

Chapter 12

Industrial Ventilation

Introduction

Industrial Ventilation is an important method for reducing employee exposures to airborne contaminants. Ventilation is used to reduce or remove contaminants from employees.

There are two major (2) types of industrial ventilation:

1. **Dilution systems:** reduce the concentrations of contaminants released in a work room by mixing with air flowing through the room. Natural or Mechanical induced air movement can be used to dilute contaminants.
2. **Local exhaust ventilation (LEV):** systems capture or contain contaminants at their source before they escape into the workplace environment. The main advantage of these systems is that they remove contaminants in place of diluted them depending upon 100% collection efficiency.

Natural ventilation: is air movement within a work area due to wind, temperature differences between the exterior and interior of a building. Even moderate winds can move large volumes of air through open doors and windows. For example, a 15 mph wind blowing directly through a window of an open area of 36 ft² can move 25,000 ft³ min or more through the building if the air can escape through a doorway or other large opening.

Mechanical ventilation: systems that range from simple wall-mounted propeller fans or roof-mounted mechanical ventilators to complex engineered designs. They are efficient air movers only as long as there is an adequate amount of make-up air supply.

Makeup Air: is air that enters the workroom to replace air exhausted through the ventilation system. A ventilation system will not work properly if there is not enough air in the room to exhaust.

Makeup Air key notes:

- The supply rate should exceed the exhaust rate by 10%.
- The air should flow from cleaner areas of the workplace or plant.
- Makeup air should provide some cooling in the summer or in hot process areas.
- Makeup air should be provided 8-10 ft from the floor.
- Air should be heated to a temperature of 65F during winter months.
- Makeup air should not be contaminated by other exhaust sources.

Fans

Fans generate the airflow needed to provide industrial ventilation. There are two (2) major classes of fans, centrifugal and axial flow fans.

Centrifugal fans move air by blades on rotating fan wheel throwing air outward from the center inlet at a higher velocity or pressure than air entering the fan.

Axial fans the air travels to the fan shaft and leaves the fan in the same direction as it entered propeller.

In Local Exhaust Ventilation systems, centrifugal fans are more widely used than axial fans because they are quieter, less expensive to install and operate and generate higher pressures than axial fans of the same airflow capacity.

Air-Cleaning Devices

The ideal air cleaner would have these features; low initial and operating costs, high efficiency, no decline in operating efficiency or any service interruptions between cleaning and maintenance cycles and without hazardous employee exposures.

Filters: trap particulates as the exhaust the flows through a porous medium. These filters may be made of woven or felted (pressed) fabric, paper or woven metal, depending upon the application. They can be disposable and/or reusable and configured to be mats, cartridges, bags and envelopes.

Electrostatic precipitators: charge the particles by means of an electric field that is strong enough to produce ions that adhere to the particles. The charged particles are then collected by weaker field that causes the particle to migrate toward and adhere to the electrode with the opposite charge. Precipitators are greatest in systems where gas volume is large and high collection efficiency for small particles is needed.

Cyclones: use a circular motion to the exhaust gas and causes particulates to move to the outer part of the air stream where they impact the cyclone walls. Air velocity is lower at the wall and the particulates drop down the wall into a collection hopper at the bottom.

Wet scrubbers: water and/or other liquids collect the particles in water droplets, to collect extremely fine particles it is necessary to generate small water droplets moving at a high rate of speed. Wet scrubbers can remove particles as small as 0.2 μm . Any smaller particles there must be an increase in the amount of energy used to create contact with the smaller water droplets. Scrubbers that use absorption and/or chemical reaction are widely used for gas and vapor removal.

“Baghouse”: is a typical example of an air cleaner, it is a configuration of tubular fabric filters arranged in a housing along with cleaning mechanism which can be automated or manual operated by shacking device and a means of blowing air back through the bags from the clean side. Another method used is the dislodging of accumulated dust cake. Chunks of cake that dislodged from the cleaning cycle should be large enough so that they are not re-entrained in the exhaust gas stream, or the section being cleaned should be isolated from the remainder of the baghouse. Baghouses can collect practically used on all particles greater than 1 μm .

Gas and vapor removal: removal techniques for gases and vapors are absorption, adsorption and oxidation.

Absorption: is a diffusion process where molecules are transferred from the exhaust gas to a liquid. Mass transfer occurs at the interface between the gas or vapor molecule and the liquid. A spray

chamber or another simple device may work for materials with low solubility or where a chemical reaction occurs between the contaminant and liquid prior to absorption a packed bed is often used to maximize contact.

Adsorption: is the process where a gas or vapor adheres to the surface of a porous solid material. The contaminant condenses into very small liquid droplets at ambient temperature higher than its boiling point. This principal is well known to industrial hygienists through the use of carbon sampling devices. The contaminant can be recovered from the adsorbent by heating, steam flushing, air stripping vacuum treating or any other method that vaporizes the condensed material.

Oxidation or combustion: devices are used when the air contaminants are combustible. They oxidize (burn) the contaminants under a variety of operating conditions. These systems are not very cost effective and do not work well when the airstream contains particulates.

Testing Equipment

Smoke tube test: smoke tubes are glass tubes containing a chemical that produces a chemical fume (smoke) as room air is blown through the tube with a hand-operated bulb. They are useful in evaluating:

- the capture range of hoods.
- identifying draft and other factors that can interfere with hood performance.
- demonstrating the capture distance of hoods to workers so they can position the hood or work item properly.

Manometer: a instrument for measuring pressure: essentially a U-tube partially filled with a liquid (usually water), mercury or light oil and constructed in such a way that the amount of displacement of the liquid indicates the pressure being exerted on the instrument.

Velometer: contains a vane or paddle that moves according to velocity of the air passing through the instrument. The paddle is connected mechanically to a meter that displays the velocity.

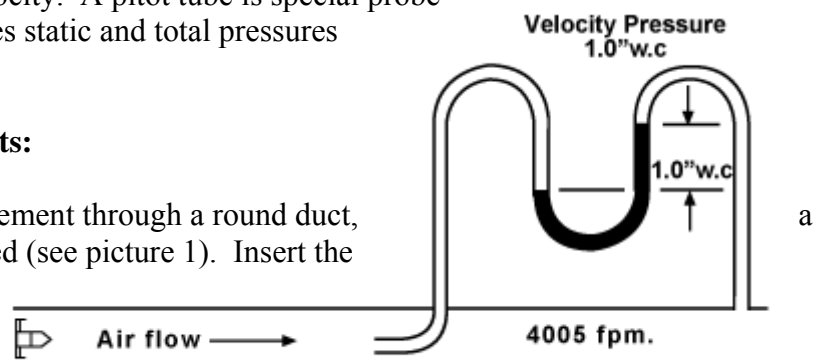
Aerometer: has a propeller-like velocity sensor connected either a mechanical or electronic readout unit. This device comes in a variety of sizes the smaller ones have a thin probe while larger ones have a propeller that is several inches in diameter.

Pitot-tube devices: these instruments determine the velocity pressure inside a duct and are connected to liquid manometer or pressure sensor that displays output in either inches of water velocity pressure or directly in velocity. A pitot tube is special probe-like device that accurately measures static and total pressures inside a duct.

Taking Ventilation Measurements:

Ducts:

To measure the amount of air movement through a round duct, pitot tube & manometer can be used (see picture 1). Insert the pitot tube into a small hole in the side of the duct. The open end of



the pitot tube must face into the air flow, so air blows into the tube. The pitot tube must be connected to a manometer. The manometer will show you the difference between static pressure & total pressure. This difference is called the velocity pressure. Thus, if the manometer reads 1" of water column, then the vapor pressure equals 1. Use the formula $V = 4005\sqrt{VP}$

Where:

V=Velocity

VP=Vapor Pressure

Once you have the velocity, calculate the CFM by using the formula $Q = AV$

Where:

Q=CFM

A=Area – Calculate using $A = \pi r^2$

Where A=Area

$\pi = \text{pie}$

r^2 = radius (half the diameter in feet) squared (multiplied times itself).

Example, to calculate the area of a 6 inch diameter duct, the formula would

be: $A = \pi \cdot .5^2 = .785CFM$ Don't

forget to change from inches to feet.

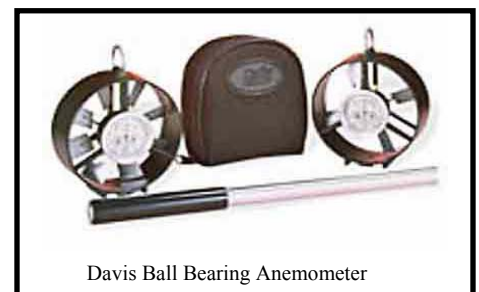
This is a common mistake.

Underground:

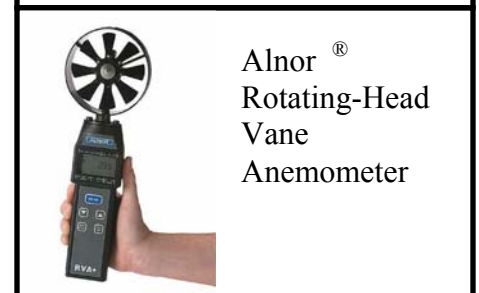
Underground ventilation readings are fairly simple to take with an anemometer. There are many anemometers available. The picture at the right has a couple of anemometers.

Taking underground ventilation readings will take several steps. Take each step on at a time & record each result. The steps are pretty easy!

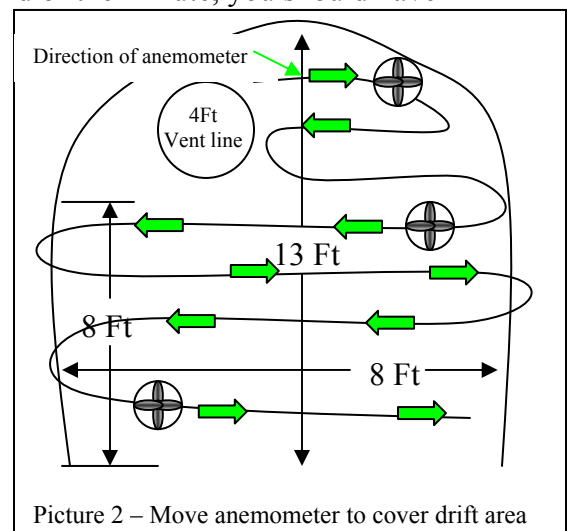
1. Using your anemometer (usually connected to a pole so you can reach the top of the drift) measure the velocity. Do this by starting at the top of the drift & move your anemometer from side to side, bringing it down about a foot each time. The intension is to cover all areas of the width & height of the drift. Do this for exactly one minute. At the end of the minute, you should have covered nearly every square foot of the drift (from bottom to top, side to side, in a straight line (see Picture 2). After one minute, read the anemometer to get the velocity (Feet Per Minute)(FPM). This can be repeated 2 or 3 times to get a consistent average. Write down the velocity in FPM.
2. Measure the drift. Picture 3 shows a theoretic drawing with dimensions of an underground drift. Most drifts will have an arched top for ground stability. This causes us to do an extra step to figure out the area.
 - a. Measure the width of the drift & the height of the sill (the distance from the



Davis Ball Bearing Anemometer



Alnor[®]
Rotating-Head
Vane
Anemometer



Picture 2 – Move anemometer to cover drift area

floor along the side to the point where the arch begins). When measuring, keep the units in feet, not inches (example 8.25 ft). Multiply the width times the height to get the area up to the sill. Write the area down.

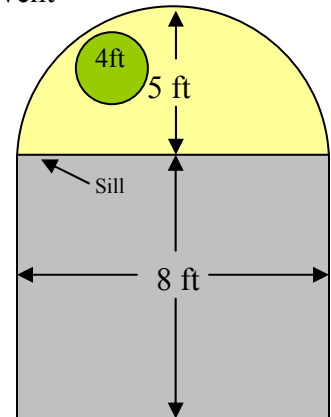
- b. Measure the distance in feet from the sill to the top of the arch (sometimes referred to as the back). This can also be done by measuring from the floor to the back, then subtracting the distance measured in the previous step from the floor to the sill.

Calculate the area by using the formula $A = \frac{\pi r^2}{2}$. Where:

- i. A=Area
- ii. $\pi = \text{pie}$
- iii. $r^2 = \text{radius squared (times itself)}$

Write the number down.

- c. In this figure, a 4-foot vent line is against the back. The vent line takes away from the area of the drift. Calculate the area of the vent line using the same formula as above $A = \pi r^2$.
- d. Now, add the area from step a & b, & subtract the area of the vent line in step c.



Picture 4

Example from Picture 4:

1. Calculate area from floor to sill (shaded in grey)
 - a. Area from floor to sill = 8 foot
 - b. Area from rib to rib = 8 foot
 - i. $8 \times 8 = 64 \text{ square feet}$
2. Calculate area at back (arch)
 - a. Use area of a circle formula $A = \frac{\pi r^2}{2}$. (Since we are only calculating half of the circle, we are dividing the answer by 2).
 - i. $A = \frac{\pi r^2}{2} = \frac{\pi * 5^2}{2} = 39.27 \text{ square feet}$
3. Calculate the area of the vent line – Please note that if there is no vent line, this step can be skipped.
 - a. Use the same formula as above, but do not divide the answer by 2
 - i. $A = \pi r^2 = \pi * 2^2 = 12.6 \text{ square feet.}$
4. Calculate the final area by adding the square feet from sill to floor to the area of the arch. Then subtract the area of the vent line:
 - a.

64.0
+39.27
<u>-12.6</u>
90.67 sqft
5. Now, multiply the final area (90.67 sqft) to the velocity (measured with the anemometer in Feet Per Minute (FPM)).
 - a.

90.67 SQFT
<u>x 350.0 FPM</u>
31,734 CFM (Cubic Feet Per Minute)

Vent Hoods:

Measure the ventilation in a vent hood exactly the same way you would an underground drift. However, it is much easier!

1. Measure velocity with anemometer. Cover face of hood with a sweeping motion for 1 minute, similar to underground above.
2. Measure height & width of face in feet.
3. Multiply height times width times velocity (FPM).
 - a. $W \times H \times \text{FPM} = \text{CFM}$
4. Example:

a.
$$\begin{array}{ccc} W & \times & H \times \text{FPM} \\ \downarrow & & \downarrow \quad \downarrow \\ 5 & \times & 4 \times 35 = 700 \text{ CFM} \end{array}$$

