Industrial Process Control; System Design Issues

Good Examples of Bad Ventilation Design

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Function of Ventilation

- Industrial ventilation is a mechanism to control an employee’s exposure to a hazardous material
- Functions to remove material from person’s breathing zone
- Exhausts to the outside
- Possibly to a control device
Common Problems

- Rain barriers
- Stack height
- Exhaust re-entrainment
- Poor system layout & design
- Fan location
- Improper usage
Decent-Looking System

- Good stack
- Adequate height
- Away from fresh air intakes
- Rain shield seems to be a proper design
Rain Shield
What the Heck are These?!
Rain Shield

- No rain caps or covers
- Increases backpressure to fan
- Use a sleeve
  - Diameter $D+1$ inches
- Offset 1-inch all around
  - Overlap about 6 inches
Rain Shield

Rain hats decrease system efficiency and also direct exhaust downward.

Rain sleeves allow unobstructed exhaust flow, keep rain out, and do not decrease system efficiency.
Rain Hat Problems

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Stack Height

Looks ugly, doesn’t it?
Stack Height

Architects hate this!
Stack Height

- Top of exhaust stack from the ground should be as an absolute minimum 1.3 times the height of the roof
  - Up to a certain point
- Two-story building, 20 feet tall
  - Stack is 6 feet tall
- Stack top 26 feet above ground
- 1.3 X 20 feet = 26 feet
Stack Height

Prevailing Winds

< 1/3 H

Insufficient stack height allows contaminants to be caught in building’s wake, possibly re-entrained

> 1/3 H

Sufficient stack height allows contaminants to be exhausted above building’s wake, avoiding re-entrainment
Where's the Roof?
Where’s the Roof?
Stack Height Alternative

Virtual stack
Fan Entry
Funny Fan Entry
Fan Entry

• The ductwork that enters a fan should have at least 10 duct diameters of straight run.
  • Duct diameter = 1 foot.
  • Straight for at least 10 feet.
    • 1 ft x 10
Fan Entry = 10 Diameters

Process Vent

10D

Roofline

D = main diameter

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Re-Entrainment

Can you identify any other air contaminant sources in this picture?
Wind Rose

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Vent podium D3
Good Examples of Bad Ventilation Design
Wind Rose

- Succinct view of how wind speed and direction are typically distributed at a particular location
- Presented in a circular format
- Shows the frequency of winds blowing from particular directions
- Length of each "spoke" around the circle is related to the frequency of time that the wind blows from a particular direction
Wind Rose

Is wind \textit{blowing from} the North West or \textit{blowing to} the North West?
Elbows
Elbowmania
Elbows

- Every 90 degree elbow = 20X the length of a straight run
- Increased static pressure = more velocity pressure = larger fan = more electricity
Hood Proximity
Hood Proximity

- The ventilation hood should be as close to the source of contaminants as possible
- Do not draw contaminated air through the employee’s breathing zone
Smooth Ductwork
Smooth Ductwork

- Rough inside surface increases static pressure (backpressure)
- Larger fan size needed
- Larger fan = more electricity
Ventilation Fan Location

Good Examples of Bad Ventilation Design
Ventilation Fan Location

- Depends on the material’s toxicity
- Have fan on roof or outside facility
- System under negative pressure
- System leaks in the system are from the building into the ductwork, and not out of the ductwork to the building
- Fan noise is outside; however...
  - Makes maintenance more difficult
Ventilation Fan Location

Air can leak through seams on the positive pressure side of fan inside building and may pose an exposure hazard.

Fan outside, seam leaks occur outside

Fan inside, seam leaks occur inside
Laboratory Hoods

Good Examples of Bad Ventilation Design
Laboratory Hoods

- Do not store large amounts of chemicals in lab hood
- Do not erect enormous apparatus inside a lab hood
- Ventilation slot is blocked
  - Chemical incompatibilities may be an issue as well
Calculations
Calculations

- Avoid this type of connection
- There is no calculation for this type of entry or ductwork
Calculations?

- Calculations come from ACGIH publication: “Industrial Ventilation, a Manual of Recommended Practice”
- Without calculations, you do not know the proper ductwork, layout, or size fan to use
Calculations

- Efficiency is the goal
- Do not need a fan "strong enough to pull someone’s clothes off"
- excess airflow =
  excess electricity costs =
  excess heating/cooling costs =
  less $ at end of year
Don’t Forget Others
Don’t Forget Others
• Ensure Facilities Services staff are aware of all of the hazards associated with ventilation system adjustment, maintenance, and repair

• May need special procedures, training and PPE
Problems Occur Anywhere
Problems Occur Anywhere

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Conspectus

- Rain Hats
- Stack Height
- Fan Entry
- Re-Entrainment
- Wind Rose
- Elbows

- Hood Proximity
- Smooth Ductwork
- Fan Locations
- Lab Hoods
- Calculations
- Maintenance Staff