Fundamentals of Fans

Speaker: Luke Powell
Vice President, Air Equipment Company

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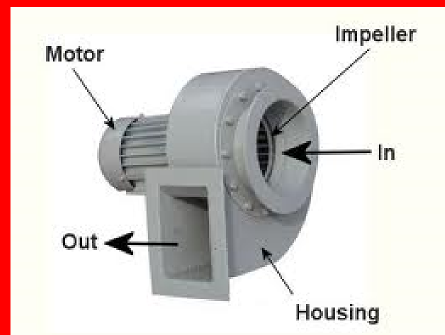
Overview

- Fan Laws
- Fan Testing
- Different Fan Types
- Bearings
- Construction Requirements
- System Effects Video



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Fan Laws

$$\frac{CFM_{new}}{CFM_{old}} = \frac{RPM_{new}}{RPM_{old}}$$

These rules are only valid within a fixed system with no change in the aerodynamics or airflow characteristics of the system. For the purpose of this discussion, a system is the combination of ductwork, hoods, filters, grills, collectors, etc., through which air is distributed.

The first fan law relates the airflow rate to the fan rotational speed: Volume flow rate (CFM) is directly proportional to the fan rotational speed (RPM). If the fan RPM is increased, the fan will discharge a greater volume of air in exact proportion to the change in speed.

Fan Laws

- CFM = **10,000**
- SP = 2”
- RPM = **1,000**
- BHP = 10

- CFM = **12,000**
- SP =
- RPM =
- BHP =

n

Fan Laws

- CFM = **10,000**
- SP = 2”
- RPM = **1,000**
- BHP = 10

- CFM = **12,000**
- SP =
- RPM = **1,200**
- BHP =

Fan Laws

$$\frac{SP_{new}}{SP_{old}} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^2$$

The second fan law relates the fan total pressure or fan static pressure to the fan rotational speed: Total or static pressure is proportional to the square of the fan rotational speed. If it is desired to increase the flow to 20,000 CFM without any physical change in the system, the required SP would be 4”

Fan Laws

- CFM = 10,000
- SP = **2”**
- RPM = **1,000**
- BHP = 10

- CFM = 12,000
- SP =
- RPM = **1,200**
- BHP =

n

Fan Laws

- CFM = 10,000
- SP = **2”**
- RPM = **1,000**
- BHP = 10

- CFM = 12,000
- SP = **2.88”**
- RPM = **1,200**
- BHP =

n

Fan Laws

$$\frac{BHP_{new}}{BHP_{old}} = \left(\frac{\mathrm{RPM}_{\mathrm{new}}}{\mathrm{RPM}_{\mathrm{old}}}\right)^{3}$$

The third fan law relates the total or static air power (and the impeller power), to the fan rotational speed: Power, is proportional to the cube of the fan rotational speed.

Fan Laws

- CFM = 10,000
- SP = 2”
- RPM = **1,000**
- BHP = **10**

- CFM = 12,000
- SP = 2.88”
- RPM = **1,200**
- BHP =

n

Fan Laws

- CFM = 10,000
- SP = 2
- RPM = **1,000**
- BHP = **10**

- CFM = 12,000
- SP = 2.88”
- RPM = **1,200**
- BHP = **17.3**

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Fan Testing

Duct Traverse Formats			
Duct Configuration	ASHRAE Handbook	Industrial Ventilation Manual	AMCA Publication 203
Rectangular	16 to 64 equal areas, maximum of 6 inches apart	16 to 64 equal areas, maximum of 6 inches apart	24 to 100 equal areas
Circular	20 equal concentric areas, along 2 diameters	6 to 12 (small duct), 10 to 20 (medium duct), 20 to 40 (large duct), equal concentric areas, along 2 diameters	24 to 48 equal concentric areas, along 3 diameters

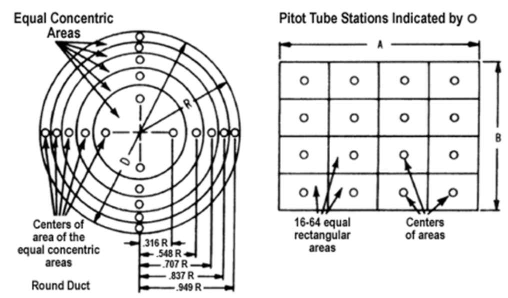

Fig. 4 – Traverse on round and square duct areas

-Since velocity in a duct is seldom uniform across any section, a traverse is usually made to determine average velocity. Velocity is lowest near the edges or corners, and greatest near center. Fig. 4 shows suggested Pitot tube locations for traversing round and rectangular ducts. To determine average velocity in the duct from the readings, average the calculated individual velocities or the square roots of the velocity heads. The number of traverse points should increase with increased duct sizes.

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Fan Testing

-Calculating velocities and air volumes for airflow measuring and traverse probe stations

$$Air\_Velocity(FPM): 4005 \times \sqrt{Velocity\_Pressure(in.wc)}$$

$$\boldsymbol{Station\_Air\_Volume(CFM): Air\_Velocity(FPM) \times Station\_Area(F^2)}$$

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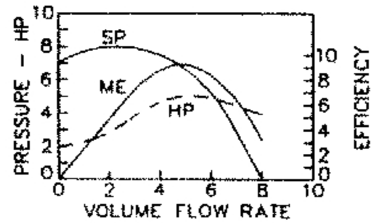
Different Fan Types

Airfoil



Impeller Design	Housing Design	Performance Characteristics	Applications
-Highest efficiency of all fan designs. 9 to 16 blades of airfoil contour curved away from the direction of rotation. Air leaves the impeller at a velocity less than its tip speed and relatively deep blades provide for efficient expansion within the blade passages. This will be the highest speed of the fans.	-Scroll-type, designed to permit efficient conversion of velocity pressure to static pressure, thus permitting a high static efficiency. The clearance and alignment between wheel and inlet bell is very close in order to reach the max efficiency capability.	-Highest efficiencies occur 50 to 65% of wide open volume. This is also the area of good pressure characteristics; the horse power curve reaches a maximum near the peak efficiency area and becomes lower towards free delivery, a self-limiting power characteristics.	-General heating, ventilating and air-conditioning systems. Used in large sizes for clean air industrial applications where power savings are significant.

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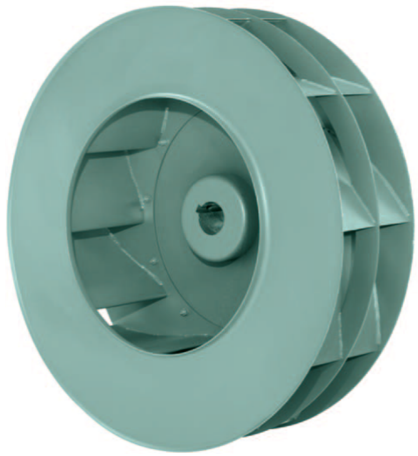
Different Fan Types



AIRFOIL WHEEL

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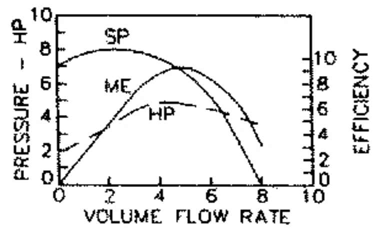
Different Fan Types

Backward-Inclined
Backward-Curved



Impeller Design	Housing Design	Performance Characteristics	Applications
-Efficiency is only slightly less than that of airfoil fans. Backward-curved blades are slightly curved away from the direction of rotation and are single thickness.	-Scroll-type, designed to permit efficient conversion of velocity pressure to static pressure, thus permitting a high static efficiency. The clearance and alignment between wheel and inlet bell is very close in order to reach the max efficiency capability.	-Peak efficiency is slightly lower than airfoil fan. Unstable left of peak pressure. Highest efficiencies occur 50 to 65% of wide open volume. This is also the area of good pressure characteristics. The horsepower curve reaches a max near the peak efficiency area.	-General heating, ventilating and air-conditioning systems. Also used in some industrial applications where the airfoil blade is not acceptable because of corrosive and/or erosion environment.

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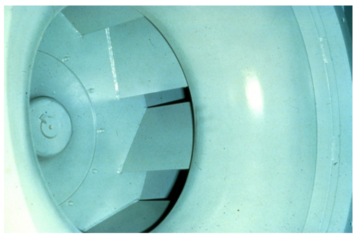
Different Fan Types



Backward Inclined Wheel

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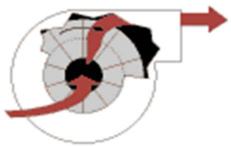
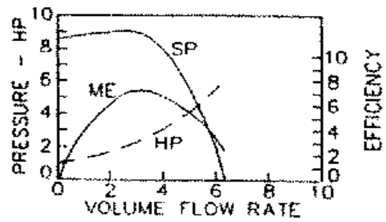
Different Fan Types

Radial



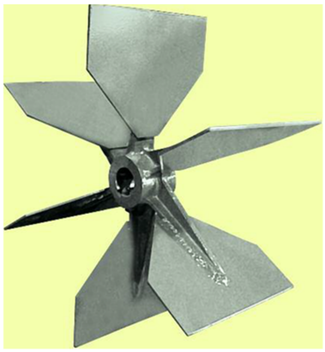


Impeller Design	Housing Design	Performance Characteristics	Applications
-Simplest of all fans and least efficient. High mechanical strength and the wheel is easily repaired. Requires medium speed for a given point of rating.	-Scroll-type, usually the narrowest design of all fan designs because of required high velocity discharge. Dimensional requirements of this housing are more critical than for air-foil and backward-inclined blades.	-Higher pressure characteristics than the backward-inclined and airfoil fans. Power rises continually to free delivery.	-Used Primarily for material-handing applications in industrial plants. Wheel can be of rugged construction and is simple to repair in the field. Wheel can be coated for special materials. Not commonly found in HVAC applications.

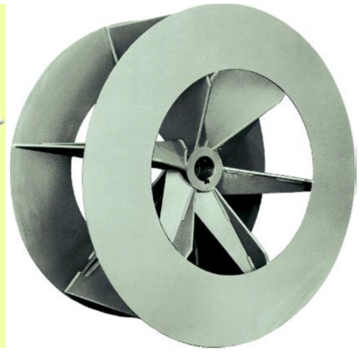
Different Fan Types

RADIAL WHEEL

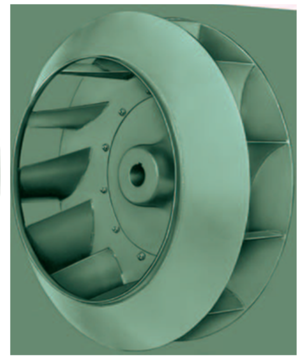
Open Sider Design



With RIMS



Radial Tip Forward Curved Heal



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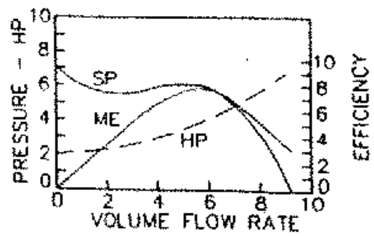
Different Fan Types

Forward Curved



Impeller Design	Housing Design	Performance Characteristics	Applications
-Efficiency is less than backward-curved fans. Fabricated of lightweight and low cost construction. Has 24-64 shallow blades with both the heel and tip curved forward. Air leaves wheel at velocity greater than wheel tip speed. Wheel is the smallest of all fans and operates at lowest speed.	-Scroll is similar to other fan designs. The fit between the wheel and inlet is not as critical as on airfoil and backward-inclined bladed fans. Uses large cut-off sheet in housing	-Pressure curve is less steep than that of backward-curved bladed fans. There is a dip in pressure curve left of the peak pressure point and highest efficiency occurs to the right of peak pressure, 40-50% of wide open volume. Power curve rises continually toward free delivery.	-Used primarily in low-pressure heating, ventilating, and air-conditioning applications such as domestic furnaces, central station units, and packaged air-conditioning equipment from room air-conditioning units to roof top units.

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Different Fan Types

Forward Curved Wheel

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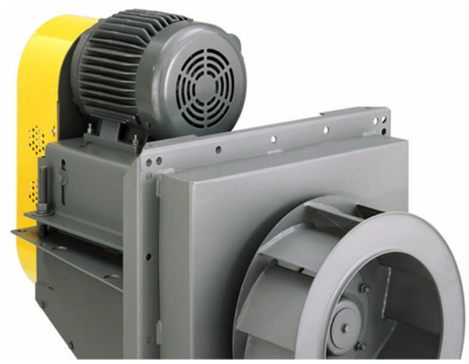
Different Fan Types



Plug Fan

(For oven or furnace recirculation)

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Different Fan Types

Vane Axial

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Bearing Types

- **Ball**
  - Single Row
  - Double Row

- **Spherical Roller**
  - Double Row

- **Cylindrical**
  - Single Row

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Bearing Failures

Common Types of Failures	**Common Causes of Failures**
Overheating	Lubrication
Brinelling	Skidding-Light Loading
Fretting Corrosion	Loose Shaft Fit
Fatigue	Bent Shaft
Misalignment	Set Screws Loosened
Preventative Maintenance	
Auto-Lubrication Device	
Vibration/Temperature Monitors	

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Fan Maintenance

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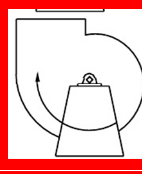
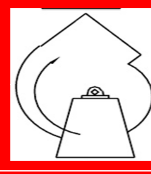
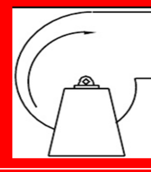
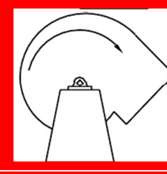
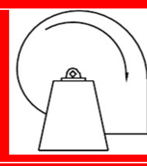
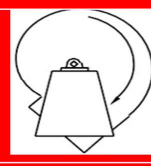
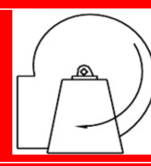
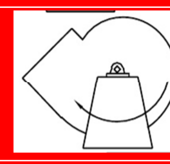
Rotation and Discharge

**Direction of rotation is determined by drive side of fan*

Description	Clockwise Up Blast	Clockwise Top Angular Up	Clockwise Top Horizontal	Clockwise Top Angular Down
AMCA STD	CW-360	CW 1-89	CW 90	CW 91-179
Customary	CW-UB	CW-TAU	CW-TH	CW-TAD

Description	Clockwise Down Blast	Clockwise Bottom Angular Down	Clockwise Bottom Horizontal	Clockwise Top Bottom Angular Up
AMCA STD	CW-180	CW 181-269	CW 270	CW 271-359
Customary	CW-DB	CW-BAD	CW-BH	CW-BAU

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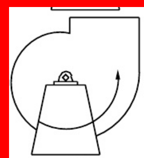
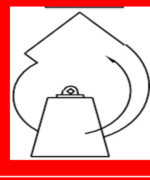
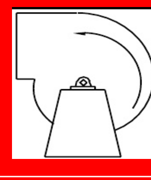
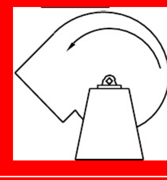
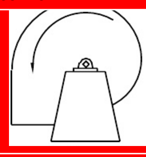
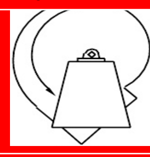
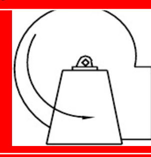
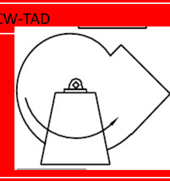
Rotation and Discharge

**Direction of rotation is determined by drive side of fan*

Description	Counterclockwise Up Blast	Counterclockwise Top Angular Up	Counterclockwise Top Horizontal	Counterclockwise Top Angular Down
AMCA STD	CCW-360	CCW 1-89	CCW 90	CCW 91-179
Customary	CCW-UB	CCW-TAU	CCW-TH	CCW-TAD

Description	Counterclockwise Down Blast	Counterclockwise Bottom Angular Down	Counterclockwise Bottom Horizontal	Counterclockwise Top Bottom Angular Up
AMCA STD	CCW-180	CCW 181-269	CCW 270	CCW 271-359
Customary	CCW-DB	CCW-BAD	CCW-BH	CCW-BAU

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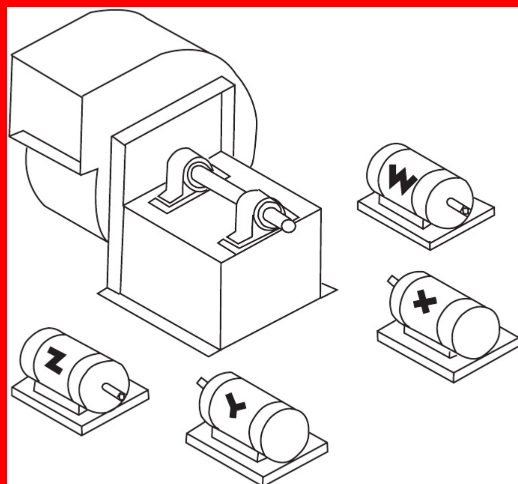
Motor Position



To determine the location of the motor, face the drive side of the fan and pick the proper motor position designated by the letters W,X,Y, or Z as shown in the drawing to the left.

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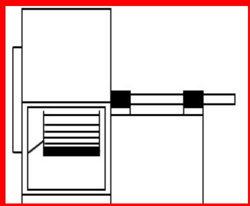
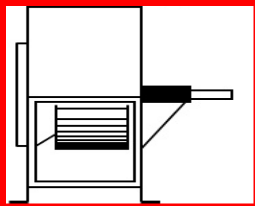
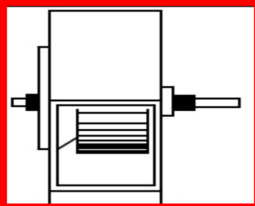
Drive Arrangements



ARR. 1 SWSI
For belt drive or direct drive. Impeller overhung, two bearings on base



ARR. 2 SWSI
For belt drive or direct drive. Impeller overhung. Bearings in bracket and supported by fan housing



ARR. 3 SWSI
For belt drive or direct drive. One bearing on each side and supported by fan housing.

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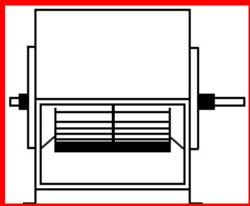
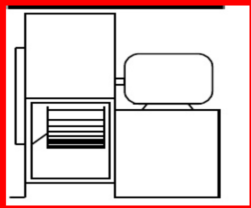
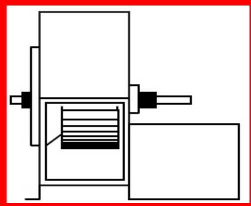
Drive Arrangements



ARR. 3 DWDI
For belt drive or direct drive. 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 directly connected



ARR. 7 SWSI
For belt drive or direct drive. Arrangement 3 plus base for prime mover.

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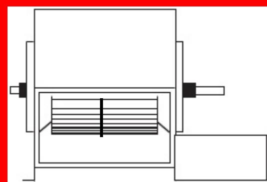
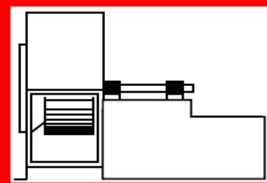
Drive Arrangements



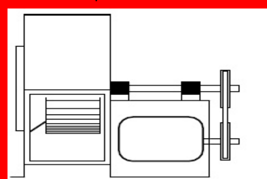
ARR. 7 DWDI

For belt drive or direct drive. Arrangement 3 plus base for prime mover



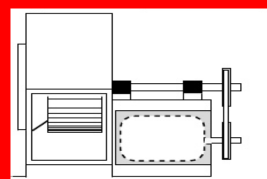
ARR. 8 SWSI

For belt drive or direct drive. Arrangement 1 plus extended base for prime mover.



ARR. 9 SWSI

For belt drive. Impeller overhung. Two bearings with prime mover outside base.



ARR. 10 SWSI

For belt drive. Impeller overhung. Two bearings with prime mover inside base.

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System Effects

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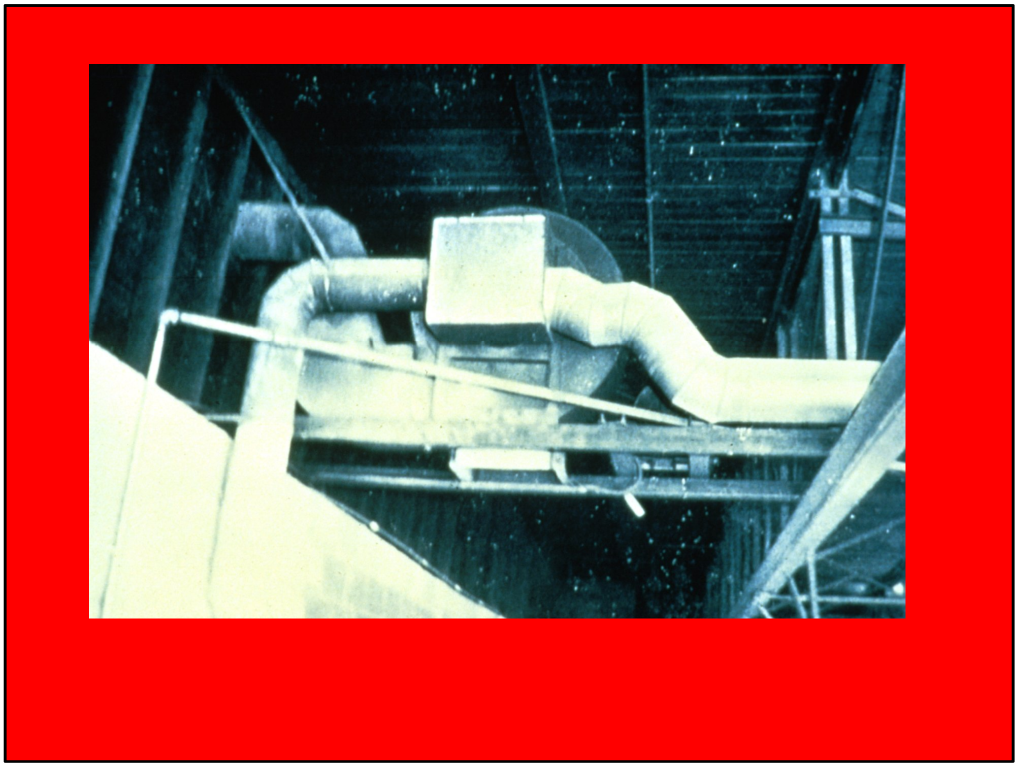

QUESTIONS
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Please visit us at www.aecky.com

THANK YOU FOR YOUR TIME!

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