Ventilation Program Management

**Paradigm Shift:**

- IV System failure - *when*, not *if*
- Old model of “*after the fact*” protection - Wait until the IV System degrades to the point that:
  - Dust or other contaminants are escaping the hoods
  - The operators complain
  - IH air samples show non-compliance with occupation exposure limits
  - Employees must wear PPE as their first line of defense
  - Take the IVS apart and clean it and start the cycle all over again

- Question: How long do you as an Industrial Hygienist want the operators to work around non-functioning IV Systems?
New model of “before the fact’ protection

- IV System being managed by engineering principles within design parameters
- Predictive Maintenance provides long term assurance of equipment performance so PPE reliance can be reduced

The Big Questions

- How often should I be monitoring the system to keep it working within design parameters, a before the fact measure?
- How do I justify the maintenance and operating resources to support the right monitoring frequency?
- How do I get out of a “breakdown” maintenance mentality into a “predictive” mode?

The 9 Key Elements of IVS Monitoring & Maintenance

1. *Consistently meet OSHA and EPA regulatory limit and requirements*
2. *Provide initial verification that the IVS system is capable of providing the protection for which it was installed*
3. *Take corrective action when IVS monitoring data exceeds a set percent deviation of from Baseline value*
4. *Complete a maintenance risk assessment of the consequences of IVS system failure by reviewing the inherent risks of the contaminants handled and risk factors that can lead to more rapid IVS system degradation.*
5. *Establish on-going monitoring of the IVS system to provide an early warning of rapid changes that could potentially hurt system performance*
The 9 Key Elements of IVS Monitoring & Maintenance, cont.

6. Establish on-going degradation and trend monitoring of the IVS System to:
   1. identify the places where and when the system routinely begins to degrade
   2. provide confidence that the alert monitoring locations in key element 5 give adequate early warning

7. Document management expectations with a written Monitoring & Maintenance Plan

8. Ensure adequate staffing available to support IVS system Monitoring and Maintenance

9. Enable a Continuous Improvement Philosophy for IVS system Monitoring and Maintenance

KE 2: Document Proof of Performance

KE 3: Baseline Performance Criteria:
- Airflow: ± 10% design
- Pressure: ± 20% baseline
- All duct branches

RT A3: IVS Monitoring & Maintenance
KE4: Maintenance Risk Analysis

- Step 1 – What are the inherent contaminant hazards to:
  - Health
  - Fire
  - Reactivity

- How bad would the exposure consequences be if the IVS failed?
- How soon do you want to know about IVS failure?

Protect Against These Risks

- Step 2: Risk Factors Leading to Rapid IV System Degradation
  - Contaminant Characteristics
  - IV System design & operability

- Consider the risk of rapid IVS degradation due to contaminant characteristics and other risks
- Consider yours and your industry's specific experience
- Set frequency based on holistic analysis
Also Consider These Risks from IVS Malfunction

- Compliance with legal or regulatory limits
- Product formulation and quality
- Buildup of combustible materials
- Equipment reliability from contaminants fouling
- Appearance and cleanup

Endpoint of the Risk Analysis
Risk Based initial frequency for:

- KE 5: ALERT Monitoring
  - Provide warning of rapid changes that could potentially hurt IV system performance (i.e., fan failure, plastic bag, etc.)
  - Change to long term frequency based on monitoring data and experience

ALERT:
Visual Indication or Automatic Alarms
Endpoint of the Risk Analysis
Risk Based initial frequency for

☐ KE 6: DEGRADATION Monitoring
  - Establish on-going degradation and trend monitoring of the IVS System to:
  - Identify the places where and when the system routinely begins to degrade, helpful for troubleshooting, and
  - Provide confidence that the ALERT monitoring locations give adequate early warning

☐ Change to long term frequency based on monitoring data and experience

Rating Inherent Risk? – Two Well Known Systems: NFPA, HMIS
Problem Particulate Contaminants

- Sticky, smearing dust (e.g. detergents, wet clay, ore after floatation)
- Hygroscopic dust (readily absorbs moisture) & ambient humidity is high enough to cause sticky or adherent dust problems
- High humidity in intake air & possible approach to the dew point that can cause sticky or adherent dust problems
- Heavy dust such as lead or large granule sand
- Abrasive dust that wears elbows rapidly
- Lightweight, low density dust such as paper dust or fibrous dust such as fiberglass fluff which can tangle and form mats in the duct

Problem Non-particulate (Vapor/Gas) Contaminants

- Contaminant change from a vapor or fine mist in the duct network to
  - A solid (by drying or precipitation or freezing)
  - Condense continuously
  - Condensing conditions possible in range of operation
- Contaminant is corrosive
  - pH <2 or >12
  - pH 2-5 or 9-12
- Contaminant has NFPA flammability rating of (closed cup flash point, °F)
  - Class I (<100 °F)
  - Class II (100-140 °F)
  - Class IIIA (140–200 °F)
- Contaminant is flammable and could exceed 25% of Lower Explosive Limit in IVS if out of balance
- Contaminant is reactive if exposed to ambient air or moisture
Impact of Contaminant Characteristics

Particulate IVS - more attention to details than vapor/gas IVS

Particulate Duct Construction
Contributions to Rapid Degradation

Sustain Conveying Velocity through:
- Straight ducts?
- Merge of two airstreams?
Maintenance Access for Cleaning the Duct?

Air Cleaning Device: Reduce Capital but Increase Administration

- Air Cleaning Device Dust Removal
  - Automated, continuous dust removal system
  - Administrative controls to remove dust from system
  - ACD used as dust surge bin
IVS Balance & Documentation

- System balancing approach
  - Balance by Design as per IVM
  - Balance with plate orifices or locked blast gates
  - Balance by un-locked blast gates
  - Huh? What is IVS Balance?

- System Baseline Documentation
  - Documentation complete, < 1 year old
  - Documentation complete, < 2 years old
  - Documentation exists but > 2 years old and not checked for accuracy
  - No documentation exists

IVS Complexity

- Single hood: (lab hood or unit filter)
- Simple: 2-5 dust pickup points
- Moderate: 5-15 dust pickup points
- Complex: >15 dust pickup points
- Very complex:
  Interaction between process air exhausts and dust control exhausts with varying conditions
### Inherent Risk Profile - What is Your Assessment of Overall Rating?

<table>
<thead>
<tr>
<th>Impact</th>
<th>Hazard</th>
<th>Risk Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Flammability</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Reactivity Physical</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Quality</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Other?</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

### Risk of Rapid Degradation Profile
What is Your Overall Rating?

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Risk</th>
<th>Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulates + your experience</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Non-particulates (Gas/Vapor) + your experience</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
### Deciding ALERT and DEGRADATION Monitoring

<table>
<thead>
<tr>
<th></th>
<th>ALERT</th>
<th>Your analysis?</th>
<th>DEGRADATION</th>
<th>Your analysis?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>Auto or shiftly</td>
<td></td>
<td>Weekly</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Daily</td>
<td></td>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>Weekly</td>
<td></td>
<td>Quarterly</td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Monthly</td>
<td></td>
<td>Semi-Annual</td>
<td></td>
</tr>
</tbody>
</table>

### Inherent Risk Profile Example:  
Powder Detergent with Granulated Enzymes

<table>
<thead>
<tr>
<th>Impact</th>
<th>Hazard</th>
<th>Risk Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health</td>
<td>Irritant 1mg/m³</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Resp.Sensit. ng/m³</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
</tr>
<tr>
<td>Flammability</td>
<td>Burns with right</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>conditions</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
</tr>
<tr>
<td>Reactivity</td>
<td>Minor ingredient -</td>
<td>Low</td>
</tr>
<tr>
<td>Physical</td>
<td>oxidizer</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
</tr>
<tr>
<td>Quality</td>
<td>Consumer product-</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>appearance, formula</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>Spills &amp; fugitive</td>
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<tr>
<td></td>
<td>emissions</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
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<tr>
<td>Regulatory</td>
<td>Enzymes: 60 ng/m³</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Severe</td>
</tr>
</tbody>
</table>
Contaminant Impact on IVS
Example: Detergent with Enzymes

- Particulate: sticky, hygroscopic, smears high velocity, drops out low velocity
- IVS Rapid Degradation Risks
  - Low limit (enzymes – ng/m³; detergent < 1 mg/m³)
  - Duct buildup can occur in a week on heavily loaded branches
  - IVS was balanced and documented
  - Trained operators at site with time to do work
- Degradation Monitoring – Severe
  - Started: weekly checks
  - Long term: Monthly checks & scheduled cleaning of known problem spots

Example: Detergent w/Enzymes ALERT, DEGRADATION Monitoring

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<td>Start</td>
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<td>Daily</td>
<td>Start</td>
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<td>Moderate</td>
<td>Weekly</td>
<td>Long-term</td>
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<tr>
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RT A3: IVS Monitoring & Maintenance
Changing Frequency Based on Data and Experience

1. Startup Learning Period (3 mo)
   - Weekly static pressure readings all test points
   - Weekly airflows at strategic test points (roughly 25% of test points)
2. Transition to Strategic Test Points & Visual Controls (20-25% of total)
3. Reducing Strategic Test Point Frequency
4. What about system modifications?

Implementing IVS Monitoring & Maintenance Program

☐ Management Supports Program
   - Commit to action based on design parameters out of limits vs. IH air samples
   - Adequate, trained resources available
   - Routine reviews of results to coach resources and drive for best value

☐ Implement Monitoring & Maintenance Key Elements
KE 8: IVS Operating Skills Needed

- 5 functional levels of increasing skill
  1. General Awareness
  2. IVS User
  3. IVS Operator
  4. IVS Troubleshooter
  5. IVS Change Reviewer

- Site complexity determines job description and number of people trained at each level

- Look at two skill descriptions

Example: IVS User (L 2)

- Individual works on a manufacturing process or in a shop facility which is served by an IVS but does not operate the IVS. The individual needs to be aware of:
  - how IVS provide protection at the workstations in the area
  - how to take and interpret local IVS data, as required
  - where to get help with IVS operational problems & making changes

- Examples: process or machine operators, maintenance shop personnel
Example: IVS Troubleshooter (L 4)

- Individual may have operating, monitoring, and possibly maintenance, responsibility for one or more IVS but knows the IVS and how to operate and maintain them.
- Individual troubleshoots and corrects system problems.
- Examples: IVS operators, Plant Engineering or Maintenance management responsible for IVS operation

Bring Your Portable Source Detection Tools!
Biggest Hood & Enclosure Interference: Room Air Currents

- Open windows
- Pedestal fans
- High velocity HVAC diffusers

Hood Maintenance

- Things that can change airflow:
  - Dirty screens
  - Deposited contaminants in plenum behind hood opening
  - Bypassing thru open access doors
  - Hood face modifications
Static Pressure Balancing

w/o balancing devices, airflow takes path of least resistance
(Balance by design, Blast gates, Plate orifices)

Fan Drives: Pulley belts & sheaves: for ease of speed change
Key Issues for Any Collector

- Meeting environmental emission permit requirements
  - contaminant collection efficiency
  - collected contaminant recycle or disposal
- Operating the collector within its design differential pressure (DP) range
  - DP high – acts like a damper & reduces airflow in rest of system
  - DP low – bypassing of collector and DC System?

Clean Bag Start-up

- Control airflow within + 10% design while bag differential-pressure builds up to 3-4 in.H₂O
- Change ALL the bags at one time
Summary

- Maintenance Risk Assessment
  - Contaminant inherent risks?
  - Likelihood of rapid IVS degradation due to contaminant characteristics and existing design capability and operability
- Key question for monitoring: HOW LONG ARE YOU COMFORTABLE WITH POOR IVS OPERATION?
- Set ALERT & DEGRADATION frequencies based on holistic assessment and experience
- Adjust monitoring frequency so it remains value added over the long term

PREDICTIVE MAINTENANCE PROVIDES RELIABLE IV SYSTEMS

- Monitoring & Maintenance of a **System**, not independent components
- Look for changes to system design resistances that can change airflows and balance between branches
  - Hoods & enclosure interferences
  - Duct conveying velocities within target range
  - Fan performance & system effects
  - Dust collector operation
  - Use the data for systematic troubleshooting
- Routinely maintain the mechanical components
- Complete Maintenance Risk Analysis & staff for success