Industrial Ventilation: It’s not just Blowing Smoke!

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Industrial Ventilation

It could be called this
Abstract

- Abstract: People have needed smoke and dust free workspaces since the beginning of time. The Industrial revolution introduced powered machinery with a surge in dust production which led to diseases such as black and brown lung – and later on asbestosis and mesothelioma. Various solvents were also identified as poisons and carcinogens as well. The capabilities of the industrial ventilation specialist are now much greater than they were in the days of the smoke blowers of the early 20th century. From dust control of industrial kilns & furnaces to laminar flow benches for semiconductor fabrication to clean rooms and controlling hazardous mists and vapors, we ensure the safety and comfort of the workforce, cleanliness of the products, and environmentally benign facilities.
Introduction

- Washington State Dept. of Labor & Industries
  Definition:

- Industrial ventilation is a method of controlling worker exposure to airborne toxic chemicals or flammable vapors by exhausting contaminated air away from the work area and replacing it with clean air. It is one alternative to control employee exposure to air contaminants in the workplace. Other alternatives include process changes, work practice changes, substitution with less toxic chemicals, or elimination of the use of toxic chemicals. Industrial ventilation is typically used to remove welding fumes, solvent vapors, oil mists or dusts from a work location and exhaust these contaminants outdoors.

- The design and troubleshooting of industrial ventilation systems should be handled by a qualified ventilation engineer or firms specializing in this field.
Hemeon’s Definition

- Plant and Process Ventilation, 1955
- “Industrial Ventilation is concerned largely with engineering techniques for controlling air currents within the plant and for introducing outdoor air in a pattern and on a scale that is just adequate to maintain satisfactory air purity without excessive waste of heated (or cooled) air.” My addition is emphasized
Basic Design Requirements

- Clean & Safe Environment for workers
- Comfortable Environment for workers
- Protect products and process from dusts, mists, fumes, vapors, gaseous hazards
- It ain’t **JUST** HVAC!
Basic Definitions

- **Fume** – suspension of microscopic droplets and/or grains – at or near condensation to solid phase – Smoke is a sub-case of Fume
- **Mist** – dispersion of droplets near the saturation line – near the dew point
- **Dust** – fine, granular particulate matter
- **Aerosol** – a dispersion of particles/droplets in air
Basic Assumptions:

- All Types of Plumes may be considered as hard spheres for collection by hoods
- Filters differ between dusts, mists, vapors, gases
  - Dusts are dry
  - Mists are damp – possibly corrosive
  - Vapors can be saturated or superheated
  - Gases can be condensible or non-condensible, combustible or non-flammable
An Early Form of Industrial Ventilation

- Open Hearth with an Open Smoke Hole
- Little difference between a Kitchen and a Forge and a Pottery Kiln!
Add a Chimney or Smokestack

- Uses the buoyancy of the smoke to exhaust the hearth, induces a draft
  - Why Victorian houses are so chilly & drafty
    - Makeup air can be cold!
“Modern” Building Ventilation

- Thermal or “Gravity” Ventilation
  - Natural Convection
  - Lower Cost
  - Difficult to Filter
“Modern” Building Ventilation 2

- Forced Supply, Thermal Vent
  - Can condition supply air
    - Filter
    - Cool or Heat
Hemeon – Sutton Method
What do you do when there’s no fire?

- Heat adds buoyancy – easier to control flow of dust & smoke
- Fans need power to work – but that’s how you need to solve this situation
  - Air-Blast transmits more force than suction
  - Suction induces negative draft – controls migration better
  - Intakes and hoods improve suction
  - Streamlining
Add a Fan

- Forced Draft – Blasts into fire
- Induced Draft – sucks out exhaust
- Remember the Smoke Blower!
Basic Collection Process
Power Sanding

- Relatively Recent
  - Porter-Cable: 1906
  - Black & Decker – similar
  - Milwaukee Electric Tools: 1924

- Mechanical advantage = increased dust evolution

Porter-Cable’s first powered sander
Woodworkers now Get It

- Probably the second industry after smokestacks to employ industrial ventilation techniques
- Sawdust can be toxic and/or carcinogenic
  - Linked to nasal and sinus tumors
Clean Rooms and Labs

- Protect Process from Environment
  - Laminar Flow benches and hoods
- Personnel Protection is Determined in Parallel
  - Must be evaluated in design / spec stage
Lab Hoods: Basic Design

Optional room air by-pass does not open until sash is closed 25–30%

Air foil jamb

Moveable sash can have horizontal sliding panels

Recessed bottom Airfoil sill

Exhaust duct

Adjustable top slot

Sash closes by-pass when raised

Fixed center slot

Rear baffle

Adjustable bottom slot

VERTICAL SASH AIRFOIL HOOD
Alternate Basic Lab Hood

- $Q = 100 \text{ ft/min across open face of hood}$
Laminar Flow Bench

Face velocity = 90 fpm ± 20 fpm

Note: Total power input must be considered as part of air conditioning load.

This hood does not provide protection for the operator.
Large Scale Applications

- Specialized Booths and Rooms
- Downdraft can be used to limit migration potential
Auto Repair Painting

**PLAN VIEW**

- Door stop in floor
- Paint arresting filters in door
- Air filters in door desirable
- Door stop in floor

**ELEVATION**

- Use vertical discharge
- Latch to close doors tightly

\[ Q = 100 \text{ cfm/ft}^2 \text{ of cross sectional area} \]

(When \( W \times H \) is greater than 150 ft\(^2\), \( Q = 50 \text{ cfm/ft}^2 \))

\[ h_w = 0.50 \text{ VDF plus resistance of each filter bank when dirty} \]

Minimum duct velocity = 2000 fpm

**Notes:**
1. Exhaust fan interlock with make-up air supply and compressed air to spray gun is desirable.
2. Paint arresting filters usually selected for 100–500 fpm. Consult manufacturer for specific details.
3. For construction and safety, consult NFPA, Reference 10.75.1.
4. For airless spray painting use
   \[ Q = 60 \text{ cfm/ft}^2 \text{ of cross section area} \]
Some of the More Challenging Situations
Real Buildings
Real Problems
CO Explosion Damage
Baghouses
Filtration Principle

Diagram showing the filtration principle with clean gas entering from one side, passing through the filter medium, and clean gas exiting from the other side.
Bag Cleaning

This picture shows a reverse-air cleaning type baghouse
Fans: How we move the Air
Typical Centrifugal Fan Features

Source: Air Moving and Control Association
Typical Fan Options

Source: Air Moving and Control Association
Fan Performance Curves

Source: Air Moving and Control Association
2 Fans in Series

Source: Air Moving and Control Association
2 Fans in Parallel

Source: Air Moving and Control Association