Change Management

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Balanced Ventilation System

- A balanced industrial ventilation system is designed by calculating the static pressure losses in the duct system
- The system is designed without dampers
- Changes in the system require review of the design
The Problem

- Balanced industrial ventilation system
- After installation change occurs
  - The process changes
  - New or additional equipment
  - New source requiring additional hoods
  - Elimination of sources (remove hood)
  - PEL, TLV, or OEL changes
- How do you modify the system to accommodate the required changes
Considerations

- Transport velocity
  - Low – Deposition in duct
  - High – Abrasion and energy loss
- Duct construction (pressure class)
- Fan
  - Capacity
  - Construction (Class)
  - Motor Horsepower
- Air Cleaning Devices
  - Capacity and efficiency
  - EPA permits

Change Management

- All change proposals reviewed by the ventilation system Change Reviewer
  - Reformulations or change in raw materials
  - Minor equipment modifications (add or remove)
  - Operating condition changes (rate, speed, temp)
  - Air cleaning equipment
- Worker acceptance of Change Management
- Verification of changes
Project Controllability

- Major Project
  - Easy to control
  - Large investments
- Minor Project
  - Hard to control
  - “Local” budgets
  - Done before you know it

Change in Volumetric Flow

- Inlet or start up dampers
- Fan speed
  - Variable Frequency Drives
  - Variable pitch pulleys
  - Belts and sheaves
Fan Laws

1. \( \frac{Q_1}{Q_2} = \frac{RPM_1}{RPM_2} \)  
   First Fan Law

2. \( \left( \frac{RPM_1}{RPM_2} \right)^2 = \frac{SP_1}{SP_2} \)  
   Second Fan Law

3. \( \left( \frac{RPM_1}{RPM_2} \right)^3 = \frac{HP_1}{HP_2} \)  
   Third Fan Law
Example

- System design: 20,000 acfm at 10 "wg
- Measured: 18,000 acfm @ 12 "wg & 22 hp.
  - Need to restore volumetric flow to 20,000 acfm
  - What changes to the fan are needed if the fan is currently operating at 1460 rpm?
  - If the maximum safe speed of the fan is 1800 rpm, will the fan require replacement?
  - The motor is 30 hp. Will the motor require replacement?

Solution

- Q = 18,000 acfm at 1460 rpm
- RPM = 1460 * (20,000 / 18,000) = 1622 rpm
- SP = 12” * (20,000 / 18,000)^2 = 14.81 "wg
- HP = 22 * (20,000/18,000)^3 = 30.18 hp
Adding a Exhaust Point

- Duct Velocity
  - Conveying velocity in all branches
  - Velocity excessive (abrasion)
- Other hoods (Rob from Peter to pay Paul)
- Air cleaning equipment capacity, efficiency
- Fan capacity
- Motor and Power
Original System

Modified System
Result of No Review

- High Transport Velocity
  - Over 8000 fpm, Fan HP, Abrasion of duct
- Fan undersized
  - Unable to get volume and static pressure
  - Capture at hood decreased
  - Motor failure
- Dust collector performance
  - High air to cloth – Bag cleaning

Workable Solution
Removing a Hood

- Keep or save the exhaust volume
- Effect on other hoods
- Conveying velocity
Removing a Hood

- Simplest approach
  - Remove the hood
  - Add air bleed in
    - Damper (added resistance)
    - Orifice plate
  - Reestablish the baseline
- No change in airflow

Capped Duct

- Remove the hood and cap the duct
  - Airflow to all hoods change
  - Potential conveying problems
  - Total exhaust flow more than required – Energy consequences
Example

- Remove a machining hood at 1250 acfm
  - Conveying velocity lost in several branches
  - Duct and fan modifications require $25,000 to avoid settling and optimize the system
- Is it economical to make the change?

Solution

- System charges
  - 1250 acfm excessive
  - 3 horsepower (32 hp with bled in 29 hp when balanced)
- Fan energy
  - 3 hp = 3* 0.746 kW = 2.24kW
  - = 2.24kW*2000hr/shift * $ 0.12/kW
  - = $ 540/shift
  - = 50+ shift-year payback
Second Consideration

- Replacement air in building
  - Air conditioned
  - Cost per cfm/24-hours = $7.5/cfm
  - 24-7 operation (four shifts)
- Cost per year = $540*4 + $7.5*1250
  = $17,000
- Payback 18 months

Less Expensive Solution

- Bleed outside air instead of room air
- Modification
  - Exhaust - $1,500
  - Supply - $1,000
- Payback = ($2500/[7.5*1250])
  = 0.17 year or two months
General Approach

- Determine the necessary hood changes
- Rebalance the system
- Look to alternative changes for the system (minimize duct changes)
- Determine the operational costs
- Optimize the changes
  - Life cycle costs
  - Process interruption

Original Design
System Change

- Replace Bucket Elevator with disk conveyor
- Two exhaust take-off to be removed
  - 7a and 7b at 250 acfm each
  - Exhaust point 8 to be modified with exhaust increasing from 1200 acfm to 1700 acfm

Foundry – Hood Removal
Foundry – Modified Design

Solution

- Changes
  - Remove Hoods 7a and 7b
  - Remove duct 5-D, 7a-D, D-C and 8-E
- Result
  - New duct 5-C (90 percent of design)
  - New duct 8-E (113 percent of design)
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