Air Sucks and Air Blows—Practical Information for Improving the Effectiveness of Your Industrial Ventilation Systems

Kay Rowntree, CIH—Industrial Hygiene Sciences LLC
Eric Pylkas, CIH, CSP—Insight IH Consulting LLC
Wisconsin Safety & Health Conference—April 2018

There is a preferred order to controlling exposures:

- Regulatory agencies have a clear preference for elimination, substitution & engineering controls and require implementation if exposures exceed a PEL.
  - OSHA requires the implementation of feasible controls when a PEL is exceeded.
  - Respirators are not considered to be a control but must be used until the controls can be put in place or if controls can't reduce exposures far enough.

Examples of engineering controls:

- Enclosures
- Ventilation
- Process changes
- Isolation

Any control method that does not consider the human interface with the system will probably fail.
From an industrial hygiene standpoint, control is all about keeping contaminants out of the breathing zone (BZ). The BZ is generally considered to be the area within a 10” radius of the worker’s nose and mouth.

- This is where exposure sampling is done.
- Area samples may not represent an employee’s BZ exposure.
- Controls should be designed to keep contaminants out of this area.
- Sounds like this should be simple, right?

But it Isn’t Always So Simple!

- Controls are often put in with little attention paid to:
  - How contaminants enter the breathing zone.
  - How the employee interacts with the process.
  - How processes vary:
    - Part size and configuration.
    - Tools used.
    - Number of employees working in area.
    - Work practices.
    - Environmental conditions.
    - Process speed/times.
- Remember, the BZ can move.

Why Provide Ventilation?

- Protect employee BZ exposures to toxic substances.
- Reduce airborne exposures for the general work environment:
  - Lower exposures for everyone.
  - Improve the visual appearance of the space.
  - Reduce odors.
- Reduce/prevent deposition of substances on work surfaces:
  - Safety concerns.
  - Reduce need for housekeeping.
- Reduce the potential for fires and/or explosions from flammable/combustible liquids or combustible dusts.
- Provide thermal comfort and prevent heat stress.
- Allow confined spaces to be entered safely.
What Do You Need to Know About Ventilation?

- Air sucks
- Air blows
- Air takes the path of least resistance
- Air needs to move contaminant out of the BZ
- Air is expensive to move
- The more you enclose a source, the easier control becomes
- Systems change after installation
- If the employee doesn't use a control, you've wasted your money - train or lose your gain

Look At the System as a Whole

Figure 6 Developing effective LEV for more complex systems

Air Sucks

- Exhaust systems SUCK air
- The harder the system has to "suck" to control a BZ exposure, the more expensive the system will be to install AND to operate
- The area from which air sucks is not very big
- Sucked air has to be replaced - if you do not manage that air it will come from the easiest path of entry
Air Blows

- You can blow air a lot easier than you can suck air
- Blowing air can move fast and far
- Air blows from cooling fans, through open doors and windows, from turbulence created by vehicles and from directed make-up air systems
- Make-up air can be your friend or enemy
- Blowing air can really mess up a sucking air system

Good Design is Important

- Poor control is a problem
  - Source becomes background
  - Very difficult to control
  - "Lawn Chair" exposures
  - Independent of work activities

What is a Ventilation System?

- Most systems will contain the following components
  - A hood - controls contaminants at the work area
  - Ductwork – transports captured contaminants
  - Air cleaner - removes contaminants from air
  - Air mover - moves air from the work area to the air cleaner
  - Supply air – replaces air removed by ventilation system
ACGIH IV Manual-Hood Designs

In general, hood designs vary in effectiveness (see descending order below)

- Enclosing hoods
- Vacuum nozzles
- Fixed slot/plenum hood on a work table
- Movable hood above a work table
- Movable hood hanging freely
- Overhead canopy
- Dilution ventilation

Some Examples of Hoods/Booths

Hoods – General Design

- Engineered for the activity to be controlled.
- Face velocity (measured at hood opening)
  - 80-100 feet per minute (fpm) (lab fume hood)
  - 2,000+ fpm (slotted hood)
- Capture velocity (measured at contaminant generation)
  - 50 fpm (evaporation from tank)
  - Up to 2,000 fpm (grinding, blasting)
**Ducts – A Variety of Types**

- Laminar Flows in ventilation (both in and out of ductwork):
  - Waste less energy (cost less, smaller blower)
  - Are much easier to measure
  - Better resist contaminant diffusion (better protection for workers)

**Turbulent vs. Laminar Flow**

- Need to maintain adequate transport velocity (dependent on weight of transported material, tungsten = high / gas = low)
- Must be tough or protected (forklifts!)
- Number of direction changes should be kept to a minimum (turbulence)
- Should be properly sized (areas should add up)
- Round is the best shape (stronger, least energy losses)
- Should be smooth (turbulence)
- Provide access for cleaning especially with heavier dusts

**Ductwork Considerations**
Sketchpad Demonstration

- A demonstration of the transition from good to bad system, how modifications can slowly destroy ventilation
  - Open ducts
  - Improper sizing
  - Missing transitions
  - Short cuts (right angles)

Air Cleaners

Air Movers
What About Recirculation Systems?

**Pros**
- No air permit needed
- Energy savings can be significant

**Cons**
- High efficiency filters
  - Expensive to buy
  - Higher pressure drop = more $ to operate
  - Higher maintenance
- How do you know the toxic substances are really being removed?
- Hard to find media to remove gases/vapors
- Some regulations may prohibit the recirculation of air
- Combustible dust issues

Fan/Collector Upkeep

- Maintenance is key
  - Routine filter/media changes (monitor using pressure differentials, manometer/magnehelic)
  - Keep an eye on belts/motors (these tend to degrade slowly over time)

Axial Fans – A Word of Warning

- Best used for temperature control
- Can disrupt good ventilation design (turbulence)
- The air they move is not necessarily clean
The ACGIH Industrial Ventilation Manual has been the design standard for many years.

There are specific designs for many operations.

There is a companion book on Operation & Maintenance.

If your ventilation designer has never heard of this book, maybe you should find someone else….

Order from
https://www.acgih.org/forms/store/CommercePlusFormPublic/search?action=Feature

Design Hints - General

- Block cross drafts
- Design product flow & fixtures to facilitate hood usage
- Increased velocities can be necessary in designs with:
  - Cross drafts
  - High Hazard Chemicals
  - Elevated Temperatures
- Design so that the BZ is not in the path of the air flow

Factors that Can Effect What Gets into the BZ

- Heat
- Method of contaminant generation
- Source strength and movement
- Worker position
- Hood position
- Worker activities
- Environmental parameters
**Heat**

- Systems can take advantage of thermal rising for capture
  - Example: an exhaust hood is placed above the process to capture the rising plume
  - BUT always ask where is the BZ during the work?
- Hot processes can result in continuing exposure

---

**Contaminant Generation**

- How the contaminant is generated will play a big role in the BZ exposures and where to position controls
- The more "active" the release, the greater the potential BZ exposure
  - Aerosolization vs. brushing, rolling or dipping
  - High velocity particle releases vs. low velocity generation work
  - Manual scooping/weighing/dumping dry materials vs. automated transfers
  - Air that propels the contaminant or product

---

**Worker Position**

From: www.hse.ie/eng/Publications_and...Local_Exhaust_Ventilation_LEV_Guidance.pdf
**Hood Position**

- Most hoods must be kept 1.5-2 duct diameters from the point of contaminant generation to be effective
- If there are cross drafts, capture still may be poor
- If particles are emitted at high velocity, capture still may be poor

**Hood Position**

- In a well mixed room (most industrial workplaces), the density of the gas or vapors doesn't matter
- Capture at the source and it really doesn't matter

**Source Strength & Movement**

- How much of the contaminant is emitted during the process
- The shape and dispersal speed of the contaminant “cloud” and where it moves
- Within a task, there may be multiple clouds requiring multiple controls
  - Break up the process to ID the sources and cloud behavior
- Capture at the point of generation prevents dispersal of the cloud and keeps it out of the BZ
### Worker Activities

- Variations in work practices
  - Tool usage
  - Dispensing of materials
  - Use of controls
- Addition of workers
  - Can change the dynamics of the source strength and movement of the cloud
- Housekeeping work

### Environmental Parameters

- Ambient and outdoor temperatures
- Wind direction and speed, especially a factor in outdoor work
- Open doors and windows
  - Localized effects
  - Building wide effects
- Use of cooling fans
- Turbulence created from other activities or vehicles

### Observations/Best Practices

- There are many different variants of hoods used in ventilation systems
- Several common types include
  - Bench-top Hood
  - Canopy
  - Laboratory Fume Hood
  - Slotted Exhaust
  - Walk-in Booths
  - Ambient Systems
Bencktop Ventilation Hoods

- Side panels can help block cross drafts
- Advantages - if properly designed, capture velocity will be met or exceeded across the entire bench
- Objects (including the weldment itself) that block airflow will decrease performance
- Top slot should be located well above the tallest object that generates heated contaminants to ensure the rising plume is captured
- The tables specified in the IV Manual for slotted welding fume hoods are BACKDRAFT not downdraft styles

Canopy Hoods

- Typically best used in unmanned operations
- Design results in contaminants being drawn up (through breathing zone)
- Receiving type hoods, often rely on contaminant rising to capture distance

Laboratory Fume Hoods

- Always work at least six inches in from opening of hood
- Do not use fume hood as a storage area
- Avoid blocking off baffle exhaust slots, elevate large equipment
- When fume hood is not in use, keep sash closed
- When fume hood is in use, keep the sash at the marked operating level
Slotted Exhaust Hoods

- These hoods are often highly adjustable (Ensure that employees are not improperly closing slots)
- Damaged slats can result in large open areas (destroying the intended high slot velocities)
- When used to control open surface tanks, push-pull is a requirement when the width is larger than 4 feet

Walk-in Booths

- Replace filtered supply media (if applicable) at regular intervals (otherwise booth will become heavily negative)
- Often designed to be operated with doors closed. Airflows disrupted when door is open
- Balance ventilation (ensure replacement of exhausted air), beware of the “Sump Effect”

Ambient Air Cleaning Systems

- Suitable for applications where fugitive concentrations are problematic
- It is always preferable to first control at the source
- Avoid using for applications where source concentrations make up majority of worker exposure
- Expensive to operate and can create a lot of noise
Cooling fans and high velocity supply air nozzles are highly disruptive to the performance of local exhaust hoods

- Introduce more air than the hood can remove, positively pressuring the device

Often positioned so they blow contaminants away from the worker, but

- If the worker moves, the fans can blow contaminant back into BZ
- Eddy currents in front of the worker can form and increase exposure

Low velocity laminar (not turbulent) flow is typically preferred in supply air systems

Pedestal fans can blow air at 1000-2000 fpm!
Open doors and windows near the hood can have similar effects

http://www.ccohs.ca/oshanswers/prevention/ventilation/hoods.html

Even the best of controls will fail if not maintained

- SOPs & PM schedule should be established right from the start & audited
- Employees must be trained and observed to ensure systems are used correctly
- Document your control efforts especially if exposures exceed a PEL
Tools for Evaluating Ventilation Systems

First Off – Use your Eyeballs!
- Hoods
  - Damaged, Louvers/dampers closed
- Ductwork
  - Open ducts, dented/damaged duct, clogs
- Collectors/Fans
  - Clogged filter media, loose belts, old motors
- Inadequate Supply – difficulty opening doors!

Tools for Evaluating Ventilation Systems

- Visual air flow devices
  - Smoke tubes/sticks
  - Borozin Powder (zinc stearate)
  - Baby powder
  - Paper
- Quantitative devices to measure airflows
  - Thermo/Vane anemometer or velometer
  - Magnehelic/Static pressure gauge
- Indirect Measurements
  - Particulate Counters, Gas Monitors, etc.
Good or bad?

Industrial Ventilation Resources

- http://www.hamlinharris.com/levs/M66V%20with%20HEPA%20Videos.wmv
- http://www.hse.gov.uk/welding/mobile-fume-extraction-hoods-1.htm
- http://www.hse.gov.uk/lev/what-is-ileve.htm (What is LEV?)
- http://www.hse.gov.uk/pubns/books/hsg228.htm (Controlling airborne contaminants at work: A guide to local exhaust ventilation (LEV))

Questions?

Kay Rowntree, CIH
Industrial Hygiene Sciences LLC
602 Fox Knoll Dr.
Waterford, WI 53185
262-534-2554
kayihhs@tds.net
www.ihsciences.com

Eric Pylkas, CIH, CSP
Insight IH Consulting LLC
893 Marquette Road
Hartland, WI 53029
262-347-6599
Eric.Pylkas@insightIHConsulting.com
www.insightIHconsulting.com