applying Greenheck tubular centrifugal fans in air conditioning, heating and ventilating systems.

SELECTION

The first consideration in any fan selection is the amount of air to be moved and the resistance to this air movement. Air volume requirements are established by specific codes, heating and cooling loads and accepted industry standards. Once the air volume is known, system resistance can be determined by summing up the losses through the system components. Duct layout, duct size, coils, filters, dampers and fan accessories all affect the system resistance. "ASHRAE Guide and Data Books" and manufacturer's data on individual system components are common sources of information available to the system designer.

The determination of airflow and system resistance defines the point of operation that the fan must be capable of providing. In most applications, several fans may meet the required airflow and system resistance conditions. Larger fans tend to turn slower and generate less noise. These fans generally have lower operating costs, however, this may be offset by higher initial costs when compared to a smaller fan. Smaller fans will have higher speeds for a given application and a steeper performance curve. The steeper performance curve minimizes airflow changes in the system as system resistance varies. Smaller fans also tend to have wider stable modulation ranges in variable air volume systems.

An optimum fan selection requires evaluation of the alternative fan sizes, as they relate to initial cost, horsepower, available space and allowable sound levels. In addition, air density, effect of installation on performance, volume control, temperature limitations and motor starting torque should be evaluated.

The relative importance of these factors varies with each system. The information presented in this section of the catalog is intended to assist the system designer in evaluating these factors.

SPEED CHANGES

A change in the speed of a fan in a fixed system will cause the volume, pressure, and horsepower to vary as follows:

$$CFM_2 = \left(\frac{RPM_2}{RPM_1} \right) \times CFM_1$$

$$SP_2 = \left(\frac{RPM_2}{RPM_1} \right)^2 \times SP_1$$

$$BHP_2 = \left(\frac{RPM_2}{RPM_1} \right)^3 \times BHP_1$$

NOTE: Subscript 1 indicates existing conditions subscript 2 indicates new conditions after speed change.

When changing the speed of a fan the actual running motor amperage should be checked against the motor's nameplate rating to prevent overloading. The fan speed should also be checked to make sure the RPM does not exceed the maximum RPM limits shown on the performance pages.

SOUND LEVEL

Sound has become an important design consideration. Fan specifications frequently contain limitations on sound levels. These limitations may be expressed in power or pressure levels, and multiple or single number ratings. For proper fan application, it is necessary to have the specified sound levels clearly identified.

Most sound ratings are derived from sound power levels for all eight octave bands. Sound power levels represent the total acoustical energy radiated from a source (in this case a fan). All eight octave bands allow a complete acoustical analysis of the conditioned room. Greenheck has complete sound power ratings on tubular centrifugal fans available on request.

The human ear does not respond to power levels. It is only sensitive to pressure variations. To obtain pressure levels, the fan sound power levels must be corrected for the attenuation effects of the room and distance from the fan to the listener. These attenuation and distance factors can be calculated through the use of the "ASHRAE Guide and Data" books or AMCA Publication 303. "Application of Sound Power Levels". The sound pressure level can only be determined if the acoustical qualities of the conditioned room are known.

Another method to simulate how the human ear responds to sound is the A-scale weighted sound power level. These ratings are attenuated much like the human ear to be less sensitive to lower frequencies (25-1000 HZ) and more sensitive to higher frequencies (1000-10000 HZ). A-scale weighted pressure levels can be obtained by correcting the power levels for the attenuation factors of the conditioned space.

Mechanical vibration can also be a source of noise problems. The fan should be placed where noise will not be transmitted through floors and walls. Flexible duct connections should be installed to prevent mechanical fan vibration from exciting the ductwork. Isolators should be used to dampen the vibrations that would be transmitted to floors or ceilings.

EFFECT OF AIR DENSITY

Ratings in the fan performance tables and curves of this catalog are based on standard air (clean, dry air with a density of 0.075 lbs./Ft.³ at 70°F, and a barometric pressure of 29.92 in. mercury).

A change in elevation, temperature or the type of gas handled will affect density.

With a fan at a constant speed and installed in a fixed system, a change in density will cause the fan pressure and horsepower to vary. The air volume delivered by the fan will remain constant.

The table below gives air density correction factors for calculating the effect of elevation and temperature on fan performance.

AIR DENSITY CORRECTION FACTORS

Air Temp. °F	ELEVATION (Feet Above Sea Level)										
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
0	0.87	0.90	0.94	0.97	1.01	1.05	1.08	1.13	1.17	1.22	1.26
50	0.96	1.00	1.04	1.08	1.11	1.15	1.20	1.24	1.30	1.34	1.40
70	1.00	1.04	1.08	1.12	1.16	1.22	1.25	1.30	1.35	1.40	1.45
100	1.06	1.10	1.14	1.18	1.22	1.27	1.32	1.37	1.42	1.48	1.54
150	1.15	1.19	1.24	1.30	1.33	1.38	1.44	1.49	1.55	1.61	1.67
200	1.25	1.29	1.34	1.40	1.44	1.50	1.56	1.61	1.68	1.75	1.81

The following example shows the procedure for selecting a fan at elevations and temperatures other than standard.

A TCF 27 tubular centrifugal fan is to deliver 9000 CFM of air at 2 1/2" SP, 200°F and 3000 Ft. elevation above sea level.

1. Since the air volume delivered by the fan is not affected by density, airflow remains 9000 CFM.
2. The static pressure must be corrected for non-standard conditions. At 200°F and 3000 feet elevation the air density correction factor is 1.4. Multiply the static pressure by the correction factor. (2.5" SP x 1.4 = 3.5" SP)
3. From the fan performance table a TCF 27 fan at 9000 CFM and 3.5" SP requires 1396 RPM and 8.01 BHP.
4. The 1396 RPM selected needs no correction.
5. The horsepower selected must be divided by the correction factor. BHP at 200°F = 8.01 BHP ÷ 1.40 = 5.72 BHP.

If a fan is selected to operate at high temperatures, the motor must be large enough to handle the increased BHP at any anticipated lower operating temperature where the air is more dense. Assume the air entering the TCF 27 fan at start-up is 0°F. For 0°F and 3000 feet elevation the air density correction factor is 0.97. BHP at 0°F = 8.01 BHP ÷ 0.97 = 8.26, therefore, a 10 HP motor is required.

EFFECT OF INSTALLATION ON PERFORMANCE

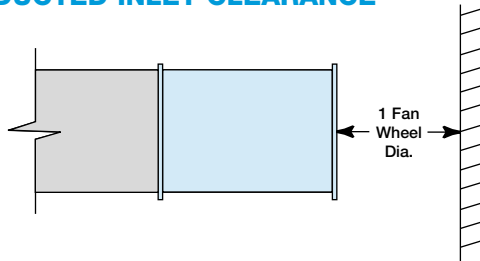
Ratings presented in the performance tables and curves of this catalog were derived from tests made in accordance with AMCA Standard 210 – “Laboratory Method of Testing Fans for Ratings”. The AMCA test procedure utilizes an open inlet and a straight outlet duct to assure maximum static regain.

Any installation with inlet or discharge configurations that deviate from this standard may result in reduced fan performance. Restricted or unstable flow at the fan inlet can cause pre-rotation of incoming air or uneven loading of the fan wheel yielding large system losses and increased sound levels. Free discharge or turbulent flow in the discharge ductwork will also result in system effect losses.

Static pressure losses due to inlet and discharge conditions can be expressed in terms of system effect factors. The static pressure for selection of the fans equals the system static pressure plus the system effect factor.

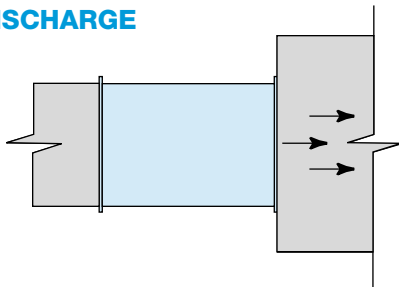
The most common inlet and discharge conditions which affect fan performance are:

NON-DUCTED INLET CLEARANCE



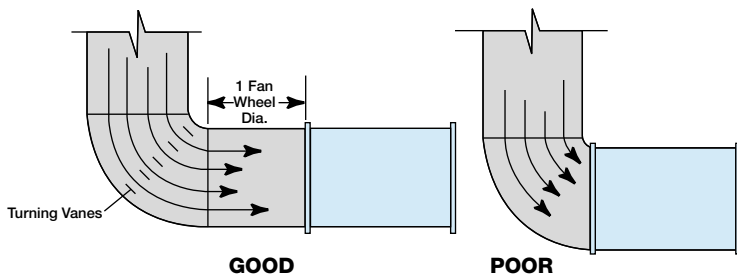
Installation of a fan with an open inlet too close to a wall or bulkhead will cause reduced fan performance. It is desirable to have one fan wheel diameter if possible and a minimum of three fourths of a wheel diameter between the fan inlet and the wall. System effect curve #2 depicts the pressure loss for one-half wheel diameter clearance.

FREE DISCHARGE



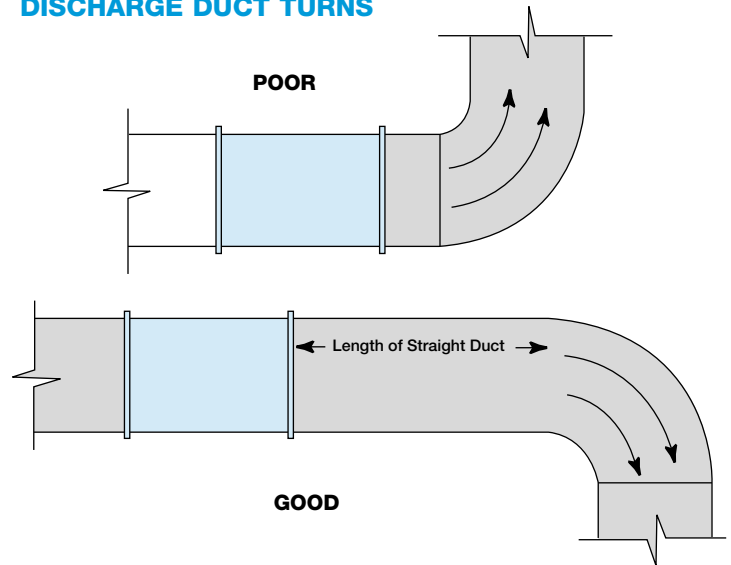
Free or abrupt discharge into a plenum results in a reduction in fan performance. The effect of static regain in discharge is not realized. System effect curve #3 depicts the pressure loss for free or abrupt discharge.

INLET DUCT TURNS



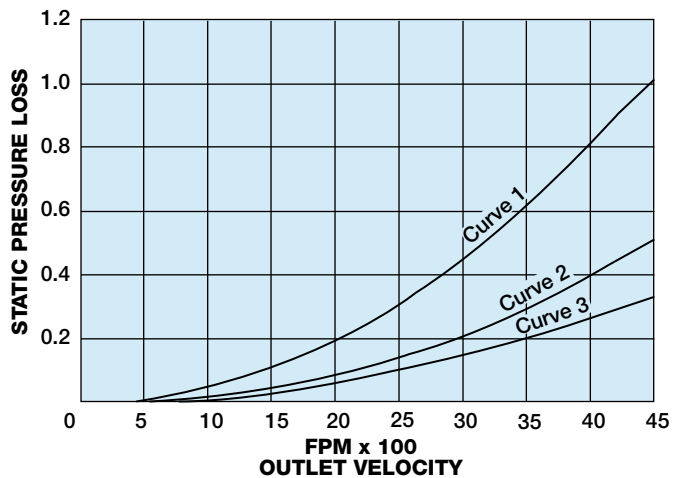
Installation of a duct turn or elbow too close to the fan inlet reduces fan performance because air is loaded unevenly into the fan wheel. To achieve full fan performance there should be at least one fan wheel diameter between the turn or elbow and the fan inlet. Curve #1 shows the system effect factor when less than one diameter is provided.

DISCHARGE DUCT TURNS



Fan performance is reduced when duct turns are made immediately off the fan discharge. To achieve cataloged fan performance there should be at least one equivalent duct diameter of straight ductwork between the fan discharge and any duct turns. Curve #3 shows the system effect factor for no discharge ductwork.

SYSTEM EFFECT FACTOR CURVES



Additional information on system effect factors can be found in AMCA publication 201— “Fans and Systems” and ASHRAE Guide and Data Books.

VOLUME CONTROL

Variable air volume systems require efficient, stable operation over the entire CFM modulation range.

Greenheck offers inlet vanes for use in variable volume systems. Inlet vanes provide better part load brake horsepower reduction, a wider CFM modulation range and more positive control than other types of volume control dampers.

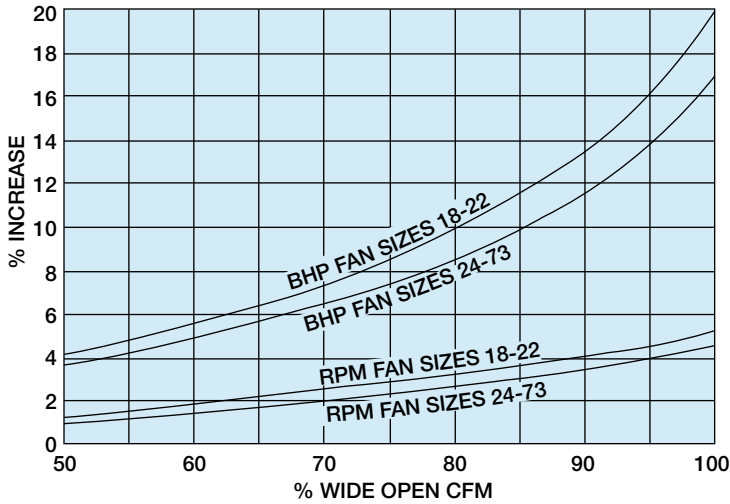
As inlet vanes close they impart a spin on the incoming air in the direction of wheel rotation. This reduces airflow, static pressure and brake horsepower as shown below in Fig. 2. The curves between points 1-4 show the effect on CFM, SP and BHP as inlet vanes are modulated from 100% open to 25% open in a typical variable air volume system.

Reductions to 30% of full load airflow are possible with inlet vanes.

Correction factors must be applied to the RPM and BHP at full load design conditions to overcome the pressure drop through the inlet vanes. These correction factors are shown on page 8.

FIG. 1

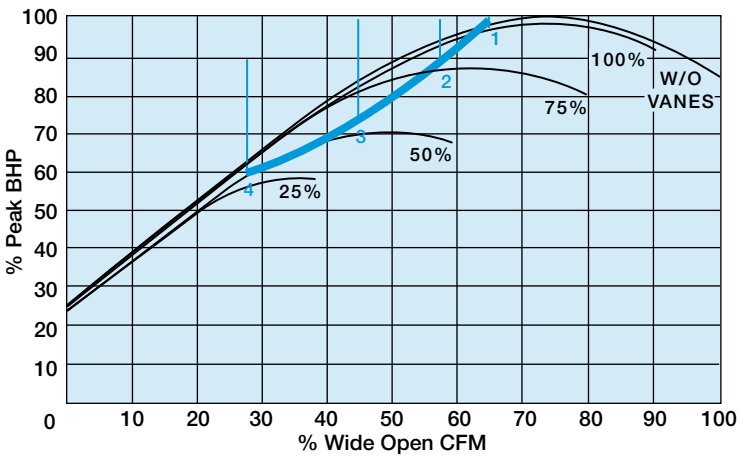
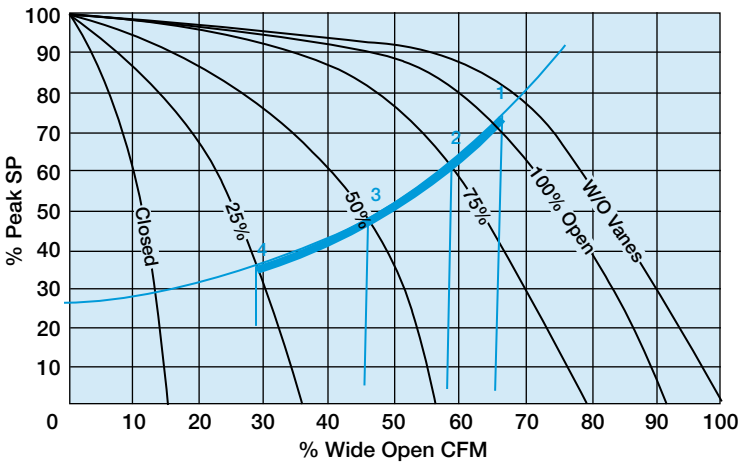
RPM AND BHP CORRECTION FACTORS FOR FANS WITH INLET VANES



Inlet vanes can be manually operated or combined with a static pressure sensor in the ductwork and a damper operator for automatic operation.

FIG. 2

INLET VANE PERFORMANCE



HIGH TEMPERATURE OPERATING LIMITS

The high temperature operating limit for tubular centrifugal fans of standard construction is 200°F.

For applications over 200°F consult the factory.

MOTOR STARTING TORQUE

When selecting a motor for a tubular centrifugal fan, the motor must be capable not only of driving the fan at operating speed, but also must be capable of accelerating the fan wheel, shaft and drive to the operating speed.

The fan performance tables and curves in this catalog show the brake horsepower required to operate the fan once it is brought to speed. For applications requiring a large air volume at a low static pressure the BHP required at the fan's operating RPM may not be sufficient to initially start the fan. If the time required to bring the fan to speed is excessive, the motor winding insulation can be damaged due to excessive temperature rise and the life of the motor seriously affected.

For a belt drive tubular centrifugal fan the required motor starting torque capability can be expressed by the following formula:

$$WR_M^2 = WR_F^2 \left(\frac{FRPM}{MRPM} \right)^2 \quad (1.1)$$

Where:

- WR_M^2 — The moment of inertia that the motor must be capable of turning at the motor shaft, LB-Ft.².
- WR_F^2 — The moment of inertia of the fan wheel and shaft, LB-Ft.².
- FRPM — Fan RPM
- MRPM — Motor RPM

Minimum motor sizes are critical for tubular centrifugal fans, size 36 and larger, operating at low static pressures. Motor starting torque can vary greatly among motor manufacturers. When motors other than those supplied by Greenheck are used, the available WR_M^2 at the motor should be obtained from the motor manufacturer.

The table below shows the wheel and shaft moments of inertia for tubular centrifugal fans.

MOMENTS OF INERTIA (LB-Ft²) TUBULAR CENTRIFUGAL FANS

FAN SIZE	CLASS I	CLASS II
18	11	11
20	16	16
22	29	30
24	40	40
27	62	63
30	95	96
33	146	147
36	209	210
40	409	411
44	580	600
49	810	860
54	1440	1520
60	2010	2140
66	2790	2980
73	4260	4280

