Dust Collection Demo Notes
Demo given at Woodcraft, Richmond, VA
August 9, 2008
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Topics:

- Health issues
- Dust collection
  - Terminology
  - Small shop requirements
  - System design
  - Machines and fittings
  - Static electricity
- Air filtration
- Respirators

REASONS FOR THIS DEMO

- Reduce/eliminate the mess of wood chips and saw dust
- Reduce health hazard of air borne dust

HEALTH ISSUES

- Health risks include
  - Skin rashes, eye irritation, other allergic reaction that usually grow worse with repeated exposure
  - Asthma
  - Chronic bronchitis
  - Alveolitis (leading to chronic lung damage)
  - Mucostasis (dryness of the mucus glands)
    - 1 in 9 woodworkers exposed to just 2.2mg/$m^3$ of wood dust will develop this
  - Cancer
- NIH classified wood dust as a carcinogen in the 1990s (no particle size given)
- NIOSH (National Institute for Occupational Safety and Health) of the CDC has recognized the following cancers caused by wood dust:
  - Nasal and sinus cavity cancers
  - Lung cancer
  - Hodgkin's disease
- OSHA currently classifies wood dust as a "nuisance" dust; no PEL (Permissible Exposure Limit) has been set; REL (Recommended Exposure Limit) as follows:
  - 15 mg/$m^3$ total
  - 5mg/$m^3$ respirable (capable of being inhaled into the lungs) for all wood dust except western red cedar
  - western red cedar is 2.5mg/$m^3$

- American Conference of Governmental Industrial Hygienists (ACGIH) and NIOSH both recommend the following wood dust concentration limits for a 8-hour day:
    - 1mg/$m^3$ for hardwoods
    - 5mg/$m^3$ for softwoods
    - 0.5mg/$m^3$ for western red cedar
    - 10mg/$m^3$ for softwood for 15 minutes repeated no more than four times per day
- Particle size and health hazard
    - No government body has established particle size recommendations or limits to help define health hazard
    - All particles that are large enough to be inhaled represent health risks, per above
    - Two categories of particle size:
        - The nose will filter particles larger than about 10 microns ("irrespirable" or "thoracic")
        - Particles smaller than about 5 to 10 microns are considered "respirable" and will enter the lungs
- Typical particle sizes generated by woodworking activities (example: hand sanding with a belt sander)
    - Over 50% of the dust generated by sanding is respirable (under about 10 microns)
    - Typical concentrations of respirable dust were between 25mg/$m^3$ and 35mg/$m^3$ for both hard and soft wood, according to one study
    - For MDF, concentration was over 100mg/$m^3$
- Wood toxicity (see chart from *American Woodturner*)

DUST AND CHIP COLLECTION

Expectations

- Properly sized dust collection systems can capture nearly all of the chips and large dust particles from equipment designed for dust collection, and most of the chips and dust from equipment retrofitted with dust collection (ex: contractor saws)
- Most (perhaps nearly all) dust collection equipment can't eliminate all of the dust generated from a woodworking process
- Best is about 90%
- Most are much less than that because most equipment is not designed to capture most of the fine dust, just the larger chips

Terminology

- Terms commonly used to describe dust collection and air filtration
    - Cubic Feet per Minute (CFM); is set by the dust collection/air filtration machine and is given by the manufacturer
    - Feet per Minute (FPM); is directly related to CFM through the diameter of the tubing/duct work: CFM = FPM multiplied by the cross sectional area (in square feet) of duct or pipe
    - Pressure Drop is measured in inches of water (barometric pressure is measured in mm of Hg); depends on the geometry of the ducting (shape and diameter)

- Static Pressure Rating, like CFM, is determined by the characteristics of the dust collector/air filtration machine and is given by the manufacturer; it is related to CFM, however
- Particle Size, usually measured in microns, or millionths of a meter, is used as a measure of the minimum size of the particles removed or filtered by the machine;

Small Shop Dust Collection Requirements (besides health)

- All small wood shop machines require 500 CFM or less at the machine, as determined by their manufacturers
- Most demanding (those that require 500 CFM) are
  - Planers (15 inch)
  - Sanders (24" drum)
  - Radial arm saws
- About 4000 FPM air flow rate requirement for large chips (50 FPM for dust)
  - Air flow rate is related to volume rate by the cross sectional area of the ducting: CFM=FPM*Area (in square feet)
- Particle size is not defined, but should be as small as possible, as a comprise with budget

System design

- Collectors loose air flow rates when the filters/bags fill with dust (keep filters and bags clean); however, dirty bags filter smaller particles
- Multiple ports reduce air flow rate by the number of open ports (use one at a time)
- Bringing the collector to the tool (portable units) maximizes air flow rate
  - 650 CFM is sufficient for all types of small shop tools
- Centralized dust collection
  - More convenient than moving the dust collector to the equipment
  - However, this introduces losses due to air flow friction and turbulence
  - Typical losses
    - by duct length, diameter and smoothness
    - by changes in directions and constrictions (45 degree and 90 degree bends, Y's, gates, restrictions)
- Design the system ducting with minimum number of bends, constructions, etc., then add up the effective distance
- Design to flow rate (Feet per Minute); should be between 3000 and 4000 FPM throughout the system for effective chip removal
  - 4" duct 250 – 400 CFM 2900 – 4600 FPM
    5" duct 400 – 650 CFM 2900 – 4800 FPM
    6" duct 650 – 800 CFM 3300 – 4100 FPM
    data on CFM to duct size requirements from JET
    upper limit on CFM is a compromise with loss rate for larger collectors
- Static pressure drop or loss is the common measurement used in system design
  - Static pressure is proportional to air speed (FPM), which is proportional to volume flow rate at constant duct diameter (see above)

- Many formulas for static pressure drop compare this loss per junction to the effective distance of straight duct pipe in feet:
  - Duct diameter | 90° bend | 30° Y | 90° T
    4" | 6' | 3' | 7'
    5" | 9' | 4' | 10'
    6" | 12' | 5' | 13'
    7" | 13' | 6' | 14'
    data from Jet
- Add all these effective lengths of duct for your system (longest run, or run length to most demanding equipment), and add that number to your actual length of duct in feet, and multiply by the static pressure drop per foot as follows:
  - 4" duct .055 in./ft. pressure (vacuum) loss
    5" duct .042 in./ft.
    6" duct .035 in./ft.
    7" duct .026 in./ft.
    8" duct .022 in./ft.
- Factor in different diameter ducts, as applies
- Add the largest pressure (vacuum) loss for your equipment; examples:
  - Jointer 1.54 in. water
    Planer 1.18 in. water
    Table saw 1.925 in. water
    Data from Jet
- This is the highest loss of pressure in your system and is used to specify the dust collector as follows:
  - Case 1: buying new to match system requirements
    - Select dust collector that has CFM greater than that required for your most demanding equipment, and
    - Static pressure rating greater than the total calculated loss
  - Case 2: determining whether existing equipment is sufficient
    - Subtract total calculated pressure loss from your system static pressure rating, and multiply the ratio of this difference to the equipment's rating by the equipment's CFM. This value of CFM should be larger than the maximum needed by your woodworking equipment

- Use 2.5" hose only for the last short distance to the equipment

Dust Collection Machines and Fittings

- Machines
  - Single stage, two stage, and up
    - Single stage collects chips and dust in one step
      - Not efficient
      - Clogs the filter bag faster
      - Fills faster
      - Cheaper and easier to empty
    - two stage has pre-separator for large chips
      - makes the collector more efficient at collecting dust and chips

        - saves the impeller
        - more expensive and more difficult to empty (two catchers)
    - Small machine specs (specs. apply to clean filters/bags):
        - Jet DC- 650 650 CFM 6.5 in. water 30 micron bag
          Jet DC- 1100RC 1100 CFM 11 in. water 30 micron bag
          (typical differences in CFM and static pressure ratings)
    - Filtering
        - Bag filters
            - Most bags filter 20 – 30 micron particles
            - Should remove the bag to clean it properly
            - Steel City offers bag filter with 1 micron filtering
        - Pleated filters recommended
            - 1 or 2 micron filter (Steel City offers 1 micron pleated filter)
            - easy to keep clean and maintain CFM
        - All filters clog eventually; filtering improves but throughput goes down
- Fittings
    - Couplers
        - Flex hose to flex hose
        - Flex hose to PVC
        - Flex hose to other
    - T couplers
    - Y couplers
    - threaded couplers
    - quick release connections
    - $90^{o}$ bends
    - reducers
    - gates
    - duct
        - flex hose; black and clear; 2.5”, 4”, and larger
        - metal (spiral and other)
        - PVC and other plastic
    - Fein connectors
    - Festool connectors
    - “ShopVac” connectors

Static Electricity

- Results from friction of dust particles against the walls of insulating duct and connectors
- Hazardous because a spark can ignite the wood dust in the duct, and wood dust, having a very large surface area, burns explosively
- Mainly a hazard in long runs
- Reduce by running a grounded conductor in close contact with the duct along the full length of the duct work
- Do no break the connection, especially across junctions; have all sections grounded
- Ground to a large metal object (furnace, etc.), water pipe, or house electrical ground
- Best to use grounded metal duct

Example

- Assume the following system:
  - 30’ of 6” duct feeds four 4” gated ports
  - The last or furthest port services a table saw through 10’ of 4” hose
  - Between the dust collector and the 6” duct is one 6” $90^{o}$ bend and one 6” Y connection
- Calculate the static pressure drop from the dust collector to the table saw
  - 30” of 6” duct = 1.05”
  - 10’ of 4” hose = 0.55” (assume smooth hose)
  - 6” $90^{o}$ bend = 12’ of 6” duct = 0.42”
  - 6” Y = 5’ of 6” duct = 0.18”
  - table saw = 1.93”
  - add 1” for “seasoned” dust collector filter bag
  - result = 5.13” of water
- we have to maintain about 4000 FPM through the 6” duct to clear the chips; need 785 CFM to accomplish this (4000 FPM multiplied by the cross sectional area of the 6” duct in square feet)
- we also need about 400 CFM at the table saw to clear the chips
- first consider the table saw requirement; calculate “static pressure rating” needed for 400 CFM at the table saw
  - use ratios to make this calculation:
  - (CFM of the dust collector – 400CFM)/(CFM of dust collector) = (5.13”)/(static pressure rating of the dust collector)
  - since we have two unknown quantities, select a dust collector that exceeds the requirement for both of these: choose CFM and pick a 650CFM dust collector having a static pressure rating of 6.5” as a first try (the JET DC650)
  - plug in the CFM rating and calculate the needed static pressure drop: required static pressure rating = (5.13”)x(650CFM)/(250CFM) = 13.3” water, which is much higher than the rating of this dust collector
  - try again: choose the next largest dust collector: say a JET DC1100 (1100CFM at 11” water static pressure rating)
  - calculate required static pressure rating as in the $4^{th}$ bullet: required rating = (5.13”)x(1100CFM)/(700CFM) = 8.1” which is smaller than the rating for this dust collector (choose it)
- next, does it develop the flow rate in FPM required for the 6” duct?
  - Again, use ratios to determine the CFM entering the 4” at the table saw:
  - (11”-5.13”)/(11”) = (actual CFM at 4” hose)/(1100CFM), or actual CFM = 590CFM
  - this is the volume of air moving through the whole system; therefore, flow rate in FPM in the 6” duct = (590CFM)/(area of the 6” duct) = 590/0.2 = 3000FPM – a little low, but it will work
- Therefore, use a dust collector that is rated at least 1100CFM with at least 11” of water static pressure rating

AIR FILTRATION

Reasons

- Dust collectors cannot pick up all dust generated by equipment
- Most dust collectors do not filter large dust particles (greater than about 20 microns); these return to the air through the filter
- Fine dust is most harmful; OSHA's recommendations cannot be met with dust collectors

Two types

- Room air filtration
- Dust masks

Room air filtration

- According to data, over 50% of the dust generated by sanding is respirable (below about 10 microns); dust levels can reach higher than 25 $mg/m^3$; most will not be captured by a dust collection system unless special effort is made to enclose tools with dust hoods
- Requirements
    - at least 600 CFM for a 20X20X8 foot room to clear room at a "reasonable" rate (select a rate that will clean 10 to 12 times per hour for the room being used, or every 5 minutes)
    - remove about 99% of 5 micron particles; about 85% of 1 micron particles
    - HEPA filter is best (can filter to less than 1 micron), but can clog quickly (HEPA: high efficiency particulate air)
    - Mount in a location that will move air throughout the room (e.g. circular air flow)
    - Timer would be nice, as dust remains after the shop has been used
- Some manufacturers of air filtration for small shops
    - Jet
    - JDS
    - Shopvac
    - Delta
    - Powermatic
    - Grizzly
    - Shopfox

Dust Respirators

- Air filtration does not remove sawdust immediately, nor completely
- Depending on operation, wood dust concentration can exceed OSHA and ACGIH recommended maximum levels
- Exposure is cumulative for all humans; repeated exposure can heighten, or even create an allergic reaction
- 3 levels of protection is recommended for woodworking
    - dust collection
    - air filtration
    - respirators
- Inexpensive dust masks are not recommended as third level of protection because
    - Too leaky
    - Filter is not as good as the air filtration system (typical rating over 1 micron)

- Respirators must be
    - Tight-fitting (beards will not work)
    - Provide suitable filters for the finest particles
    - Can provide positive air pressure
- Examples or air supplied respirators
    - Aircap2
        - 99% efficient at 1 micron
    - Triton powered respirator
        - Eliminates 95% of particles under 1 micron
    - Power Mask
        - Unrated
- Examples of air purifying respirators
    - Common dusk mask
    - Replaceable filter vapor/dusk mask
    - Most meet or exceed N95 (NIOSH rating for 95% filtering)

DEMONSTRATIONS

- Display 20mg or sawdust (respirable) to show how small this amount is, and compare to the concentration recommendation of OSHA
- Demonstrate 6.5" of water vacuum generated by a Jet 650 dust collector by drawing that height of water using a sealed hose and clear plastic column
- Demonstrate the change in air flow caused by the following
    - 90o bend
    - several bends in a 4" flexible hose
- Display the static pressure drop contributed by each of the main dust collection fittings by apply signage to each example
- Demonstrate the Jet AFS-1000B air filtration system
- Display an air purifying respirator
- Display an air supplied respirator

REFERENCES


- WMH Tool Group, "Dust Collection in the Wood Shop"
- Australian Wood Panels Association
- OSHA, CDC, NIH web sites
- *Wood Industry*, "Total Respirable Dust Concentrations Measured Under Wood Sanding"
- AMCOSH Ltd. Report on wood dust
- Specifications from respective manufacturers catalogs and web sites
- American Woodturner, June 1990 (chart on wood toxicities)