Hartzell
AIR MOVEMENT

Fan Engineering Data

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The Hartzell History

The history of Hartzell Air Movement actually dates back to 1875 when John T. Hartzell began manufacturing farm wagons in Western Ohio. The development and growth of the company from that point on is intriguing, but the details are too lengthy to include here in total.

But some 30 years later, John Hartzell's grandson, Robert, joined the company after studying engineering at the University of Cincinnati. He was interested in aviation and often talked with Orville and Wilbur Wright and Glen Curtis when they came to Piqua to pick out straight-grained walnut lumber to make their propellers. He saw the possibilities in manufacturing propellers and hired a young engineer, Fred Charavay, to design a line of airfoil blades, which they would hand-draw from a laminated block of Hartzell walnut.

From that point, and for the next 70 years, Hartzell Propeller, Inc. would be an industry leader in the design and manufacture of aircraft propellers.

Hartzell Air Movement grew from the roots of the aircraft division as Chief Engineer Charavay placed an aircraft propeller in an industrial ventilation application in the early 1920's. The design was refined and Hartzell engineered the first propeller type fan.

Prior to 1920, most industrial fans were centrifugal designs, generally large in size with radial blades. The idea of moving air at pressure in an industrial application with an airfoil propeller encountered substantial opposition from skeptical aerodynamic "experts" at the time. Robert Hartzell instructed his engineers to set up a laboratory complete with a small wind tunnel that was similar to the present-day AMCA/ASHRAE test configurations and which, in time, would become AMCA approved. The test results were excellent and substantiated the merits of the Hartzell design. As you can read on the following page, the same commitment to design engineering and manufacturing excellence to provide a quality, reliable industrial air-moving device continues to be the first order of business with Hartzell.

Since the first Hartzell fan was put into use, the Hartzell name has been synonymous with quality air-moving equipment. Hartzell is well known throughout the industry for its design innovations and marketing procedures to meet the changing demands of the industrial consumer. Hartzell was the:

- first to develop a solid fiberglass, single piece, die formed, highly efficient,
  non-overloading, airfoil design centrifugal wheel.
- first to manufacture industrial fans using an airfoil propeller-type blade.
- first to use the air seal venturi orifice fan ring in a propeller fan application.
- first to develop all fiberglass industrial fans.
- first to establish a stocking program with three-day shipment of over 150 types of fans and blowers.
- first to offer a fiberglass center-pivoted motor operated shutter.
- first to publish engineering literature for the proper application of industrial fans and AC frequency controllers.

For more than 90 years, innovative design concepts, engineering expertise, and production capabilities have made Hartzell an industry leader. Its manufacturing facilities produce air-moving equipment designed and built with traditional Hartzell quality.

This flexibility enables Hartzell to customize equipment and solve a wide range of air moving problems.

VISIT OUR WEBSITE www.hartzellairmovement.com OR CALL TOLL-FREE 1-800-336-3267 FOR THE NAME OF YOUR LOCAL HARTZELL REPRESENTATIVE WHO CAN PROVIDE FAN ENGINEERING, APPLICATION, OR SELECTION ASSISTANCE.

Flow is a complete online fan selection tool with -2D drawings, 3D models, and Fan Curves. Flow is a web based program that does not require any apps to download. Works on PC or MAC, desktop, laptop, smartphone, and tablets.

Quality • Value • Commitment

PRODUCT CONCEPT

Reliable, efficient performance is the underlying principle of the product concept of every Hartzell fan that is built. Its principle is adhered to in the early design and development stages of the prototype and is demonstrated by the special care given to the development of propeller and wheel patterns in the pattern shop.

PROTOTYPE DEVELOPMENT

- After completion of the fan pattern, it is taken to the Research & Development Lab for testing and further refinement.
- Hartzell laboratory is AMCA* accredited to test for air and sound performance and is located on the grounds of the main Hartzell plant in Piqua, Ohio.
- In addition to the 12 ft. test chambers capable of 50,000 CFM at up to 24" W.G. pressures, Hartzell Air Movement added a small test chamber capable of 11,000 CFM at up to 80" W.G. pressures. The lab is also equipped with precision instruments for sound and vibration testing.
- Hartzell has an overspeed cell for fans up to 200 HP.
- Additional equipment allows for Hartzell to conduct overspeed tests, check blade movement while fan is rotating, check noise levels, frequencies and vibration stresses.

CERTIFIED FAN RATINGS

- Hartzell Air Movement is a charter member of the Air Movement and Control Association International, Inc. (AMCA) which has adopted AMCA Standard 210 “Laboratory Methods of Testing Fans for Rating” and AMCA Standard 300 “Reverberant Room Method for Sound Testing of Fans".
- Hartzell pioneered the testing of its products in accordance with the AMCA Standard test codes.

MANUFACTURING

- Hartzell has over 100,000 square feet of manufacturing space in its Piqua plant location.
- Facilities and capabilities include full metal forming fabrication and welding, a modern foundry and machine shop, and fiberglass molding equipment.
- Recent equipment upgrades include an Amada laser cutting system and a horizontal computer balancing system.
- Our 3D modeling system provides maximum accuracy for manufacturing.

QUALITY

The quality of Hartzell’s air moving products is ensured by a Quality Assurance Program that is certified to ISO 9001:2015. Hartzell Air Movement has made this investment in modern, sophisticated engineering methods in order to provide the best possible quality products for your use.

***Product laboratory data based on tests in an AMCA Accredited Laboratory are not to be construed as being licensed to bear the AMCA Seal.**

Large Test Chamber

Wind tunnel and calibration equipment

Patern Shop

Foundry Patterns

Fiberglass

Fabrication

Balance

Inspection

General Ventilation Equipment

General ventilation applications typically involve the movement of uncontained air. These applications include dilution ventilation (intake, exhaust, recirculation), make-up air, personnel cooling and spot machine or equipment cooling. Hartzell Air Movement offers a wide selection of quality, efficient industrial fans for these types of applications.

PROPELLER FANS

Propeller fans are designed for general ventilation, fume removal, cooling, air supply or exhaust in direct drive and belt drive arrangements. Standard motors are totally enclosed fan cooled.

Ring Fans – Series 01

Belt drive units available. 2, 3, 4, 6 and 8-bladed high efficiency ring fans for general exhaust ventilation. Sizes 12" to 72". CFM from 1475 to 108,156 at free air. Also available as low-speed, high-volume fan in sizes 72" to 120" with CFM from 63,000 to 229,000 at free air. Reversible double-ring construction available in sizes 18" to 60".

Panel Fan – Series 02

Belt drive units available. Any single propeller (2-blade), 3 or 4-blade or multiblade fan in sizes ranging from 12" to 60" may be ordered panel mounted. Fast, easy, economical to install. CFM from 1475 to 66,850 at free air.

ROOF VENTILATORS

All Hartzell ventilators are designed as packaged units, ready for installation. Models available are either direct drive, belted or belt driven, in hot rolled steel, galvanized steel or aluminum.

Upblast Roof Ventilator Direct Drive – Series 61

Butterfly dampers in windband open when fan starts, close weathertight when fan stops. Direct drive sizes 12" to 72". Available in painted steel or aluminum to 60". 66" and larger available in hot rolled steel or aluminum. 1390 CFM to 124,500 CFM at free air. Standard motors are totally enclosed fan cooled. See Bulletin A-157 for details.

Optional Filtered Hooded Ventilator Direct Drive – Series 15 F | Belted – Series 16 F

The Hartzell Series 15 (direct drive) and 16 (belted) hooded roof ventilators are available with an optional filter rack, designed to accept standard sized filters. Permanent, washable filters and disposable filters are both available. This optional filter rack must be installed at the factory. The ventilator hood on sizes 18" through 36" is one piece. On size 42" through 84", the ventilator hood is in two pieces. Filters are accessible by removing retainer clips in the filter rack, for ease of filter installation and maintenance. See Bulletin A-157 for details..

Hooded Ventilator – Series 15, 16, and 17

Direct drive, belted and reversible low noise, low speed ventilator for intake or exhaust. Reversible unit offers air delivery in both directions, exhaust and intake. Direct drive sizes 18" to 72". Belted sizes 24" to 84". Reversible sizes 18" to 72". CFM from 2350 to 131,000 at free air. Standard motors are totally enclosed fan cooledr. See Bulletin A-157 for details.

Upblash Roof Ventilator – Series 69

Belt drive units meet the need for a simple, efficient weatherproof closure for vertical air discharge. Butterfly dampers in stack cap open when unit is on, close weathertight when unit is off. Sizes 12" to 84". CFM from 1455 to 126,500 at free air. Standard motors are totally enclosed fan cooled. See Bulletin A-157 for details.

Recirculating Roof Ventilator – Series 26
Recirculating Hooded Roof Ventilator – Series 27

Recirculating units were designed to solve summer ventilator and winter heat recovery problems economically. Sizes 24" to 60". CFM from 7530 to 54,761 at free air. Standard motors are totally enclosed fan cooled. See Bulletin A-157.

Process Ventilation Equipment

Process ventilation applications typically involve the controlled or contained movement of air from one point to another. The air must be contained because it is contaminated in some way, i.e. (fumes, dust, material, temperature, etc.). Hartzell Air Movement offers a complete selection of process ventilation fans and blowers. These include axial fans from low pressure duct fans to high pressure vaneaxial blowers, as well as centrifugal blowers for both air and material handling applications.

DUCT AND DUCT AXIAL® FANS

Duct fans are best suited for applications with low pressure characteristics from free air to 1 1/4" static pressure. These fans can be used to remove fumes, foul air, steam, hot air and smoke; or to supply air for cooling, drying and general ventilation; or in air makeup applications.

Duct Axial fans are ideal for applications where requirements dictate pressure characteristics between those of a duct fan and a vaneaxial blower. Maximum efficiency occurs in the static pressure range from 1" to 4" at low speeds with low noise characteristics.

Corrosive resistant fans are constructed of stainless steel as standard. Belt drive high temperature duct axial fans constructed of hot rolled steel are available for temperatures to 500° F maximum.

Belt Drive Duct Fan – Series 31 (shown) Steel and Aluminun Models Available

For applications requiring motor out of airstream. Motor cover for Series 31 is optional. Sizes 12" to 96". CFM 1,680 to 156,800 at free. See Bulletin A-130 for details.

Direct Drive Duct Fan – Series 38 Steel and Aluminum Models Available

Multiblade styles assembled in an easy-toinstall duct section. Lo-noise blades available in sizes 18" to 44". Designed for minimum resistance to airflow. Sizes 12" to 48". CFM from 1345 to 45,500. Standard motors are totally enclosed fan cool. See Bulletin A-130 for details.

Belt Drive Duct Axial Fan – Series 46
Direct Drive Duct Axial Fan – Series 48 (shown) Steel and Aluminum Models Available

Fan combines the best features of the vaneaxial blower and the duct fan in both direct and belt drive units. Sizes 12" to 60". Direct drive units have totally enclosed fan cooled motors as standard with CFM from 470 to 56,700 at 2" S.P. Belt drive units have open end motors as standard with CFM from 1204 to 45,100 at 3" S.P. See Bulletin A-118 for details.

High Temperature Fan – Series 46 (HS Prop) (Shown)
Corrosive Resistant Duct Fan – Series 46 (CS Prop)

Belt drive duct fans with totally enclosed fan cooled motor out of air stream in sizes 12" to 54". By the addition of various components, the high temperature fan is ideal for converting into an energy efficient smoke ventilator. CFM from 1942 to 35,000 at 2" S.P. See Bulletin A-118 for details.

VANEAXIAL BLOWERS

Vaneaxial blowers are designed for handling relatively clean and corrosivefree air at static pressures up to 10". These units can also move large volumes of air at low pressure, with low speed characteristics.

Adjustable pitch vaneaxial fans feature high total efficiency providing a space and energy saving unit that offers a wide range of performance and quiet operation. The adjustable pitch vaneaxial blades can be quickly adjusted without removing the wheel from the motor shaft.

Direct Drive Vaneaxial Blower – Series 53

Guide vanes insure maximum efficiency in converting velocity pressure to static pressure with minimal turbulence. Suitable where conditions are not detrimental to operation of totally enclosed fan cooled motor in the air stream. Cast aluminum impellers. Sizes 18" to 42". CFM from 4350 to 36,250 at free air. See Bulletin A-110 for details.

Belt Drive Vaneaxial Blower – VA and VB – Series 54

Both VA and VB type impellers are a one-piece cast aluminum airfoil design. Both are designed to work efficiently at high static pressures. VA units in sizes 12" to 60" with CFM from 1545 to 104,400 at free air. VB units in sizes 18" to 48" with CFM from 2340 to 46,697 at free air. Both models have totally enclosed fan cooled motors as standard. See Bulletin A-110 for details.

Adjustable Pitch Vaneaxial Blower Direct Drive – Series 65 Belt Drive | Series 66

Adjustable pitch vaneaxial fans feature adjustable pitch blades in both direct drive and belt driven units. Sizes 35" to 79". CFM from 5900 to 232,500 at free air. Standard motors on belt driven units are open end drip proof out of air stream. See Bulletin A-142 for details.

CENTRIFUGAL BLOWERS

Backward curved centrifugal blowers in either direct drive or belt drive are best suited for clean air applications.

Belt drive radial blowers are ideal for material conveying, dust and fume removal and handling of hot air and industrial gases. With some modifications, these units can operate in 800° F temperature. Direct drive pressure blowers were designed for use in air laden with dust and dirt in temperatures to 200° F.

The steel in-line centrifugal fan was designed for clean air applications providing medium to high static pressures. The in-line centrifugal fan is a highly efficient unit with low noise characteristics. Standard motors on steel centrifugal blowers are totally enclosed fan cooled.

Backward Curved – Belt or Direct Driven – Series 03

Backward curved non-overloading wheel is high performance in efficiency. Single thickness or hollow airfoil blades are available and permit use in rugged clean air industrial applications. Sizes 12" to 66" wheel diameters. Performance from 700 to 99,960 CFM, up to 14" W.G. static pressure. Request Bulletin A-147.

Utility Blower – Belt Drive – Series 03U

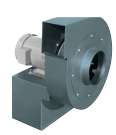
Packaged unit. SWSI. For industrial clean air applications. Furnished with weather and drive cover. Top horizontal discharge; rotatable in the field. Available with backward curved single thickness. Sizes 10" to 30" wheel diameters. Performance from 515 to 15,655 CFM. Static Pressure to 5" W. G. Request Bulletin A-147.

Extractor industrial – Serie 05

Diseñado para cumplir con las necesidades industriales de movimiento de aire y transporte neumático. Adecuado para la eliminación de polvo y gases, y para el control del aire caliente y los gases industriales. Modelos de cuatro palas disponibles. Diámetro de la rueda de 305 a 1448 mm. Rendimiento de 339 a 77,517 cmh. Intervalo de presión estática hasta 1168 mmH20 para todas las ruedas. Solicite el Catálogo A-155.

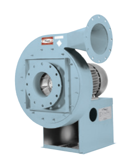
In-Line Centrifugal Belt Drive – Series 04

The in-line centrifugal fan offers straight airflow for duct installation. Identical inlet and discharge dimensions. Curved single thickness or hollow airfoil blades. Blower sizes available 12" to 49" wheel diameters. Performance from 600 to 70,000 CFM. Static pressures to 13" W.G. Request Bulletin A-154.



Presssure Blower – Direct Drive – Series 07

Best suited for air laden with dust and grit. Works economically up to static pressures of 11" W.G. Sizes 11", 12" and 14". Performance from 490 to 1660 CFM at 5" S.P. Request Bulletin A-134.



Turbo Pressure Blower – Series 07T

Ideal for applications with a high static pressure and low flow requirement. Compact design, easy installation, and low maintenance. Sizes 14" to 26" wheel diameters, SWSI construction only. CFM from 100 to 5250. Request Bulletin A-135.

Fiberglass Equipment

Hartzell Air Movement pioneered the development of fiberglass reinforced plastic fans and blowers and manufactures the most complete line available to industry. Fiberglass construction is recommended where corrosive elements exist in fume and vapor form. See the Corrosion Resistance Guide on pages 22 and 23 for information on specific chemicals and temperature limitations.

GENERAL VENTILATION

Fiberglass Wall Ventilator – Series 59

Direct drive wall ventilator designed for general ventilation where corrosive elements exist in fume or vapor form. Temperatures to 180° with specially insulated motors. Unit constructed of solid fiberglass. Sizes 12" to 60". Performance from 1,315 to 55,500 CFM at free air. Request Water and Wastewater Bulletin for details.

Fiberglass Upblast Roof Ventilator – Direct Drive – Series 57

Provides an efficient, yet economical choice for general ventilation of mild corrosive atmospheres. Suitable for temperatures up to 180° with specially insulated motors. Sizes 28" to 60". CFM from 7330 to 50,400 at free air. See Water and Wastewater Bulletin for details.

Fiberglass Upblast Roof Ventilator – Belt Drive – Series 37

Meets the need for a heavy duty, belt drive, upblast ventilator with motor out of the airstream. Ideal for applications where severe corrosive elements are present. Available in sizes 12" to 60". Performance ranging from 1260 CFM to 61,765 CFM at free air. See Water and Wastewater Bulletin for details.

Fiberglass Hooded Roof Ventilator – Belt Drive – Series 58E

Hooded ventilator's design provides complete protection from the elements for exhaust operation. Unit's belt drive configuration and exterior motor mounting makes this the logical choice where corrosive elements exist and protection from the weather is essential. Sizes 12" to 60" with CFM from 1280 to 63,470 at free air. See Water and Wastewater Bulletin for details.

Fiberglass Centrifugal Exhausters – Series 82 Direct Drive Downblast (shown) | Series 83 Belt Drive Downblast | Series 87 Direct Drive Upblast | Series 88 Belt Drive Upblast

The fiberglass exhausters provide a low profile roof or wall exhaust solution in a corrosive environment. Sizes 12" to 40" with CFM from 500 to 22,000. See Water and Wastewater Bulletin for details.

PROCESS VENTILATION

Fiberglass Duct Fans, Belt Drive – Series 34 | Direct Drive – Series 28

Best suited for applications with low static pressure characteristics where some corrosive elements exist. Sizes 12" to 60". Belt drive units have totally enclosed fan cooled motors as standard with CFM from 1370 to 62,200 at free air. Direct drive units have totally enclosed air over XT motors as standard with CFM from 1325 to 66,700 at free air. See Water and Wastewater Bulletin for details.

Fiberglass Duct Axial Fans, Belt Drive – Series 35 | Direct Drive – Series 29

Designed for maximum efficiency in the static pressure range of 1" to 3" at low speeds and low noise. Internal hardware of stainless steel. Sizes 12" to 60". Belt drive units have totally enclosed fan cooled motors as standard. CFM from 470 to 70,000 at 1" S.P. Direct drive units have totally enclosed chemical plant motors as standard. CFM from 1204 to 68,950 at free air. See Water and Wastewater Bulletin for details.

Fiberglass By-Pass Fan – Direct Drive – Series 28B and 29B

Engineered and built to be used in a variety of corrosive applications. Direct drive motor out of the airstream. Suitable for temperatures to 200°F with specially insulated motors. 28B has Type FW low pressure propeller; 29B has Type E, medium pressure propeller. Sizes 24" to 48", with performance ranging from 6012 CFM to 46,145 CFM at free air. See Water and Wastewater Bulletin for details.

Fiberglass Inline Centrifugal Blowers, Belt Drive – Series 40

The inline blower offers straight airflow for duct installations with the highly efficient, backward curved airfoil-bladed wheel in a vane equipped tube. Identical inlet and discharge dimensions. Compact, efficient low noise units. Sizes 12" to 60" wheel diameters. Performance from 800 to 85,000 CFM. Static pressures to 12". See Water and Wastewater Bulletin for details

Fiberglass Radial Blowers – Belt Drive – SWSI – Series 43

Versatile corrosive resistant air-moving blower is designed for installations where air flows at static pressures up to 16" W.G. Clockwise rotation. Rotatable in field. Internal hardware of stainless steel. Available in Arr. #1, #9 or #10. Sizes 16" to 33" wheel diameters. Performance 977 to 14,659 CFM at 8" S.P. See Water and Wastewater Bulletin for details.

Fiberglass Backward Curved Centrifugal Blowers, Belt Drive – SWSI – Series 41 (shown) | Fiberglass Backward Curved Centrifugal, Packaged – Series 41P

Airfoil, one-piece solid fiberglass wheel has non-overloading horsepower characteristics. The wheel and housing constructed with special corrosive-resistant polyester resin plus flame retardant additives. Internal hardware is stainless steel. No metal parts are exposed in the airstream. Sizes 12" to 60" wheel diameters. Static pressures up to 20" W. G. Performance from 700 to 84,000 CFM at 5" S.P. See Water and Wastewater Bulletin for details.

Fiberglass Radial Blowers Direct or Belt Drive – SWSI – Series 42

Suited for lab hood installation at static pressures from 0" to 8". Clockwise rotation. Rotatable in field. Packaged unit completely assembled. Internal hardware is of stainless steel encapsulated with fiberglass. Sizes 10", 12" and 14" wheel diameters. Performance from 100 to 2000 CFM at 2" S.P. See Water and Wastewater Bulletin for details.

FIBERGLASS AIR CONTROL PRODUCTS

Fiberglass Fixed Blase Louver – FFL

For air intake or relief applications.

Fiberglass End-Pivoted Shutter – FEP (shown)

Recommended for gravity back-draft prevention applications.

Fiberglass Center-Pivoted Low Velocity Damper – FLC

Recommended for back-draft prevention applications. Manually or motor operated.

Fiberglass Center-Pivoted High Velocity Damper – FCO/FCP

For volume control and back flow prevention in medium to high pressure applications. Parallel or opposed blade.

See Water and Wastewater Bulletin for details.

Heating Equipment

Hartzell's heating equipment is designed as a single package assembly with controls mounted and wired at the factory. Engineered to eliminate negative pressure problems in a plant. Gas air intake units can be used for total fresh air heating systems as well as tempered makeup air. Steam air intake units have a standard control package to provide for constant discharge air temperature and low temperature shutdown to protect against coil freeze-up.

GAS FIRED AIR INTAKE UNITS

Gas Fired Door Heater – Series 79

Unit works whenever door is raised far enough to trip the switch. Comes equipped with all standard controls and safety features. Capacities from 700,000 to 990,000 input BTU. Standard motors are totally enclosed fan cooled. See Bulletin A-125 for details.

Econo Units – Series 78H/78V

For supplying tempered make-up air or for total fresh air heating systems. Three sizes, 7100 to 23,580 CFM at 1/4" est. static pressure. IRI and FM control packages available. Standard motor is totally enclosed. See Bulletin A-125 for details.

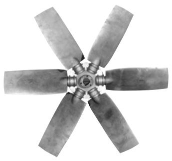
Other

ADJUSTABLE PITCH FAN ASSEMBLIES

All Aluminum – Series 90

Blades and hubs of sturdy corrosive resistant aluminum alloy castings. Four- and six-blade assemblies in 4' to 12' sizes. Drop in blade retention, manually adjustable. Right- or lefthand rotation.

Also available in threaded blade retention, Series 89, right- or left-hand rotation. Request Technical Data Sheet A-111-90.



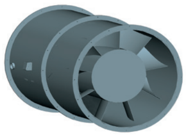
Adjustable Pitch Reversable – Series 90R

Aluminum alloy blades are designed so the leading edges and trailing edges of the blades are identical in either direction of rotation. Blades fit into recessed hub, retained by two S.A.E. Grade 5 "U" bolts per blade. Can be manually adjusted to meet changes in air delivery. Sizes 48" to 84" diameter. Four- and Six-blade design. Request Technical Data Sheet A-111-90R.

MARINE AND MINE DUTY BLOWERS

Series 44 or 44M – Duct Axial® Fans

Heavy-duty direct drive Duct Axial® fans Wheel is one piece, airfoil type with six blades, made of aluminum. Sizes 12" through 60". Performance from 300 to 91,920 CFM at free air. Static pressures to 3". Guide vanes can be added for increased performance at 1" to 4" static pressure with the same or less power. Request Bulletin A-143.



Series 50 or 50M – Vaneaxial Blowers

Direct drive fans in rugged two-piece design. Housings are heavy gauge welded steel. Wheel is one piece, airfoil type with seven blades made of cast aluminum. Sizes 12" through 60". Performance from 1,930 to 123,000 CFM at free air. Units are designed for use in 2" to 5" static pressure. Request Bulletin A-143.

Performance Envelopes

HARTZELL AXIAL FLOW FANS

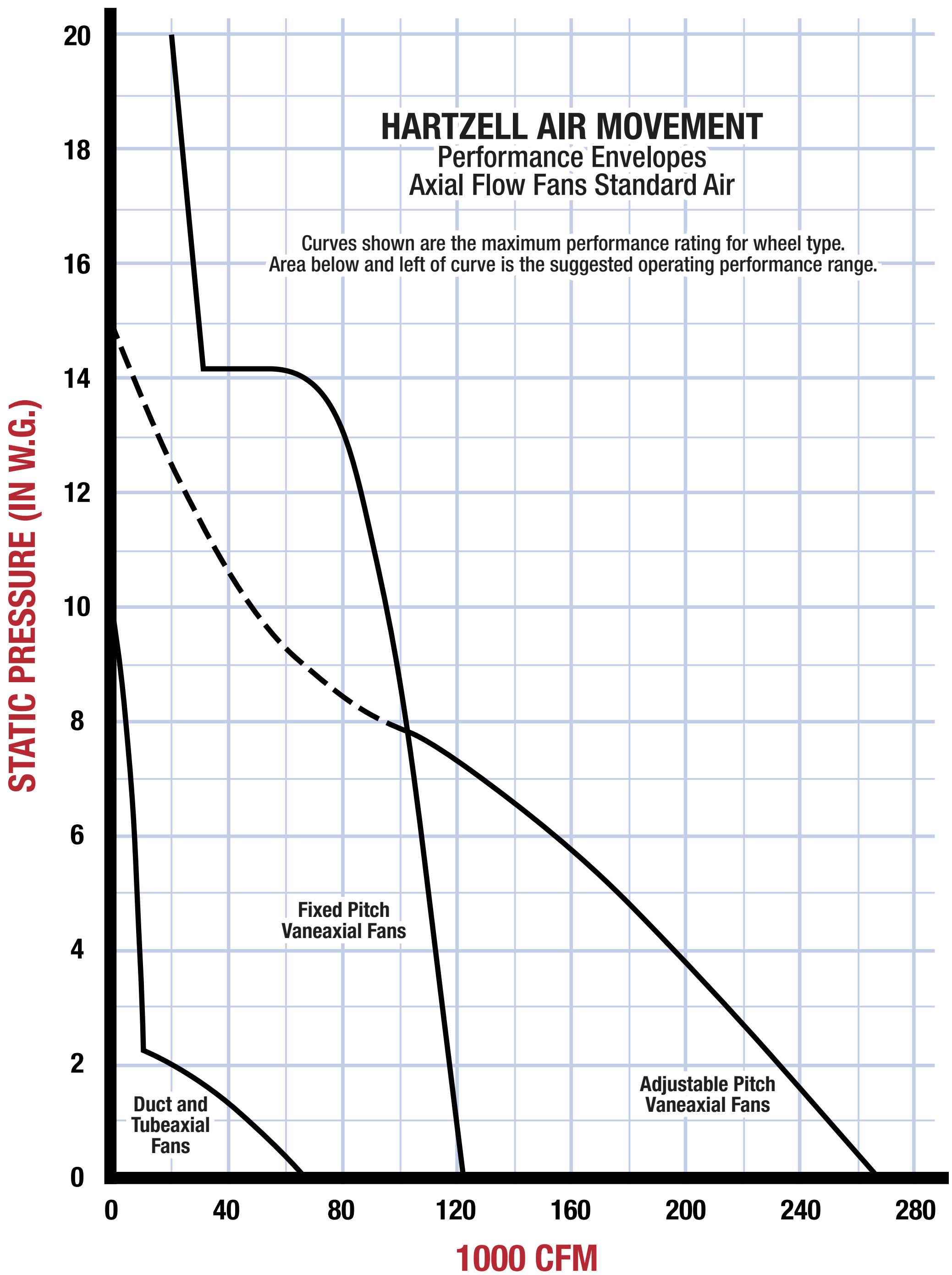
At a glance, you can look at the typical maximum performance curve envelopes on this page to determine what type of fan can satisfy your application. The curves on this page represent axial flow selections and are based on maximum fan size, operating speed, flow and pressure.

Propeller fans are available from 12 inch to 14-foot fan diameters, operating typically at static pressures that do not exceed 2". These fans are typically used for general ventilation applications and applications involving heat transfer. The operating envelopes for these fans are so long and narrow that they are not shown on this curve.

Hartzell tube and duct fans are shown on this curve up to a maximum diameter of 60" with fixed pitch props. However, these fans are available on a custom basis with adjustable pitch props tto 144". For applications in this range, please contact your Hartzell representative.

Tube and duct type fans are primarily used in general ventilation applications for supply and exhaust air at low pressures. These applications would most typically involve power roof ventilators or make-up air units. These fans are also utilized for process ventilation applications at all pressure ranges.

Hartzell vaneaxial fans are illustrated on this page with a maximum fixed pitch prop of 60", and a maximum adjustable prop of 79". These fans are used for both general and process ventilation applications as described above, and are typically capable of operating at lower specific fan speed, enabling them to operate at higher static pressures more efficiently.

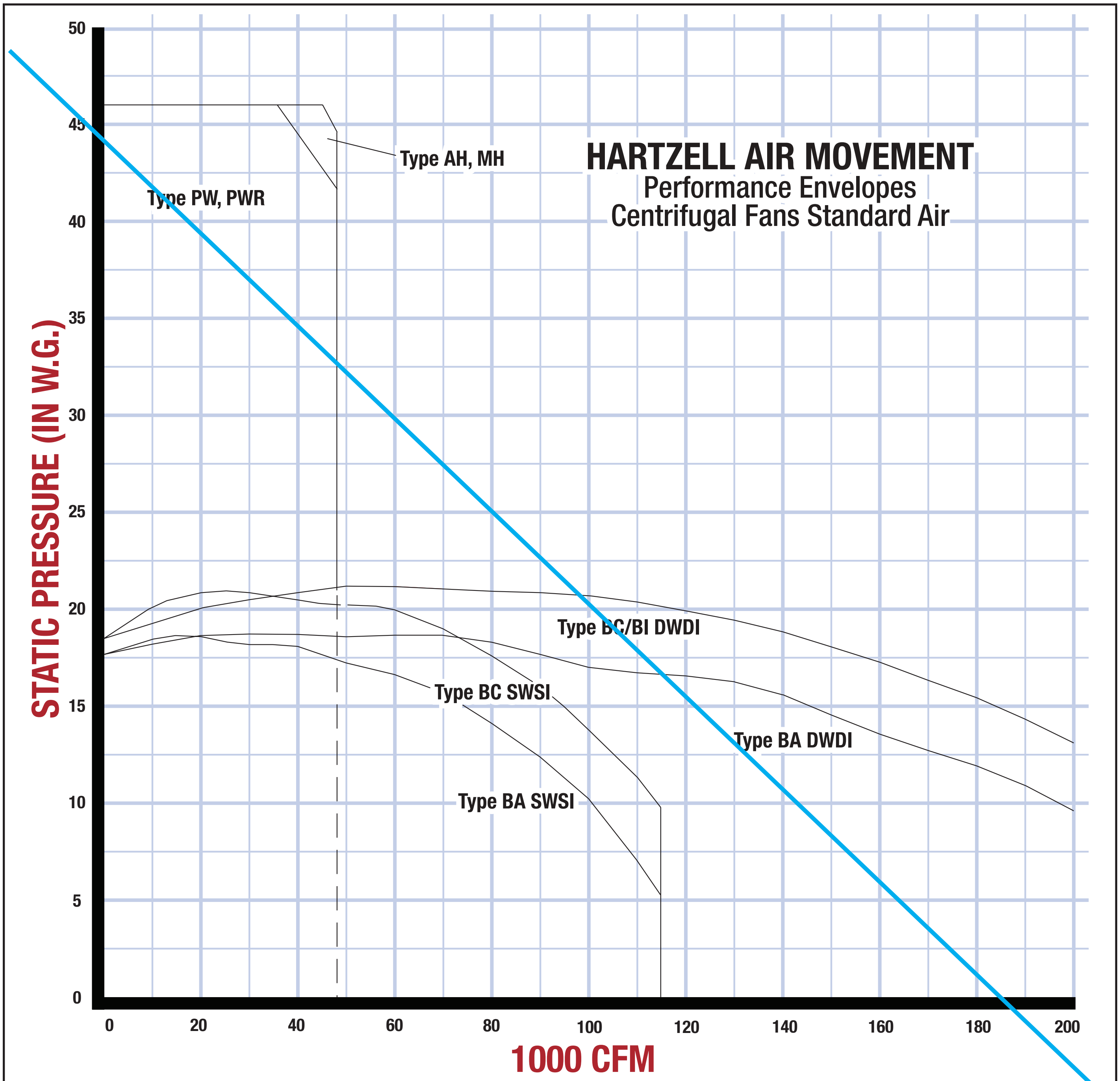


Performance Envelopes (cont.)

HARTZELL CENTRIFUGAL FANS

Centrifugal fans are typically used in process ventilation type applications. The performance envelopes on this page represent maximum flows and pressures at maximum fan size and speed. The radial bladed fans, wheel type PW, MH and AH, are capable of handling material from heavy concentrates to granular dust.

The backward curved fans, both single thickness and hollow airfoil, are designed to efficiently move clean air at moderate pressures. Maximum wheel size for the radial bladed fans is 57"; maximum wheel size for the backward curved fans is 60".



Curves shown are the maximum performance rating for wheel type.
Area below and left of curve is the suggested operating performance range.

Aplication Data

GENERAL VENTILATION FANS

- **Inlet Conditions –** The fan inlet should be free from obstructions to airflow, at least three to six fan diameters from the fan inlet under ideal conditions.
- **Discharge Conditions –** The fan discharge should be free from obstructions, depending on the application. For example, automatic shutters should be located no closer than eight inches from the propeller. Guards can be located fairly close to the propeller (refer to OSHA requirements). However, relative position of accessories to the discharge of a fan can affect fan performance and static pressure losses.
- **Structural Interference –** Structural support members should in no case be located closer than 1/2 fan diameter to the inlet of the discharge of the fan. Members should be configured so as not to interfere with air to the inlet or to the discharge of the fan. Structures should be configured so as not to induce self excited vibrations
- **Ambient Conditions –** Fans should be installed in locations within the physical limitations of the material of construction, motors, and drive assemblies. Fans installed in corrosive, erosive, or volatile environments should be constructed in a suitable fashion. Fans should be located so that condensation in a wet system will not run or drip through the rotating blades.
- **Air Velocities –** Discharge velocities should be adequately designed to create the appropriate turbulence (see spread and throw calculations). Discharge velocities for upblast roof ventilators should be established so as to prevent entry of rainfall and open backdraft dampers. However, limits of construction for accessory items, such as dampers, guards, etc. Inlet velocities should be selected so as to properly exhaust and ventilate the area without entraining undesirable items such as rain or loose items into the fan assembly.
- **Secure Mounting –** Fans should be rigidly attached to a proper building structure (portable fans should be mounted on a stable surface, clear on high traffic areas). Vibration elimination devices may be mounted as required. Precautions should be taken to properly restrain ventilator housings and accessories for high wind load conditions. Prefabricated mounting structures should be secured properly to structural members and designed to accommodate minimum windload conditions as specified.
- **Spread and Throw Calculations – See page 12.**
- **PROPERLY GUARD ALL FANS AND DRIVES.**

MAINTENANCE AND LUBRICATION

All ball and roller bearings used in the construction of Hartzell fans are greased at the factory. This should be sufficient for 1000 running hours. A good non-corrosive grease only, with a lithium base, should be used. Do not over grease ball bearings and do not use a high-pressure gun. Too much grease will cause heating and sometimes leakage and may lead to failure. Consult factory for special greases for use in hot, cold, or extremely wet atmospheres.

When bearings are being used in high temperature or in a dusty atmosphere, their lubrication should be attended more closely. Before greasing be sure to clean thoroughly the grease receptacle to prevent the clean grease from carrying foreign matter to the ball bearings.

Direct drive fans used outdoors should have shaft slinger and outdoor weatherproof motors. Weep holes or breathers and drains should be used to prevent water accumulation in the motor. Fans used in cold rooms are also subjected to moisture during defrosting.

In addition, the load due to cold air increases rapidly. While the motor needed will probably not be any larger than standars, the overloads must be larger than standard. For instance, a 1 HP fan at 70°F takes 1.15 HP at 0°F, and 1.29 HP at -50°F.

Keeping the propeller, ring, and unit in general free from dirt and grease will add to the efficient operation of the fan at all times and also increase the life of the unit. On belt driven units, do not over-tighten belts. Extra tension overloads bearings, overheats belts, and shortens drive life.

MAXIMUM TEMPERATURE LIMITATIONS FOR HARTZELL FANS

	Max.Airstream Ambient ºF
Axial Fans	
Direct drive or close couple belt drive, Standard insulation motor	105 °F
Direct drive or close couple belt drive, "F" insulation motor	122 °F
Direct drive "H" insulation motor	131 °F
Extended shaft fans	225 °F
Belt drive tubeaxial fans	180 °F
Belt drive tubeaxial fans modified for high temperature	350 °F
Belt drive steel tubeaxial, corrosion resistant	200 °F
Belt drive steel tubeaxial, high temperature	500 °F
Belt drive vaneaxial blowers	180 °F
Belt drive HVA vaneaxial blowers	350 °F
Aluminum props	300 °F
Centrifugal Fans	
BC/BA and industrial exhausters	
Arrangement 4	200 °F
Arrangement 1 and 9, standard construction	300 °F
Arrangement 1 and 9, high temperature construction	800 °F
Arrangement 10, standard construction	250 °F
Arrangement 10, hight temperature construction	600 °F
Arrangement 1 and 9, in-line construction	180 °F
Cast aluminum pressure blowers	200 °F
Fiberglass fans and blowers	200 °F

For detailed information consult Product Bulletin.

Process Ventilation Fans

TUBEAXIAL/VANEAXIAL TYPE

- **Inlet Conditions –** Fan inlets should be free of interference and provide a laminar flow of air into the propeller. Different inlet conditions result in different static pressure losses. Please refer to page 17 in this bulletin. Entry losses can be reduced by the utilization of inlet bells, inlet cones, or design of a low velocity system. For ducted inlets, completed turning elbows should be located no closer than one duct diameter away from the fan. The more gradual the radius of the elbow and the further away from the inlet of the fan, the better the fan will operate in your system.
- **Outlet Conditions –** Fan outlets should also be free from interference and conducive to a laminar flow of discharge air. Fan performance can be decreased by undesirable flow conditions imposed on the fan. That is, flow can be reduced and pressure loss increased if elbows or obstructions are placed too close to the discharge of the fan. For further information on the "System" effect for fans in ducted systems, refer to AMCA publication #201, Fans and Systems.
- **Ambient Conditions –** The fan should be suitably constructed for application in normal, ambient, corrosive, hazardous, high temperature or erosive applications. Contact your local Hartzell sales representative for selection assistance in these situations.
- **Mounting –** All tubeaxial and vaneaxial fans should be secured to a structure properly designed to accept the weight and loading conditions of the fan. Hartzell tubeaxial and vaneaxial fans are designed to accept mounting in any position from horizontal to vertical. Specify whether your fan will be duct mounted, supported or suspended, especially when vibration isolation is required.
- **Accessories –** Guards, sound attenuation devices, rigid or flexible duct connectors, inspection doors, extended electrical leads, and motor covers are available and should be specified for your application.

CENTRIFUGAL TYPE

- For centrifugal fans, drive arrangement, rotation, and discharge must be properly specified since centrifugal fan wheel rotation is determined by viewing the direction of rotation from the drive side of the wheel (not the inlet). Discharge configurations are shown in the table below.
- **Inlet Conditions –** Inlet boxes are a common option for directing flow into the inlet of a centrifugal fan. A reduction in capacity and pressure for this type of inlet condition is impossible to tabulate. Inlet conditions can be improved on a centrifugal fan with guide vanes or the conversion to square or mitered elbows with guide vanes.
- **Motors and Drives –** The fan motors and drives can be mounted in a variety of configurations. Please refer to the chart for common types of centrifugal fan drive configurations.
- **PROPERLY GUARD ALL FANS AND DRIVES.**

SPARK RESISTANT CONSTRUCTION

For safety handling fumes and vapors, Hartzell offers three types if spark resistant construction. Types A, B, and C as outlined in the AMCA Standard 99-0401-86. Types A, B, and C have a temperature limitation of 350°F, with high temperature construction.

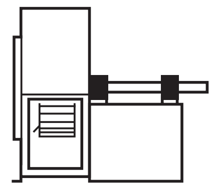
- **Type A –** All aluminum fan housing, inlet cone and wheel with a ground and polished steel shaft covered with aluminum sleeve.
- **Type B –** Aluminum wheel and aluminum wear plate where the shaft passes through the housing.
- **Type C –** Aluminum inlet cone and aluminum wear plate where the fan shaft passes through the housing.

Notes: No bearings, drive components or electrical devices shall be placed in the air or gas stream.

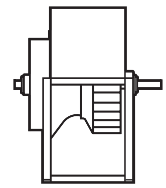
The user shall electrically ground all fan parts.

The use of above standard in no way implies the guarantee of safety for any level of spark resistance. Spark resistant construction also does not protect against any airstream material that may be present in a system which might cause ignition of explosive gases.

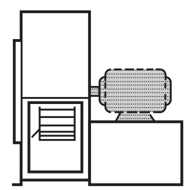
CENTRIFUGAL FAN ARRANGEMENTS



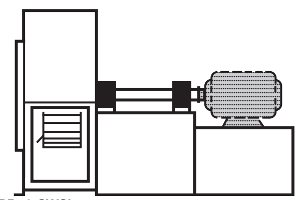
ARR. 1 SWSI.
For belt drive or direct connection. Impeller overhung. Two bearings on base.



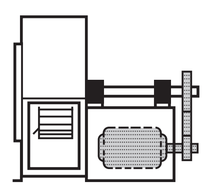
ARR. 3 SWSI.
Unit furnished with shaft and bearings, for belt drive configuration. One bearing on each side and supported by fan housing.



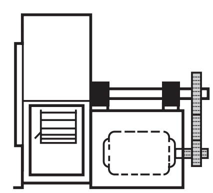
ARR. 4 SWSI.
For direct drive. Impeller overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally direct.



ARR. 8 SWSI.
Direct Coupled configuration with motor mounted to cmmon fan base. Impeller is overhung and supported by two bearings on fan base. Temperature Limitations: 250°F.



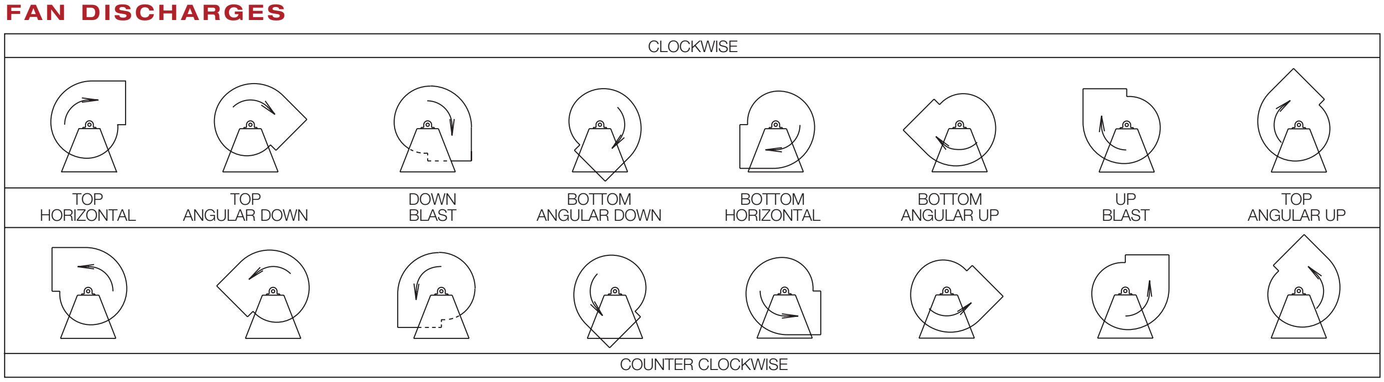
ARR. 9 SWSI.
For belt drive. Impeller overhund, two bearings, with prime mover outside the base.



ARR. 10 SWSI.
For belt drive. Impeller overhung, two bearings with prime mover inside base.

Adapted by permission from AMCA 99-86

FAN DISCHARGES



Formula Laws and Formulae used in Performance Calculations

Fan efficiencies remain constant for symmetrical design. When one or more conditions change, the other conditions vary according to certain fan laws for an established fan size, system of ductwork and air density.

WHEN FAN SPEED IS VARIED:

1. Fan's air delivery will vary directly as the RPM ratio.

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

2. Developed fan pressures will vary as the RPM ratio squared.

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

3. Horsepower absorbed by fan will vary as the RPM ratio cubed.

$$HP_2 = \left(\frac{RPM_2}{RPM_1}\right)^3 (HP_1)$$

WHEN FAN PRESSURE VARIES:

1. Fan's air delivery and RPM will vary as the square root of the pressure ratio..
2. Power absorbed by the fan will vary as the square root of the pressure ratio cubed.

WHEN DENSITY OF AIR VARIES:

1. Since the fan is essentially a constant volume machine when run at a constant speed, the volume will not vary with a change in density, but the power absorbed and the static, velocity, and total pressures will vary directly with the density ratio and inversely as the absolute temperature.
2. For constant pressure – fan speed, air delivery and power absorbed vary inversely as the square root of the density ratio.
3. For constant air delivery and fan speed – power absorbed by fan and pressure developed vary directly as the air density ratio.
4. For constant amount of air by weight – air delivery, fan speed and developed pressure vary inversely as the density ratio.

For constant amount of air by weight – power absorbed by fan varies inversely as the square of the density ratio.

Note: Most fan curves and ratings are based upon standard air of 0.075 pounds mass per cubic foot. For air densities at other temperatures and elevations, see the chart on page 14.

USEFUL FAN APPLICATION FORMULAE

$$d = 1.322 \times \frac{PB}{°F + 460}$$

$$FAN\ Eff = \frac{AHP}{BHP} = \frac{CFM \times TP}{6356 \times BHP}$$

$$VP = \left[\frac{FPM}{4005}\right]^2 = \left[\frac{CFM}{A \times 4005}\right]^2$$

$$TP = SP + VP$$

$$FAN\ BHP = \frac{CFM \times TP}{6356 \times Eff_T} = \frac{CFM \times SP}{6356 \times Eff_S}$$

FOR 3 PHASE MOTORS: $KW\ INPUT = \frac{E \times I \times Pf \times 1.732}{1000}$

To plot a system curve where SP1 & CFM1 are known, use the following formula to find other curve points:

$$SP_2 = SP_1 \left[\frac{CFM_2}{CFM_1}\right]^2$$

To determine round duct equivalent of rectangular duct for same friction loss and volumetric capacity:

$$DR = 1.265 \sqrt[3]{\frac{(ab)^5}{(a+b)^2}}$$

FOR 1 PHASE MOTORS: $KW\ INPUT = \frac{E \times I \times Pf}{1000}$

SYMBOL	DEFINITION
A	AREA (FT.^{2})
a	SIDE a OF RECTANGULAR DUCT
b	SIDE b OF RECTANGULAR DUCT
CFM	AIR VOLUME FLOW (FT.^{3}/MIN)
d	AIR DENSITY (LB./FT.^{3})
DR	DIAMETER OF ROUND DUCT
E	VOLTS
Eff	FAN EFFICIENCY (DECIMAL)
°F	TEMPERATURE (DEGREES FAHRENHEIT)
I	AMPS
Kw	KILOWATTS
ME	MOTOR EFFICIENCY (DECIMAL)
PB	BAROMETRIC PRESSURE (INCHES MERCURY)
Pf	POWER FACTOR
SE	STATIC EFFICIENCY
SP	STATIC PRESSURE (INCHES WG)
TP	TOTAL PRESSURE (INCHES WG)
VP	VELOCITY PRESSURE (INCHES WG)
V	VELOCITY (FT./MIN)

FORMULAE FOR DETERMINING THE SPREAD AND THROW OF A FAN*

By using the following formulae, information can be obtained on the velocity from a fan and also the width of the stream at a specific distance. While these values are influenced greatly by the presence or absence of walls, floors and obstructions, the following formulae will give a good approximation for most cases.

SPREAD: $W = .36L + \frac{d}{12}$

W = Maximum width in feet of airstream perpendicular to axis of rotation of the fan

L = Distance from fan in feet

d = Fan diameter in inches

VELOCITY (Not less than 10 feet from fan):

(1) $k = 5\left(\frac{2.5 \times CFM}{d}\right)^2$

(2) $^{V}La = 1.15\sqrt{\frac{k}{L}}$

(3) $^{V}max = \left(\frac{d}{73} + 1\right)^{V}La$

k = Fan constant

^{V}La = Average velocity across the width of the spread L feet from the fan (feet per minute)

^{V}max = Maximum velocity L feet from the fan (feet per minute)

CFM = Free Air Delivery of fan

Note: These formulae are applicable only to fans with a seal ring configuration. For general stamped blade circulation fans, a factor of 50% of calculated value should be used.

*Applies to Coolblast and Utility Fans only

Fan Performance Curves

A fan performance curve is a graphical presentation of the results of a fan test. The test points may be calculated to a constant speed, in which case only a statement of the speed need be given. If the test results are "as run", i.e. at varying speeds for each point, a curve should be shown with speed as an ordinate.

Since total pressure, total efficiency and static efficiency are easily calculated, only flow rate, static pressure and power are generally shown on the performance curve.

Flow rate (CFM) is always given as the abscissa (X-axis) and the other values as ordinates (Y-axis). A typical axial flow fan performance curve for a belt drive duct axial fan is reproduced here. This curve will be used as our basis for discussion.

Note that the fan performance curve identification number (G-3603-A) is shown above the plot. The type of fan (Series A46___166DA___STOPK3) and the propeller pattern number (P-1794) is shown in the title at the top of the plot. The title also lists the fan speed(s) presented on the curve. Listed near the title are the ambient air conditions (Std. Air) and the type of AMCA test (Duct Inst., AMCA Bul. 210, Fig. 5, Type D) used for testing the fan. The fan series number can be added to the curve if desired.

Fan performance curves are shown for a number of different values of RPM. The brake horsepower (BHP) curves are shown near the top of the plot. Airflow rate (CFM) is read on the horizontal axis and the BHP is read on the vertical axis on the right-hand side of the plot. The lower set of curves is for airflow rate vs. static pressure. Static pressure is read on the vertical axis on the left-hand side of the plot. Static pressure for fans is measured in terms of inches water gauge (in W.G.).

Suppose you have a Series A46___166DA___STOPK3 duct fan and you know that it is operating at 3205 RPM. You need to supply 3500 CFM with this fan and you need to know the fan's static pressure capability, the brake horsepower required, as well as the efficiency of the fan.

Go to example fan curve and read 3500 CFM (Point) on the horizontal axis. Move vertically upward along the 3500 CFM line until you intersect the SP vs. CFM curve for 3205 RPM (Point). At this intersection move horizontally to the static pressure axis and read 2.15 in. W.G. static pressure.

Now, going back to the 3500 CFM line, continue to move vertically until you intersect the BHP vs. CFM curve for 3205 RPM (Point).

At this intersection, move horizontally to the right to the BHP axis and read 2.85 brake horsepower. This fan will require a minimum of a 3 HP motor. The complete fan model number is Series A46___166DA___STOPK3. What about efficiency?

Static Efficiency = SE

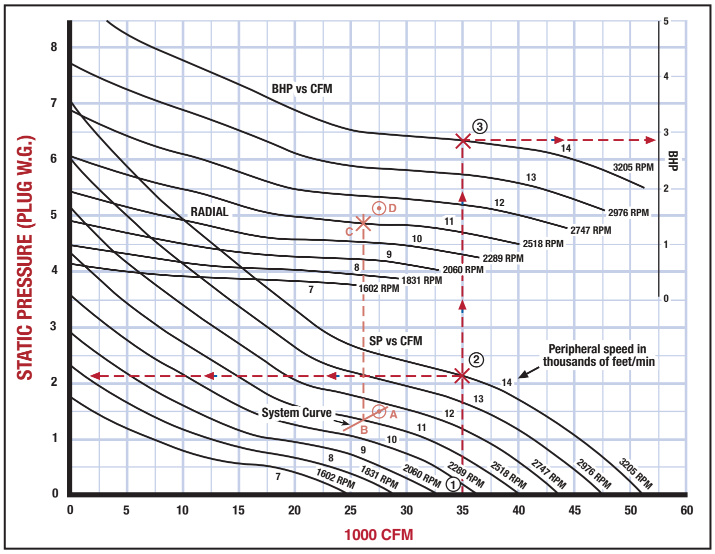
$$SE = \frac{CFM \times SP}{6356 \times BHP} = \frac{3500 \times 2.15}{6356 \times 2.85} = 0.415 \text{ or } 41.5\%$$

FPM = CFM/Fan Cross Section Area

Total Pressure = Static Pressure + Velocity Pressure

$$\text{Velocity Pressure} = \left[\frac{FPM}{4005}\right]^2 = \left[\frac{3500/1.396}{4005}\right]^2 = 0.392 \text{ in. W.G.}$$

$$TE = \frac{CFM \times TP}{6356 \times BHP} = \frac{3500 \times [2.15 + 0.39]}{6356 \times 2.85} = 0.491 \text{ or } 49.1\%$$



Performance of Fan in a System

When a system is designed for moving air, the air flow rate (CFM) and the static pressure (SP) seldom fall conveniently on the RPM curve shown for fan performance. In this case, you can use the fan laws to determine the exact fan RPM and BHP needed.

Suppose you need 2750 CFM at 1.5" SP. Using the fan curve shown, you can see that this point (indicated as "A") falls between 2518 and 2747 RPM. Going to the BHP curves, you can see that the BHP will be between 1.4 BHP and 1.8 BHP. The motor HP needed may be 11/ 2 or it may be 2 (Point B).

Algebraically rearranging the fan laws to show:

$$SP_2 = \left[\frac{CFM_2}{CFM_1}\right]^2 \times SP_1$$

you may calculate a system curve based on 2750 CFM and 1.5" SP (Point A). This system curve crosses the 2518 curve at 2625 CFM..

Using the fan laws, we see:

$$RPM_2 = RPM_1 \left[\frac{CFM_2}{CFM_1}\right] = 2518 \left[\frac{2750}{2625}\right] = 2638 \text{ RPM}$$

This is the operating RPM for this fan at the specified performance point.

Following the 2625 CFM line up to the BHP curves, we see that we intersect the 2518 RPM curve at 1.4 BHP. Again, using the fan laws we find:

$$BHP_2 = BHP_1 \left[\frac{RPM_2}{RPM_1}\right]^3 = 1.4 \left[\frac{2638}{2518}\right]^3 = 1.61 \text{ (BHP)}$$

To obtain 2750 CFM at 1.5" SP, you would have to operate this fan at 2638 RPM and would use 1.61 BHP. You would need a 2 HP motor with a 1.0 service factor or a 11/2 HP motor with a 1.15 service factor. The 2 HP model code would be 46-16DJ3.

Effects of Air Density on Fan Performance

Air is a mixture of gases. This mixture can be changed by varying the amounts and types of gases involved. When the make-up of this mixture is determined, its weight can be calculated. The weight of the mixture (we use pounds – lbs.) per unit volume (we use cubic foot – ft.3) is the density (lbs./ft.3) of the mixture.

We refer to “standard air density” as being 0.075 lb./ft.3 at sea level, at 70°F, 50% relative humidity and 29.92" Hg barometric pressure. The ratio of specific heats is 1.400, viscosity is 1.222 x 10-5 lbm/ft.-s, and absolute pressure is 408.0" W.G. (14.7 lb./ft.2). This is for a gas mixture that is 78% nitrogen, 21% oxygen, and about 1% argon, neon, helium, kryton, xenon, and “others”.

There are a number of factors that can cause changes in the density of the air that your fan is handling. The chief factors or industrial applications are the temperature of the air being handled and the altitude above sea level at which the fan is operating. Two other factors, relative humidity and the mixture of gases being handled (fans are sometimes used for dilution, ventilation, and conveying of other gases or contaminants) can be very important also. However, relative humidity and the mixture of gases is usually not a consideration for industrial applications – if you feel that these items need consideration for application, then you should CONTACT THE FACTORY FOR ASSISTANCE.

When dealing with high pressure centrifugal fans (at static pressures above 15" W.G.) density corrections for rarefication (inlet depression) and/or compression must be considered. When this situation arises it is best to note whether required fan performance is at the inlet or the outlet of the fan then CONTACT THE FACTORY FOR ASSISTANCE.

The density of the gas (air) in which a fan is working has a definite effect on the fan performance. A fan handling “air” is, for all practical purposes, a constant volume machine. This is to say, no matter what the density, the CFM handled by the fan remains the same. When the density of the air is changed, the power absorbed by the fan and the pressures created by the fan vary directly as the density of the air varies.

Most fan performance tables and curves are stated at a standard air density (0.075 lbs./ft.3). When the altitude at which your fan is operating is other than sea level and/or the temperature of the air being handled is other than 70°F, adjustments need to be made for static pressure and brake horsepower in order to determine fan performance.

Temperature rise across fan is approximately one half degree F per inch of water column.

TEMPERATURE/ALTITUDE APPLICATIONS

When a fan operates in standard ambient conditions, it is handling air generally at 70°F, 29.92 in. Hg barometric pressure, weighing 0.075 lbs./cu. ft. Where the fan operates at other than standard ambient conditions (temperature, altitude, or both) correction factors must be applied to the fan performance for proper fan selection. In addition, the standard construction of the fan may have to be modified. See the section on Safe Operating Speeds.

Correction factors for temperatures and altitudes are provided in Table 1 and Table 2. When a fan operates at other than standard ambient conditions, the correction factors in Table 1 and Table 2 will be required to correct static pressure and horsepower.

TABLE 1 TEMPERATURE CORRECTION FACTORS

Temp. ① (°F)	-25	0	25	50	70	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
Factor	0.82	0.87	0.91	0.96	1.00	1.06	1.15	1.25	1.34	1.43	1.53	1.62	1.72	1.81	1.91	2.00	2.09	2.19	2.29	2.38

TABLE 2 ALTITUDE CORRECTION FACTORS

Altura (Pies) ②	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000
Factor	1.00	1.04	1.08	1.12	1.16	1.20	1.25	1.30	1.35	1.40	1.46	1.51	1.57

Above table has inverted values. Actual density ratio is the reciprocal of the above values.
At sea level, at 70°F.
For corrections involving both temperature and altitude, correction factors should be multiplied.
Example: 175°F at 7000 ft.
Temperature factor 1.15 x altitude factor 1.30 = 1.50 combined correction factor.

USE OF TEMPERATURE – ALTITUDE CORRECTION TABLES

If non-standard temperature or altitude is involved, correct to standard air. Example: Assume the required performance of a duct fan is to be 11,990 CFM at 1.43 in. SP at a temperature of 200°F and an altitude of 3,000 ft. above sea level.

1. Combined correction factor = 1.25 (Table 1 – temperature) x 1.12 (Table 2 – altitude) = 1.40.

2. 1.43 in. SP x 1.40 = 2.0 in. SP for 70°F at sea level.

3. A Hartzell Series 46 Duct Axial fan, 28" size, with vanes, selected from the Hartzell Bulletin A-118 rating tables for the new conditions shows 11,990 CFM at 2.0" SP, 1864 RPM and 6.9 BHP.

4. Correct the horsepower and static pressure in #3 to non-standard performance by dividing by the correction factor:

   Actual BHP at 200°F, 3000 ft. = 6.9 ÷ 1.4 = 4.93 BHP

5. If this unit is always to operate at 200°F, 3000 ft. altitude, a 5 HP motor will be adequate. However, if the unit can be expected to operate at standard temperature at 3000 ft. for significant periods of time, a 71/2 HP motor will be a better selection.

Safe Operating Speeds for Fans and Blowers

A rotating body will be acted upon by a variety of forces. The aerodynamic forces of lift and drag due to the body moving through the air, the effects of gravity due to the body's weight, the thrust effects on the body due to air being put into motion and the resulting stresses due to centrifugal acceleration trying to pull the body apart as it rotates are all acting upon the body. At some speed of rotation, the stresses on the body will exceed the strength of its material(s) of composition and the body will permanently distort or possibly even disintegrate.

When the rotating body is a fan propeller or wheel, such an event as failure due to an over speed condition is best avoided. This brings us to the question of how fast can a fan propeller or wheel be safely operated?

The usual way we measure the operating speed of a fan propeller or wheel is in revolutions per minutes (RPM) or tip speed in feet per minute (FPM). Tip speed is the velocity at which the blade tip is moving and is calculated from the blade diameter (D) and the propeller or wheel RPM.

Tip speed (FPM) = 3.1416 x D (ft.) x RPM

Safe operating speed of a fan propeller or wheel is determined primarily by such things as materials of construction, design of the equipment, and the environment in which the fan must operate.

A major factor that affects the maximum safe operating speed of a fan propeller or wheel is operating temperature. Some materials get stronger with decreasing temperature and some do not. All materials lose strength with increasing temperature but there is a wide variation in temperatures at which the loss of strength begins to take effect.

Typically, the maximum safe operating speed for a propeller or wheel operating at 70°F is determined through a series of tests and calculations. A safety factor is included in the design and analysis, and the safe operating tip speed/RPM is determined.

The effects of operating temperature on the maximum safe operating speed of a propeller or wheel are determined by the temperature effects on the materials of construction.

Presented in Table 1 are maximum safe operating speeds for various types of fan propellers and wheels manufactured by Hartzell Air Movement.

It should be noted that the cataloged operating speeds shown for many fans are subject to other limits besides maximum safe propeller or wheel speed. Things such as bearing and shaft sizes and types are important also in determining maximum fan operating speeds. When in doubt, consult the factory.

SAFE OPERATING SPEED

Product/ Wheel Type	Material of Construction	Maximum Catalog Tip Speed FPM	Temperature Limit
__A, AA, AL __C __L __N, NA, NB, NC, ND, NE __O __P __Q __R __W	Cast Aluminum ↓	15,000 19,000 15,000 20,000 10,000 17,000 10,000 20,000 15,000	350° ↓
DA VA VB AV __T	Cast Aluminum ↓	24,000 22,000 29,000 22,000 24,000	350° ↓
HS, CS BA, BC Class I Class II Class III Class IV Class V AH, MH, PW, PR 052 053 054	Steek ↓	14,000 11,000 14,000 18,000 16,000 20,000 24,500	500° 800° ↓
__I (07)	Cast Aluminum	15,000	200°
07T	See Catalog for Maximum Tip Speeds		

SAFE OPERATING SPEED FOR ADJUSTABLE PITCH PROPS

Wheel Type	SERIES/ Product	Tip Speed
A	10, 31, 89	15000
AA	01, 08, 15, 16, 19, 20, 39, 61, 69, 90	15000
AF	34, 58E	12000
AL	01, 39, 61	15000
AM	44	20600
AR	17, 26, 27, 90R	17000
AS	89	15000
AU	90U	17000
AV	65C, 66, 67	22000
AW	08, 16, 19, 31, 61	13800
BA	01, 08, 15, 16, 19, 31, 61, 69, 90	15000
BN	16, 19, 91	11000
BT	16, 19, 92	15000
A, AS	89	15000
AA, BA	90	15000
AR	90R	17000
AU	90U	17000
BN	91	15000
BT	92	15000

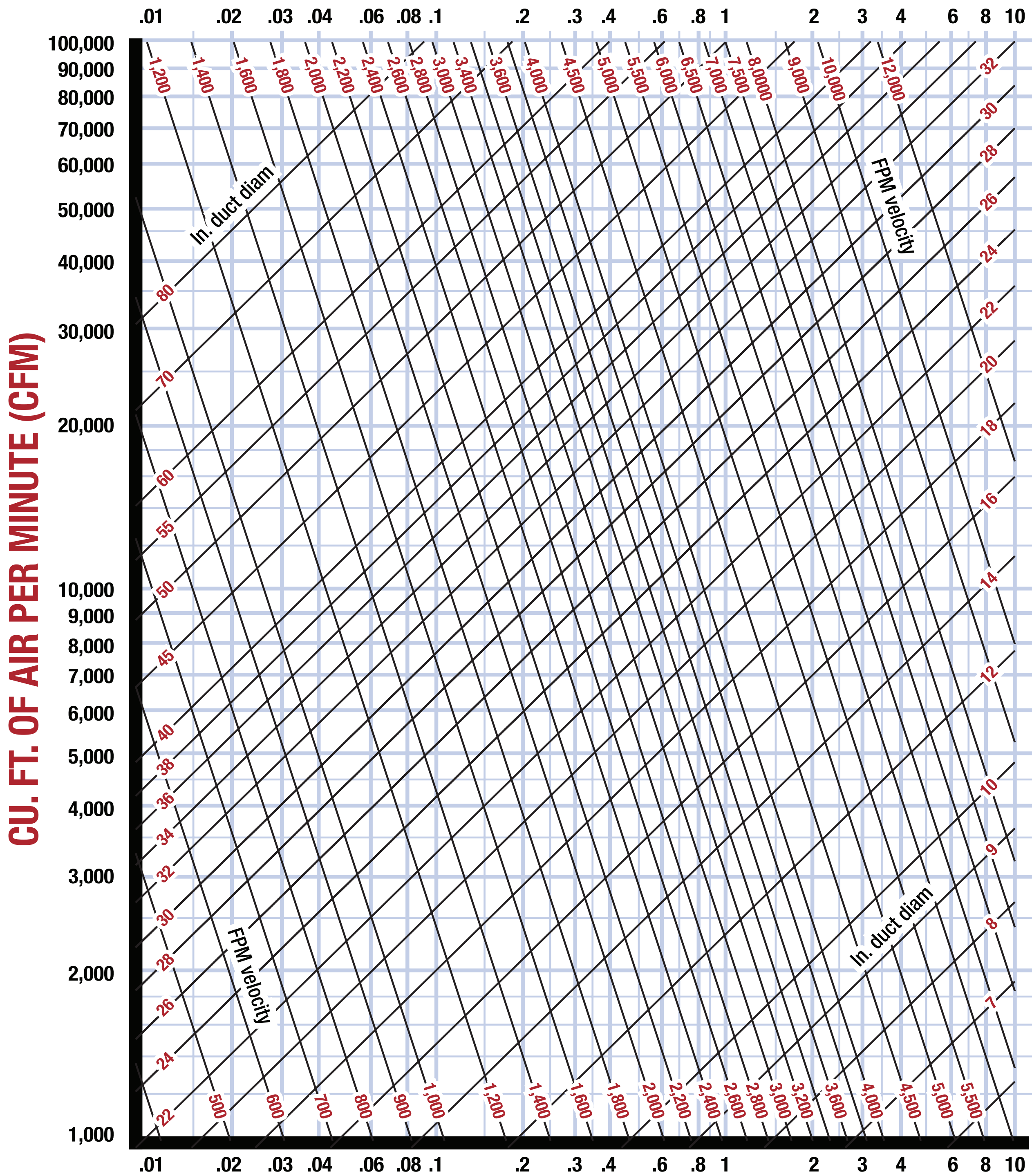
SAFE OPERATING DERATE FACTOR

Product Type/ Material of Construction	Derate Factor for Various Temperatures								
	– 50	0	70	150	350	400	500	600	800
Cast Aluminum	1.0	1.0	1.0	1.0	0.91				
Steel Axials	0.71	1.0	1.0	1.0	0.94	0.93	0.89		
Steel Centrifugals	0.71	1.0	1.0	1.0	0.94	0.93	0.89	0.86	0.77

Note: 1. Other construction features such as drive configurations can affect maximum operating temperatures.
2. The data in this table is subject to change based upon changes to Hartzell Air Movement designs.
3. For other materials of construction please refer to Hartzell Bulletins A-147 and A-155.
4. For fiberglass construction, please refer to Hartzell Bulletins A-131, A-139, A-141, A-140, A-160 and A-410

Useful Engineering Data

DUCT RESISTANCE CHART



Friction in inches of water per 100 feet (based on standard air...40 joints per 100 feet).
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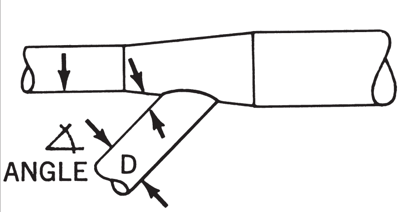
FRICTION IN ROUND DUCTS

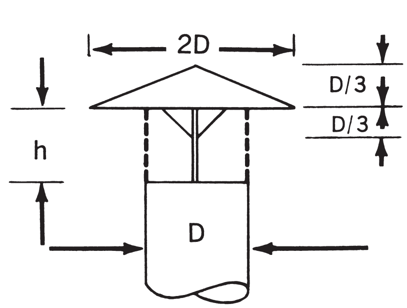
The duct resistance chart above presents the relation between airflow and friction. To show the use of this chart, assume we wish to pass 15,000 CFM through 32" duct 150' long. Find 15,000 CFM on the left-hand vertical scale, and read horizontally to the right to the intersection of the sloping line marked 32 on the right-hand side. Reading vertically down to the water-gauge scale shows a fraction of .26" per 100'. For 150' the friction will be .26" x 1.5 or .39" water gauge. Also, the lines sloping to the right from the intersection of 15,000 CFM and 32" give the velocity in the duct. In this case, 2700 FPM. In a similar manner, any two variables can be determined by the intersection of the lines representing the other two known variables.

EQUIVALENT ENTRY LOSS



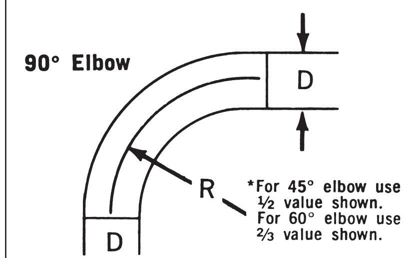
Dia. of Pipe	30°	45°
4”	3’	5’
6”	5’	7’
8”	7’	11’
10”	9’	14’
12”	11’	17’
14”	13’	21’
16”	16’	25’
18”	18’	28’
20”	20’	32’
24”	24’	37’
28”	28’	46’
30”	31’	49’
32”	33’	53’

EQUIVALENT WEATHER CAP LOSSES



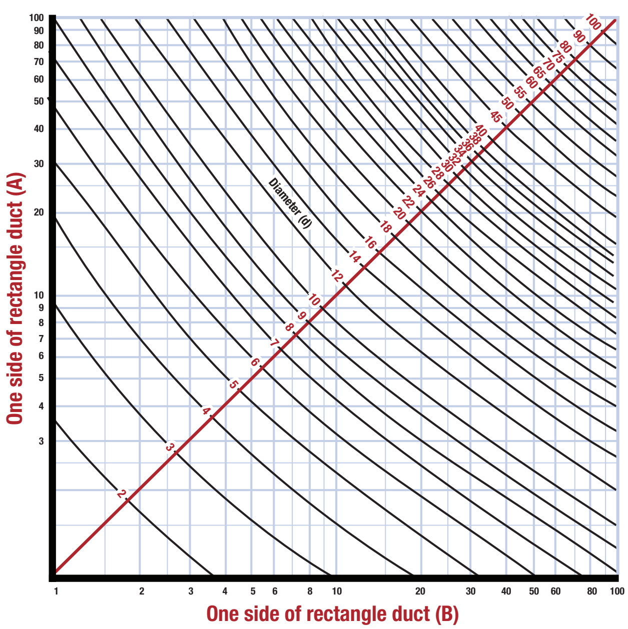
D	h = ½ D	h = ¾ D	h=D
12”	44’	11’	6’
16”	62’	15’	9’
18”	71’	18’	10’
20”	80’	20’	11’
24”	92’	24’	13’
28”	115’	28’	16’
32”	137’	33’	19’
36”	159’	39’	22’
40”	177’	44’	25’
44”	196’	49’	28’
48”	215’	54’	32’

EQUIVALENT RESISTANCE OF ROUND ELBOWS



D”	R/D = 1.5	R/D = 20”
4’	6’	4’
6”	12’	7’
8”	15’	10’
10”	20’	14’
12”	25’	17’
14”	30’	21’
16”	36’	24’
18”	41’	28’
20”	46’	32’
24”	57’	40’
28”	68’	47’
30”	74’	51’
32”	80’	54’
36”	93’	64’
40”	105’	72’
42”	111’	76’
44”	118’	81’
48”	130’	89’

RECTANGULAR EQUIVALENTS OF ROUND DUCTS



$$DR = 1.265 \sqrt[3]{\frac{(ab)5}{(a + b)2}}$$

TYPICAL ENTRANCE LOSSES

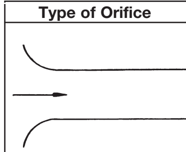
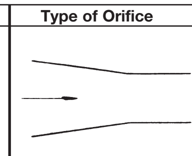
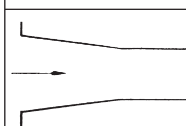
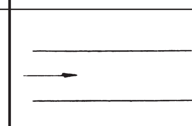
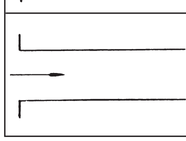
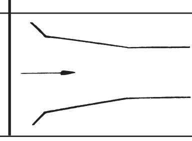
Type of Orifice	Description	Loss*	Type of Orifice	Description	Loss*
	Smooth, well rounded	5		Unflanged cone, 15° per side	13
	Flanged cone, 15° per side	7		Unflanged pipe	90
	Flanged pipe	50		Two-cone, 45° & 15° per side	6

Fig. DV
***Loss is given in percent of velocity pressure (%VP)**

AIR PRESSURE CONVERSION TABLE

Density Air = 0.075 lb/ft³ | Density Water = 62.30 lb/ft³ | Density Mercury = 845.60 lb/³

Inches of Water	Feet of Water	Inches of Mercury	Pounds per in²	Pounds per in²	Ounces per in²
1.00	0.0833	0.0734	0.03605	5.19	0.5767
12	1.00	0.882	0.4326	62.3	6.922
13.596	1.133	1.00	0.4912	70.6	7.843
			14.696		
407.54	33.96	29.92	(1 atmósfera)	2116.2	235.14
1.7328	0.1444	0.1272	0.0625	9.0	1.00

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AVERAGE AIR CHANGES REQUIRED FOR GOOD VENTILATION

	Minutes per change
Assembly Halls	2-10
Auditoriums	2-10
Bakeries	2-3
Boiler Rooms	1-5
Bowling Alleys	2-10
Churches	5-15
Dairies	2-5
Dance Halls	2-10
Dry Cleaners	1-5
Engine Rooms	1-3
Factories	2-5
Forge Shops	2-5
Foundries	1-5
Garages	2-10
Generator Rooms	2-5
Gymnasiums	2-10
Kitchens - Hospital	2-5
Kitchens - Restaurant	1-3
Laboratories	1-5
Laundries	1-3
Markets	2-10
Offices	2-10
Packing Houses	2-5
Plating Rooms	1-5
Toilets	2-5
Transformer Rooms	1-5
Warehouses	2-10

Note: The above chart is a general guideline only

RECOMMENDED VELOCITIES FOR EXHAUST HOODS

Area slot or Face (sq. ft.) x Velocity (FPM) = CFM Required

Type Process	Type Hood	Required Air Velocity (FPM) Average
Aluminum Furnaces	Enclosed hood, open one side Canopy hood	150-200 FPM over open face 200-250 FPM over face
Bottle Washing	Enclosed booth, open one side	150-250 FPM over face
Brass Furnaces	Enclosed hood, open one side Canopy hoods	200-250 FPM over open face 250-300 FPM over open face
Chemical Laboratories	Enlosed hood, door front Enclosed hood, open front Down draft, table type	100 FPM over door opening 100-150 FPM over face 150-200 FPM over table gross area
Degreasing	Canopy hood Slot type for tanks up to 4' wide – (slot 1 side)	150-200 CFM over face 2' width use 1500-2000 FPM thru 2" slot 3' wide use 1500-2000 FPM thru 4" slot 4' width use 1500-2000 FPM thru 6" slot For tanks over 4' use slots on 4 sides
Driers	Canopy hood Slot type at each end continuous drier	125-150 FPM over face 150-200 FPM over 6' to 8' slot
Electric Welding	Enclosed booth, open front Canopy hood	100-150 FPM over face 125-150 FPM over face
Electroplating	Canopy hood Slot type for tanks up to 4' wide (slot 1 side)	125-175 FPM over face 2' width use 1500-2000 FPM thru 2" slot 3' wide use 1500-2000 FPM thru 4" slot 4' width use 1500-2000 FPM thru 6" slot For tanks over 4' use slots on 4 sides
Foundry Shake Out	Enclosed booth, open front Down draft, grill type	150-200 FPM over face 300-500 FPM
Grain dust, wood, flour, etc.	Slot types Canopy hoods	2000 FPM thru 2" to 4" slot 500-600 FPM over face
Grinding (disc) and sanding	Down draft, grill types Bench types with slot one side	400 FPM over open face 2000-2500 FPM thry 4" slot
Hand forge	Canopy type hood Enclosed booth, one side	150-250 FPM over face 200-300 FPM over face
Kitchen Ranges	Canopy hoods	125-150 FPM over face
Metal Spraying	Enclosed hood, open one side	200-250 FPM over face
Paint Spraying	Enclosed booth, open one side	125-200 FPM over face
Paper Machine	Canopy type	100-300 FPM over face*
Pickling Tanks	Canopy type Slot for tanks up to 6' wide (slot one side only)	200-250 FPM over face Minimum 4" slot 2000-2500 FPM thru slot
Quenching Tanks	Canopy type hoods	200-300 FPM over face
Rubber mixing rolls	Canopy type slot type	150-200 FPM over face 2000-2400 FPM thru 2" slot
Soldering booths	Enclosed booth, open one side	150-200 FPM over face
Steam tanks	Canopy type Slot for tanks up to 6' wide (slot one side only)	200 FPM over face 1500-2000 FPM thru minimum 4" slot
Stone cutting	Enclosed booth, open face	400-500 FPM over face
Varnish Kettles	Canopy type Slot type – all around slot	250-350 FPM over face 2" minimum slot 2000 FPM thru slot

TABLE OF CORRESPONDING AIR VELOCITIES FOR VARIOUS PRESSURES

In inches of water (Air Density: 0.075 lb/ft³)

F.P.M. Velocity	Pressure Inches	F.P.M. Velocity	Pressure Inches	F.P.M. Velocity	Pressire Inches	F.P.M. Velocty	Pressure Inches
500	0.0156	1300	0.106	2250	0.316	4250	1.130
600	0.0225	1400	0.122	2500	0.391	4500	1.265
700	0.0305	1500	0.141	2750	0.473	4750	1.410
800	0.0400	1600	0.160	3000	0.562	5000	1.560
900	0.0504	1700	0.181	3250	0.661	5250	1.720
1000	0.0625	1800	0.203	3500	0.768	5500	1.890
1100	0.0758	1900	0.226	3750	0.880	5750	2.060
1200	0.0900	2000	0.250	4000	1.000	6000	2.250

AREA AND CIRCUMFRENCE OF CIRCLES (AND SIDES OF SQUARES OF EQUAL AREAS)

Diameter in Inches	AREA		Circum-ference in Feet	One side of a square of equal area	Diameter in inches	AREA		Circum-ference in Feet	One side of a square of equal area
	Square Inches	Square Feet				Square Inches	Square Feet		
1	0.7854	0.0054	0.2618	0.89	51	2043	14.19	13.35	45.20
2	3.142	0.0218	0.5236	1.77	52	2124	14.75	13.61	46.08
3	7.069	0.0491	0.7854	2.66	53	2206	15.32	13.88	46.97
4	12.57	0.0873	1.047	3.54	54	2290	15.90	14.14	47.86
5	19.63	0.1364	1.309	4.43	55	2376	16.50	14.40	48.74
6	28.27	0.1964	1.571	5.32	56	2463	17.10	14.66	49.63
7	38.48	0.2673	1.833	6.20	57	2552	17.72	14.92	50.51
8	50.27	0.3491	2.094	7.09	58	2642	18.35	15.18	51.40
9	63.62	0.4418	2.356	7.98	59	2734	18.99	15.45	52.29
10	78.54	0.5454	2.618	8.86	60	2827	19.63	15.71	53.17
11	95.03	0.6600	2.880	9.75	61	2922	20.29	15.97	54.06
12	113.1	0.7854	3.142	10.63	62	3019	20.97	16.23	54.91
13	132.7	0.9218	3.403	11.52	63	3117	21.65	16.49	55.83
14	153.9	1.069	3.665	12.40	64	3217	22.34	16.76	56.72
15	176.7	1.227	3.927	13.29	65	3318	23.04	17.02	57.60
16	201.0	1.396	4.189	14.18	66	3421	23.76	17.28	58.49
17	227.0	1.576	4.451	15.06	67	3526	24.48	17.54	59.38
18	254.7	1.767	4.712	15.95	68	3632	25.22	17.80	60.26
19	283.5	1.969	4.974	16.84	69	3739	25.97	18.06	61.15
20	314.2	2.182	5.236	17.72	70	3848	26.73	18.33	62.04
21	346.3	2.405	5.498	18.61	71	3959	27.49	18.59	62.92
22	380.1	2.640	5.760	19.49	72	4072	28.27	18.85	63.81
23	415.5	2.885	6.021	20.38	73	4185	29.07	19.11	64.99
24	452.4	3.142	6.283	21.27	74	4301	29.87	19.37	65.58
25	490.9	3.409	6.545	22.15	75	4418	30.68	19.63	66.47
26	530.9	3.687	6.807	23.04	76	4536	31.50	19.90	67.35
27	572.5	3.976	7.069	23.93	77	4657	32.34	20.16	68.48
28	615.7	4.276	7.330	24.81	78	4778	33.18	20.42	69.15
29	660.5	4.587	7.592	25.70	79	4902	34.04	20.68	70.03
30	706.8	4.909	7.854	26.59	80	5027	34.91	20.94	70.89
31	754.7	5.241	8.116	27.47	81	5153	35.78	21.21	71.80
32	804.2	5.585	8.378	28.36	82	5281	36.67	21.47	73.35
33	855.3	5.940	8.639	29.25	83	5411	37.57	21.73	73.55
34	907.9	6.305	8.901	30.13	84	5542	38.48	21.99	74.45
35	962.1	6.681	9.163	31.02	85	5675	39.41	22.25	75.48
36	1017.8	7.069	9.425	31.90	86	5809	40.34	22.51	76.22
37	1075.2	7.467	9.686	32.79	87	5945	41.28	22.78	77.10
38	1134.1	7.876	9.948	33.68	88	6082	42.24	23.04	77.99
39	1194.5	8.296	10.21	34.56	89	6221	43.20	23.30	78.87
40	1256.6	8.727	10.47	35.45	90	6362	44.18	23.56	79.76
41	1320.2	9.168	10.73	36.33	91	6504	45.17	23.82	80.65
42	1385.4	9.621	10.99	37.22	92	6648	46.16	24.09	81.54
43	1452.2	10.08	11.26	38.11	93	6793	47.17	24.35	82.42
44	1520.5	10.56	11.52	38.99	94	6940	48.19	24.61	83.31
45	1590.4	11.04	11.78	39.88	95	7088	49.22	24.87	84.19
46	1661.9	11.54	12.04	40.76	96	7238	50.27	25.13	85.08
47	1734.9	12.05	12.30	41.65	97	7390	51.32	25.39	85.96
48	1809.5	12.51	12.57	42.58	98	7543	52.38	25.66	86.85
49	1885.7	13.09	12.83	43.42	99	7698	53.46	25.92	87.74
50	1963.5	13.64	13.09	44.31	100	7855	54.54	26.18	88.63

A Discussion of Fan Sound

Hearing, particularly as a measurement of sound, is a relative judgment. Noise is defined as "unwanted sound," and the difficulty in noise analysis is in determining how much noise is unwanted. Sound reaches our ears as pulsations of air upon the eardrums. The relative strength of these pulsations is indicated by the sound pressure. The frequency or frequencies of these pulsations determine the pitch of the tone(s) we hear. Sound is measured relative to the smallest sensations a normal person can discern, This pressure is taken to be a standard equal to .0001 microbar (1 microbar = 1 dyne/sq. cm or a pressure of 10-6 atmospheres). Decibels or dB's, as these units are abbreviated, are used to express sound pressure levels.

Sound pressure levels in dB's are siply 10 x log (Sound Pressure/.002 microbars $10)^2$. The sound pressure ratio is squared because sound intensity is proportional to the sound pressure squared. Decibels, then are a measure of the strenth of a noise. As one can see, doubling the intensity only increases the sound pressure level 3dB (10 x log 10 (2)) = 3.

The ear does not respond as effectively to low pitched tones. Also at very high levels, the ear's response becomes limited. However the ear is the most responsive to sound in the 1000 Hz - 5000 Hz frequency range. This range of frequencies falls in the speech interference range, where noise is most likely to affect conversation.

Now we can establish a weighting level to correspond to the human ear's response. One commonly accepted weighting is the A level, which is based upon the 10dB loudness contour. Sound level meters that have this weighting electrically decrease the response of the lower frequencies relative to the 1000 Hz band so that the sound pressure level that the meter measures is what our ears would hear. This weighting provides a simple single number rating that allows us to judge the loudness of a noise.

As mentioned earlier, sound is governed by natural laws just as fan air performance is governed by laws of size and speed. A very useful quantity used by sound analysts is 'sound power level". As you might suspect, sound power level, like fan power, is not measured directly, but must be calculated. Sound pressure levels can be affected by distance and the absorptive quality of the sound environment. The sound power level of a particular fan configuration, however is constant.

Any sound analyst may take these sound power levels or spectrum and knowing his room constant, directivity factor, and distance from the noise source, can calculate the sound pressure level in a particular environment. This is not practical for us in the fan business. We use instead a substitution method. We have a sound reference source with a given sound power level (in eight bands). One might think of the sound law as Sound Power Level = Sound Pressure Level + Room Effect. We measure the sound pressure of the reference source in our lab, then subtract this from its known sound power level to obtain the room effect. The room effect for each band is then added to the respective sound pressure band levels of our test fan to obtain its sound power. This method is quite easy and surprisingly accurate. Again, we emphasize publishing sound power level. The sound pressure level that we measure in our lab is irrelevant in predicting the noise level in a different application.

APPLICATIONS

As mentioned previously, the dBA weighting is a convenient single number rating for judging the loudness of a sound. dBA's, however, are not practical when comparing two or more noise sources. First, they are relevant only to the environment where they are measured. Second, since dBA's are derived from logarithms, noise that appears twice as loud as another is not twice as many dBA's. To solve this dilemma, a difference loudness rating was developed. Called sone, it is the linear rating, i.e., a noise that appears twice as loud as another is twice as many sones as the other noise. It is then possible to compare any fan to another. See AMCA bulletins 300, 301, and 302 for techniques using sones.

Hartzell has in the past released dBA ratings of fans. A fan is almost always installed in some degree of reverberant field (an environment where reflections are possible). This rating could in reality (upon installation of the fan) be conservative (low). In fact, there can be as much as 4 dB difference in a rating between a soft room, (much acoustic absorption) and a hard room (reverberant)! These ratings are calculated assuming that sound radiated from both the discharge and upstream opening of the fan contributes to the noise heard.

We can only publish such a dBA rating with an accuracy of ± 6 dB, though. We have no knowledge of the acoustical environment in which the fan will be installed (a must if one really wishes to accurately approximate the level) and offer our rating only as an in-field approximation. Hartzell engineering will continue to accurately measure the sound output of our fans and to provide guidelines for controlling fan noises. Accurate sound power levels are a must for the sound engineer to work with.

Sound originates from two basic sources: direct radiation and reflected radiation. We have all removed furniture from a room that we wished to paint and noticed the acoustical change. Echoes appear when we speak; the room seems to be more "alive". This is because we have removed acoustic absorbers (rugs, drapes, furniture, etc.). This is a good example of the effect of a noise source in an acoustic environment.

A Discussion of Fan Sound (cont.)

Any environment has a near field (very close to the sound source) and a far field (reverberation field). As we move farther away from the source, the noise eventually levels off and we are in the far field, or reverberation field, where the level changes little with distance. A free field is an environment where the sound may radiate in all directions without reflections. In the free field sound pressure level decays 6 dB for each doubling of distance. Practically, we encounter various reverberation fields where the decay is much less than 6 dB per doubling of distance.

For a particular fan, we can change its sound pressure level in a room by various attenuation techniques, but we do not change the sound power level of the fan. This is why a sound engineer publishes sound power levels instead of sound pressure levels, which are valid only for the particular environment where measured. AMCA only sanctions the publishing of sound power levels and sones.

The most common method of publishing sound data is to divide the audible frequency range into bands centered at 63, 125, 250, 500, 1000, 2000, 4000 and 8000 Hz. See Table 1 below.

#	1	2	3	4	5	6	7	8
Band Range cps	45-90	90-180	180-355	355-710	710-1400	1400-2800	2800-5600	5600 11200
Center cps	63	125	250	500	1000	2000	4000	8000

A sound pressure level is measured for each band (all eight of which make up a full octave band) which together comprise a sound pressure level spectrum. Sound power levels of each of the eight bands similarly constitute a sound power spectrum. Sound power levels and sound pressure levels of these eight bands (or any number of bands) may be added to arrive at a single value. This "addition" involves logarithmic functions. This spectrum of eight bands is most commonly used for reporting sound data.

We publish sound data for fans for various fan speeds at a reference distance of 5 feet as required by AMCA. Many times a customer will need data at intermediate speeds (for which no data is published) at a distance from the fans other than
5 feet.

There are several techniques that are useful to the layman in adapting noise ratings to his particular application. The first is adjusting a dBA rating to the distance where you are concerned. dBA ratings are generally published at five-foot distance. The adjustment is: dBA2 = dBA1 - 20 Log 10 (r2/r1) where r1 = 5 ft. and r2 is the distance or the desired rating. Note: if r2 is less than r1, this term is added to dBA1.

Speed also determines a fan's sound output. To adjust a dBA or sound power rating, the following approximation works well for speed: dBA2 = dBA1 + 55 Log 10 (RPM2/RPM1).

Using the example problem shown on page 13, let us assume that the customer needs to know the sound level of the fan. This fan is our Series A46-166DA-ST-J3 operating at 2638 RPM to provide 2750 CFM at 1.5" SP. From the manufacturer's published sound data, we find that the dBA at 5 feet is 89.0 at 2518 RPM and 91.1 at 2747 RPM. Since 2638 RPM is closer to 2747 RPM, we will use that data to calculate our actual sound level at 2638 RPM.

$$\text{dBA2} = \text{dBA1} + 55\ \text{LOG}\ \frac{\text{RPM2}}{\text{RPM1}}$$

$$\text{A 5 feet dBA2} = 91.1 + 55\ \text{LOG}\ \frac{2638}{2747} = 90.1\ \text{dBA}$$

Now suppose that the customer needs to know the sound level at a distance of three meters (3m).

$$\text{dBA2} = \text{dBA1} - 20\ \text{LOG}\ \frac{r2}{r1}$$

Now dBA1 = 90.10 at 5 feet

r1 = 5 feet

r2 = 3 m

$$\text{A 3 m dBA2} = 90.1 - 20\ \text{LOG}\ \frac{9.84}{5} = 84.2\ \text{dBA}$$

Noise control can involve several methods of attenuation. These methods depend upon which path the noise must travel to reach your ear.

In the fan business, most air related noise transmission can be attenuated with a muffler. In the case where installing a muffler may 0 The barrier should be of massive, dense material, acoustically lined, if possible, and at least two fan diameters square and one fan diameter away from the inlet. Barriers increase the distance sound must travel to reach our ears in addition to absorbing some acoustical energy.

SAFETY ACCESSORIES, APPLICATION AND USE WARNING

The safe application and use of equipment supplied by Hartzell Air Movement is the responsibility of the installer, the user, the owner, and the employer. Since the application and use of its equipment can vary greatly, Hartzell Air Movement offers various product types, optional safety accessories, and sound performance data per laboratory tests. Hartzell Air Movement sells its equipment with and without safety accessories, and accordingly, it can supply such safety accessories only upon receipt of an order. The need for safety accessories will frequently depend upon the type of system, fan location and operating procedures being employed. The proper protective safety accessories to meet company standards, local codes, and the requirements of the Occupational Safety and Health Act must be determined by the user since safety requirements vary depending on the location and use of the equipment. If applicable local conditions, standards, codes or OSHA rules require the addition of the safety accessories, the user should specify and obtain the required safety accessories from Hartzell Air Movement and should not allow the operation of the equipment without them.

Owners, employers, users and installers should read "RECOMMENDED SAFETY PRACTICES FOR USERS AND INSTALLERS OF INDUSTRIAL AND COMMERCIAL FANS" published by the Air Movement and Control Association International, Inc., 30 West University Drive, Arlington Heights, Illinois 60004. A copy of this publication is enclosed with each fan shipped from Hartzell Air Movement, and is available upon request at Hartzell's office in Piqua, Ohio 45356.

Please contact Hartzell Air Movement or your local Hartzell representative for more information on product types, safety accessories, and sound performance estimates. Remember, the selection of safety accessories and the safe application and use of equipment supplied by Hartzell Air Movement is **your** responsibility.

Material Corrosion Resitance Guide

Hartzell fans and blowers have rings, frames, housings, and supports fabricated from low carbon steel. All steel parts are phosphatized or sandblasted and finished with an enamel coating.

The standard axial flow propeller material is a sand-cast aluminum equivalent to Federal Spec. QQ-A-601, and chosen for its good strength, durability, and casting qualities. Other high strength alloys can be furnished at extra cost for special applications. Standard centrifugal wheels are fabricated from ASTM Standard A569 carbon steel.

Hartzell standard coatings specifications are tied to ASTM standards used within industry. These coatings are considered to be good to excellent for indoor/outdoor structures in an industrial environment.

CORROSION-RESISTANT MATERIALS AND COATINGS

For installations where extreme corrosive fumes are encountered, Hartzell fiberglass fans give unsurpassed resistance to the great majority of corrosive elements at a cost substantially below that of corrosion resistant metals. These fan units feature special high grade fiberglass propellers, duct sections, drive housings, bearing covers and seals - plus efficient shaft seals and slingers to protect bearings.

The special vinylester resin used in the construction of Hartzell's regular fiberglass duct fans, offers tremendous advantages over general purpose polyester and epoxy resins. It has higher corrosion resistance and it retains its strength when wet to a much greater degree than other polyester resins.

As a further refinement of the resin system, additives are made which give a flame spread rate of 25 or less without materially affecting the corrosion resistance. This feature is particularly desirable where both extreme corrosion resistance and high flame resistance are required.

Extra strength is built into all Hartzell fiberglass fans by the use of heavy flanges, extra glass tape joints, and extra glass reinforcing. In addition, all fans are given a finish brush coat of resin after assembly for more complete protection.

All bearing bolt and nut heads as well as bearing cover bolts and nuts exposed to the airstream are of stainless steel (or Monel, if specified) and are coated with resin after assembly. Shafts are normally of stainless steel but can be specified Monel for special service.

A modification can be furnished with special flange drilling to meet chemical plant specifications.

Hartzell can also furnish coatings to resist attack to fans made of metal. When conditions are moderate and the corrosive agent is a common acid or mild alkali, an epoxy coating can be used on steel and aluminum. This coating is also moisture and abrasion resistant. Based on converted epoxy/cycloaliphatic amine technology the epoxy coating has superior flexibility and toughness plus resistance to thermal shock. It may be used in air temperatures up to 250°F.

For more severe corrosive fumes and for excellent abrasion resistance plastisol and phenolic coatings are recommended. Applications for coatings of this type are usually sufficiently severe to justify a call to the factory to check on exactly what is needed for your specific application.

Housings and frames can be furnished in all stainless steel, aluminum or Monel. The exact grade of metal used depends on the nature of the installation. Unless otherwise specified, #304 housings will be furnished when stainless steel is ordered. #316 stainless steel is also available. All Hartzell fans and blowers for corrosive applications are guaranteed for one full year from the date of shipment.

Hartzell engineers are continually experimenting with special materials and coatings. Your Hartzell sales representative is prepared to recommend the most dependable solution to your corrosion problem.

									FIBERGLASS ***			COATINGS			
	Aluminum	Stainless 304	Stainless 316	Carbon Steel	Monel	Neoprene	Teflon	Viton	Interplastics 8441	Derakane 470	Derakane 510A/B	Epoxy (250 °F)	Inorganic Zinc (150 °F)		
Acetic Acid, to 10% (Fumes Only)	F	F	G	N	F	G	G	F	210	210	210	G	N	G	F
Acetone (Fumes Only)	G	G	G	G	G	F	-	N	N	N	180	G	G	-	F
Alcohol - Ethyl	F	G	G	F	F	G	-	F	150	N	80	G	G	-	F
Aluminum Acetate	N	-	G	-	F	N	G	N	-	-	-	G	-	-	F
Aluminum Hydroxide	G	G	G	N	N	G	G	-	180	-	180	G	N	-	F
Aluminum Sulphate	N	F	-	N	N	G	G	G	-	210	210	G	N	-	G
Amonia (Dry - 1%)	F	G	G	F	N	G	-	-	100	100	100	G	-	G	G
Amonia (Moist - 1%)	F	G	G	F	N	G	-	-	150	100	N	G	-	-	F
Ammonium Chloride	N	F	F	N	F	G	G	G	*210S	*210	*210	G	N	G	G
Ammonium Hydroxide to 5%	N	G	G	N	N	G	F	F	180S	180S	180S	G	N	G(10)	F
Ammonium Nitrate	F	G	G	N	N	F	G	G	210	210	220	G	N	G(30)	G
Ammonium Perchlorate	-	-	G	-	-	-	-	-	-	-	-	N	-	-	G
Ammonium Persulfate (Saturated)	N	G	G	N	N	G	N	G	180	180	180	N	-	-	G
Ammonium Phosphate	G	G	G	N	N	G	G	G	210	210	210	G	-	-	G
Ammonium Sulfate	N	G	F	N	F	G	G	F	210	210	220	F	-	G(10)	G
Ammonium Sulphite	N	G	F	N	N	G	-	-	-	100	150	G	-	-	G
Barium Chloride	N	G	N	N	F	G	G	G	210	210	210	G	N	-	G
Barium Hydroxide	N	F	G	N	F	G	G	G	150S	150	150	G	N	-	G
Barium Nitrate	F	G	G	G	N	G	-	-	-	-	-	F	N	-	G
Barium Sulphate	N	G	F	N	F	G	G	G	210	210	210	F	-	-	G
Benzene	F	G	G	F	G	N	G	G	N	N	N	G	G	-	G
Benzoic Acid	F	G	G	N	F	N	-	G	210	210	210	G	-	-	G

									FIBERGLASS ***			COATINGS			
	Aluminum	Stainless 304	Stainless 316	Carbon Steel	Monel	Neoprene	Teflon	Viton	Interplastics 8441	Hetron FR992	Dow 510A	Epoxiy(250 °F)	Inorganic Zinc (150 °F)	Coal Tar Epoxy (300 °F)	PLASITE 7122L (HAR,TFE)
Boric Acid (5%)	F	G	G	N	F	N	G	-	-	210	210	G	N	-	G
Bromine, Wet Gas	N	N	N	N	N	N	-	-	-	*90	N	G	-	G	F
Butyric Acid, to 50%	F	G	F	N	F	N	-	-	210	160	210	N	-	-	G
Calcium Carbonate	N	G	F	N	F	G	G	-	180S	180S	180S	G	-	-	G
Calcium Chlorate	F	F	F	F	F	F	G	-	210S	210	210	G	-	-	F
Calcium Choride	N	F	N	N	F	G	G	G	210S	210	210	G	N	-	G
Calcium Hydroxide	N	G	G	N	G	G	G	G	180S	180S	180S	G	N	-	F
Carbolid Acid	-	G	F	N	-	N	-	G	N	-	N	N	F	G(5)	N
Carbon Monoxide Gas	G	G	G	F	F	N	F	G	210	210	250	G	-	-	G
Carbon Tetrachloride	F	G	G	N	G	N	G	G	100	150	150	G	G	G	G
Chlorine Gas (Dry)	F	F	F	F	G	N	G	G	*210S	*180S	*220S	F	N	-	F
Chlorine Gas (Moist)	N	N	N	N	F	N	G	F	180S	180S	*220S	F	N	-	N
Chlorine Water	N	F	F	N	N	N	-	-	*180S	*180	*180	G	N	G	F
Chlorobenzene	F	G	G	F	G	N	G	G	N	N	N	F	F	-	F
Chromic Acid, to 5%	N	F	N	N	N	N	F	G	150	100	150	G(20)	N	N	F
Citric Acid	F	G	F	N	F	G	G	G	*210	*210	*210	G	N	G	F
Copper Acetate	N	-	G	N	N	F	-	N	-	160	-	G	-	-	F
Copper Chloride	N	N	N	N	N	G	G	G	*210	*210	*220	G	N	-	G
Copper Cyanide	N	G	F	N	N	G	G	G	210	210	210	G	-	-	F
Copper Nitrate	N	G	F	N	N	G	-	-	210	210	210	F	-	-	F
Copper Sulfate	N	G	F	N	N	G	G	G	210	210	210	F	N	-	G
Detergents	F	G	G	G	F	F	-	G	210	100	150	G	G	G	G
Ethyl Chloride	N	G	G	N	F	N	G	G	N	N	N	G	F	-	N
Ethylene Chloride	N	G	G	N	F	N	G	F	N	N	N	G	F	-	N

									FIBERGLASS ***			COATINGS			
	Aluminum	Stainless 304	Stainless 316	Carbon Steel	Monel	Neoprene	Teflon	Viton	Interplastics 8441	Hetron FR992	Dow 510A	Epoxy (250 °F)	ZInorganicinc (150 °F)	Coal Tar epoxy (300 °F)	PLASITE 7122L (HAR,TFE)
Ferric Nitrate	N	G	G	N	N	G	G	G	210	210	-	F	-	-	-
Ferric Sulphate	N	F	F	N	N	G	G	G	210	210	210	F	-	-	-
Ferrous Sulphate	N	F	N	N	F	G	G	-	210	210	210	F	N	-	G
Fluoboric Acid	N	F	-	-	F	G	G	-	210	180S	210S	N	-	-	F
Formalin Formaldehyde	F	F	G	N	G	N	G	N	150	-	120	G(20)	F	G	F
Formic Acid, to 10%	N	G	F	N	N	G	G	N	180	180	180	N	N	-	F
Furfural, to 10%	G	G	G	F	F	N	N	N	100	120	100	F	N	-	F
Gallic Acid	G	G	G	N	F	F	N	G	-	-	180	F	-	-	-
Gasoline	G	G	G	F	G	N	G	G	180	-	120	G	G	G	G
Hydrobromic Acid, to 25%	N	N	N	N	N	N	-	G	*180	*200	*180	N	-	-	-
Hydrochloric Acid, to 15%	N	N	N	N	N	F	G	F	*180S	*210S	*210S	N	N	G	F
Hypochlorous Acid	N	N	-	N	-	-	-	G	160S	90	100	N	-	-	-
Hydrocyanic Acid, to 10%	G	F	N	F	F	G	-	G	180	150	210	N	-	-	F
Hydrofluosilicic Acid, to 10%	N	N	N	N	F	F	G	G	*150S	*150S	*180S	N	N	-	G
Hydrofluoric Acid to 10%	N	N	N	N	F	F	G	N	*130S	*100S	*150S	N	N	-	N
Hydrogen Peroxide to 30%	G	G	F	N	N	N	G	F	150	100	150	G	N	G	F
Hydrogen Sulfide, to 5%	N	F	G	N	N	G	G	N	180	210	210	F	-	G	F
Lactic Acid	N	F	F	N	N	F	G	G	*210	*210	*210	N	-	-	G
Magnesium Carbonate	F	G	F	F	F	G	-	-	210S	-	180	G	G	-	-
Magnesium Chloride	N	N	N	N	F	G	G	G	210	210	210	G	N	-	G
Magnesium Nitrate	F	G	F	F	F	G	-	-	-	160	210	F	-	-	-
Magnesium Oxychloride	-	N	-	-	-	-	-	-	-	-	-	N	-	-	-
Maleic Acid	F	G	G	N	F	N	F	G	210	180	180	N	N	-	G
Manganese Carbonate	F	-	-	-	-	-	-	-	-	-	-	G	-	-	-
Mercurous Nitrate	N	G	G	F	N	F	-	-	-	-	-	F	-	-	F
Methyl Ethyl Ketone, to 10%	G	G	G	G	G	N	G	N	N	N	N	G	G	F	F
Mehtylene Chloride	N	G	G	G	F	N	-	F	N	N	N	N	F	-	F
Naphtha	G	G	G	G	F	N	G	G	180	180	180	G	G	G	G
Napthalensulfonic Acid	-	N	-	-	-	N	-	-	-	-	-	N	-	-	G
Nickel Chloride	N	N	N	N	N	F	G	G	210	210	210	G	-	-	G
Nickel Nitrate	N	G	F	F	N	G	-	-	210	210	210	F	-	-	-
Nickel Sulfate	N	F	F	N	F	G	G	G	210	210	210	F	-	-	-
Nitric Acid, to 5%	N	G	G	N	N	F	G	F	150	160	150	N	N	F	F
Nitrous Acid	N	G	F	N	N	N	-	-	-	-	-	N	-	-	F
Oleic Acid	F	G	G	N	F	N	G	F	210	200	210	G	N	-	G
Oxalic Acid, to 10%	N	G	F	N	F	N	G	G	*210	-	*120	G	N	G(20)	G
Ozone	F	F	G	F	G	N	G	G	-	-	N	-	-	-	-
Perchloric Acid to 10%**	N	N	F	N	G	F	G	G	150	150	150	N	N	-	F
Phenol, to 10%	G	G	G	N	F	N	G	G	N	-	N	G(10)	F	-	N
Phosphoric Acid, to 10%	N	N	G	N	N	F	-	G	*210S	*210S	*210S	N	N	N	F
Phosphoric Anhydride	G	-	-	N	-	N	-	-	-	-	-	F	-	-	-
Picric Acid, to 10%	N	G	G	N	N	G	G	G	-	-	N	N	-	-	F
Potassium Bromide	N	G	F	N	F	G	-	-	160	160	210	G	-	-	G
Potassium Chloride	N	G	F	N	F	G	G	G	210	210	210	G	N	-	G
Potassium Cyanide	N	G	N	F	F	G	G	G	N	-	-	F	-	-	G
Potassium Dichromate	G	G	G	F	F	G	G	G	210	210	210	F	-	-	-
Potassium Ferricyanide	F	G	G	N	F	G	-	-	210	210	210	G	-	-	-
Potassium Ferrocyanide	F	G	G	N	G	G	-	-	210	210	210	G	-	-	G
Potassium Hydroxide, to 25%	N	G	G	F	G	G	G	G	-	150S	150S	G	N	G	G
Potassium Hypochlorite	-	N	F	N	N	F	-	-	-	-	-	G	-	-	-
Potassium Nitrate	G	G	G	G	F	G	G	G	210	210	210	G	N	-	G
Potassium Permanganate	F	G	G	G	F	G	-	-	210	210	210	F	-	G(5)	-
Potassium Sulfate	F	G	F	G	G	G	G	G	210	210	210	G	N	-	F
Pyrogallic Acid	F	G	G	G	F	G	-	-	-	-	-	F	-	-	-
Salt Spray	F	F	-	N	F	G	G	G	200	-	210	G	-	G	G
Silver Bromide	N	N	-	N	F	-	-	-	-	-	-	G	-	-	-
Silver Nitrate	N	G	G	N	N	F	G	G	210	210	210	G	-	-	F
Sodium Acetate	G	G	F	N	F	F	G	N	210	210	210	G	N	-	-
Sodium Bisulfate	N	N	G	N	F	G	G	G	210	210	210	G	-	-	G
Sodium Borate	F	G	G	F	F	G	G	G	-	210	210	G	-	-	-
Sodium Carbonate, to 35%	N	G	G	G	G	G	-	-	160S	160S	180S	G	-	-	G
Sodium Chlorate	N	G	G	F	N	G	-	-	210	210	210	N	N	-	G
Sodium Chloride	F	F	F	N	F	G	G	G	210	210	210	G(30)	N	G	G
Sodium Citrate	N	-	-	-	-	-	-	-	210	-	-	F	-	-	G
Sodium Dichromate	-	-	G	F	F	N	-	-	210	210	210	F	-	-	-
Sodium Ferricyanide	G	-	G	-	F	-	-	-	210	210	210	G	-	-	-
Sodium Fluoride	N	N	G	N	F	F	-	-	180S	180S	180S	F	-	-	-
Sodium Hydroxide, to 10%	N	G	G	F	G	F	G	F	150S	160S	180S	G	N	G	F
Sodium Hypochlorite, to 15%	N	F	N	N	N	F	G	G	150S	150S	180S	F	N	G(5)	F
Sodium Hyposulfite	N	G	-	-	F	-	-	-	-	-	-	F	-	-	-
Sodium Nitrate	G	G	F	G	F	F	G	G	210	210	210	F	N	-	G
Sodium Nitrite	G	-	G	F	N	N	-	-	210	210	210	F	N	-	G
Sodium Perchlorate, to 10%	-	-	-	-	-	-	-	-	-	-	100	N	-	-	-
Sodium Peroxide	N	G	G	N	F	F	G	F	-	-	-	F	-	-	-
Sodium Phosphate	N	-	F	F	F	N	G	G	-	-	210	G	N	G(10)	F
Sodium Salicylate	N	-	-	-	-	-	-	-	210	-	-	G	-	-	F
Sodium Silicate	F	G	G	G	F	G	-	-	210S	210	210	G	N	-	G
Sodium Sulfate	F	G	F	F	G	G	-	G	210	210	210	F	N	-	F
Sodium Sulfite	F	G	F	N	N	G	-	-	210	210	210	F	N	-	G
Sodium Sulfide	N	G	F	F	F	G	-	-	210S	210S	210S	G	N	-	G
Stannic Chloride	N	N	N	N	N	F	G	G	*210	*180	*210	N	-	-	-
Stannous Chloride	N	F	F	N	F	G	-	G	*210	*210	*210	F	-	-	G
Steam Vapor	G	G	G	G	F	N	G	-	200	210	180	F	-	-	N
Stearic Acid	G	G	G	N	F	F	G	G	210	210	210	G	N	-	G
Strontium Hydroxide	N	-	G	-	-	-	-	-	-	-	-	G	-	-	-
Strontium Nitrate	N	-	-	-	-	-	-	-	-	-	-	F	-	-	-
Sulfur Dioxide Gas	F	N	G	F	F	N	G	F	210	210	210	N	-	-	G
Sulfuric Acid, to 25%	N	N	F	N	F	F	G	G	*200	*210	*210	N	N	G	F
Sulfurous Acid, to 10%	N	F	F	N	N	N	G	N	100	100	120	N	-	-	F
Tannic Acid	N	G	G	F	F	G	F	G	210	210	210	G(50)	N	G	G
Tartaric Acid	F	F	G	N	F	G	G	G	210	210	210	G	N	-	F
Trichlorethylene	F	G	G	F	F	N	G	G	N	N	N	N	F	-	F
Water (Moisture)	G	G	G	N	G	G	G	G	180	180	200	G	G	G	G
Xylol-Toluol	G	G	G	G	F	N	G	G	N	N	80	G	G	G	G
ZInc Chloride	N	G	N	N	-	G	G	G	-	*210	*210	G	N	-	G
Zinc Cyanide (Moist)	N	-	-	-	-	-	-	-	-	-	-	G	-	-	-
Zinc Nitrate	-	-	G	-	-	-	-	-	210	210	210	F	-	-	-
Zinc Sulfate	N	G	F	N	F	G	G	G	210	210	210	F	N	-	-

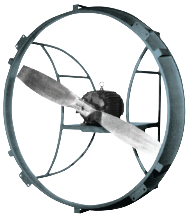
* - Special shaft and hardware required.
** - Special design considerations (explosive environment), contact factory.
*** - Temperature values shown for fiberglass resins are for immersion or condensate contact applications.

Where temperature values are shown, resin is suitable for hood and duct type applications for the full operating temperature of the product. See product specifications for materials of construction and maximum operating temperature limits. Concentrations are considered to be 100% except when indicated by (%).

KEY: G = Good F = Fair N = Not Recommended
- = Unknown S = Synthetic Veil Required
H&D: Suitably for hood and duct applications at ambient conditions only

Hartzell
AIR MOVEMENT

OTHER PRODUCTS INCLUDE: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Vaneaxial Blowers


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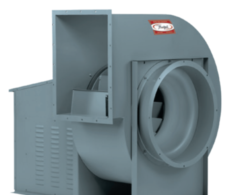
Steel Centrifugal Blowers


Roof Ventilators – Steel and Fiberglass


Direct Gas Fired Door Heater


Fiberglass Axial Flow Fans


Fiberglas Centrifugal Blowers


Marine – Mine Duty Blowers

More than 50 Hartzell representative offices can provide specific performance and installation data to meet your requirements. Call your Hartzell Air Movement representative for assistance. Visit www.hartzellairmovement.com or call 800.336.3267 for the name of your representative.

CONNECT WITH US!

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