Worldwide Pollution Control Association

WPCA-Duke Energy
FF/HAPS Seminar
October 12-13, 2011

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WPCA-Duke Energy Pulse-Jet Fabric Filter Training

Robert Brinkley
Babcock & Wilcox

Tim Stark
GE-Fabric Filter
Typical SDA System Schematic
Hot Gas Market APC Trends

Historically, 95% of applications utilized Reverse Air collector designs:

- Woven Fiberglass bags
- Woven Fiberglass with PTFE
- 2:1 air-to-cloth ratio
- 11.5" x 30' filters (29cm x 9m)
- 4 – 8 year filter life
- Large footprint housing
Hot Gas Market APC Trends

In the past 10 years, the trend is moving to Pulse Jet collectors (approximately 80% of applications):

- Felt used for under 375°F (190°C)
- 2.5-3.5:1 Air-to-Cloth ratio
- 3 – 6 year filter life
- Smaller housing footprint
Pulse-Jet Baghouse
Three Types of Cleaning Systems

- High Pressure/Low Volume
  - 8-7bar (80-100psi)
- Medium Pressure/High Volume
  - 2-3bar (30-45psi)
- Low Pressure/High Volume
  - 1bar (15psi)
Medium Pressure/High Volume

- 2.5" to 3" pulse valves
- Typically round filters with cages
- Do not use traditional venturis
- Filters: 125-159mm x 3000-6000mm
  5"-6.25" x 10'-20'
- Requires an air compressor
Pulse Jet Baghouse

Clean Gas Outlet

Dirty Gas Inlet
Pulse-Jet Designs

- Hatch Design
- Plenum Design

Bags & Cages

Bags & Cages
Pulse Jet Fabric Filter

Clean Gas Outlet

Flue Gas Inlet

8 and 10 m bags
Pulse Air System

- "J" Pipes
- Tubesheet
- Bag/Cage
- Blow Pipes
Pulse Jet Baghouse

- Pulse Valves
- Pulse Header
- Solenoid Boxes
Medium Pressure Cleaning System
Cleaning Systems
Cleaning Systems
Medium Pressure / High Volume Pulsing

- Standard pulsing system
- 14" nominal diameter compressed air header
- 3" diameter pulse valve & blowpipe
- Blowpipes typically include nozzle extensions at each blow hole
- 3" diameter pulse valve @ 30 psi consumes 140 scfm max.
  
  \[
  \text{pulse interval: 6 seconds} \\
  \text{duration: 230ms} \\
  \text{volume: 14.03 scfm/pulse}
  \]
- Horsepower required to compress air to 30 psi: 15.26 Hp = 11.38 Kwh
- Formula:
  \[\text{HP} = 0.2267Q \left[\frac{\text{PSI}}{14.7} + 1\right] 0.283 - 1\] + 30% safety factor
Cleaning Systems
Actual Cubic Feet of gas per Minute

The volume of the gas flowing per unit of time at the operating temperature, pressure and composition.

(also measured in cubic meters per hour)
Air-to-Cloth calculations

Air-to-cloth ratio = acfm ÷ total filter area

(Filter dia. X length x 3.14) = filter area

Total # filters x filter area = total filter area
## Air-to-Cloth ratio (filter rate)

<table>
<thead>
<tr>
<th>Type of Filter Cleaning System</th>
<th>Maximum Recommended Air-to-Cloth Ratio</th>
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<tbody>
<tr>
<td></td>
<td>Imperial</td>
</tr>
<tr>
<td>Shaker</td>
<td>3.0</td>
</tr>
<tr>
<td>Reverse Air</td>
<td>2.5</td>
</tr>
<tr>
<td>Pulse-Jet:</td>
<td></td>
</tr>
<tr>
<td>A. Cylindrical Filter Bags:</td>
<td></td>
</tr>
<tr>
<td>-For elevated temp</td>
<td>2.5-4</td>
</tr>
<tr>
<td>B. Pleated Filters (Non-Paper Media)</td>
<td>3.5</td>
</tr>
<tr>
<td>C. Pleated Filters (Paper Media)</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Can velocity

In a pulse jet dust collector with the filter elements suspended from the tubesheet and a hopper level inlet, Can Velocity is the upward air stream speed passing between the filters calculated at the horizontal cross-sectional plane of the collector housing at the bottom of the filters.
Can velocity

6:1 AC Ratio

6' bags

8' bags

10' bags

12' bags
Can velocity

Industry Standard with hopper inlet: <300 fpm

Point of measuring can velocity (bag bottom)
Diaphragm valve
Manifold
Solenoid valve with bleeder tube or integral to valve
Blowpipe
Tubesheet (cell plate)
Bags
Cages
Valve / solenoid operation
Pulse Air Headers
Pulse Jet Valves
Inside a Compartment
Compartment Outlet Dampers
Bypass Dampers
Actual length of the bag(s) may vary.

Actual length of the bag(s) may vary.

Actual length of the bag(s) may vary.

Actual length of the bag(s) may vary.
Valve Energy

Time (standard for 1.5” DD valve, .250 sec target for 3” valve)
Clean-on-Demand system

High-Low set points at no greater than 1" apart... Ideal is no more than 0.5"
3 1/2 - 4
Gauge Connection Modification

- Clean Air Plenum
- Copper or Plastic Tubing
- Pipe Cap Reducer
- 12" Pipe Nipple (or shorter)
- 2 1/2" diameter
- Weld
- Tubesheet
- Dusty Air Plenum or Hopper Wall
- Gauge
Cleaning sequence

1  4  7  10  2  5  8  3  6  9
Multi-Compartment Cleaning
Common Inlet Design

- Inlet baffle directs airflow down into hopper.
- Collected material can swirl upward, causing heavier than design grain-loading.
- Narrow hoppers and nearby bag bottoms may experience abrasion damage.
Photo of Bags as Viewed from the Hopper

1352 Bags
Per Compartment
Abrasion failure: Bottom of filter bags located directly in line with inlet gas stream
Excessive movement of filters causing bag-to-bag abrasion
Blowpipe problem
Blowpipe manifold/bag seam alignment
Bag house refurbishment
Fabric characteristics and suitability for power generation applications

<table>
<thead>
<tr>
<th></th>
<th>Polypropylene</th>
<th>Polyester</th>
<th>Acrylic</th>
<th>Fiberglass</th>
<th>Aramid</th>
<th>PPS</th>
<th>P84 ***</th>
<th>Teflon® ***</th>
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</thead>
<tbody>
<tr>
<td>Max. continuous</td>
<td>170° F (77° C)</td>
<td>275° F (135° C)</td>
<td>265° F (130° C)</td>
<td>500° F (260° C)</td>
<td>400° F (204° C)</td>
<td>375° F (190° C)</td>
<td>500° F (260° C)</td>
<td>500° F (260° C)</td>
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<td>operating temp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Abrasion</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair*</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
</tr>
<tr>
<td>Energy absorption</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Good</td>
<td>Good</td>
<td>Good*</td>
<td>Good</td>
</tr>
<tr>
<td>Filtration properties</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
<tr>
<td>Moist heat</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>God</td>
<td>Excellent</td>
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<td>Alkaline dust</td>
<td>Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Fair</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mineral acids</td>
<td>Excellent</td>
<td>Fair</td>
<td>Good</td>
<td>Poor**</td>
<td>Fair</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
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<tr>
<td>Oxygen (&gt;15%)</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Relative cost</td>
<td>$</td>
<td>$</td>
<td>$$</td>
<td>$$$</td>
<td>$$$$$</td>
<td>$$$$$$$</td>
<td>$$$$$$</td>
<td>$$$$$$$$</td>
</tr>
</tbody>
</table>

* Sensitive bag-to-cage fit
** Fair with chemical or acid-resistant finishes
*** Must oversize bag for shrinkage for temperatures above 450°F (232°C)
Filtration Application Conditions Where PPS Excels

- Continuous temperature is 375°F (192°C) or less
- Oxygen content is 15% or less
- Sulfur is present in the fuel, and/or oxides of sulfur are present in the flue gas
- Moisture is present in the flue gas
- Dew-point excursions take place
Bag and cage selection

Standard recommended bag pinch
Dependant upon fabric selection:
Precoating New Filters

GE Energy
New fabric receives more airflow

- New fabric accepts airflows in the range of approximately 20 to 50 cfm.
- Filter bags that have been in service and have a good porous dustcake have airflows at 5 to 10 cfm.
- The new filters will be subjected to three times the airflows as the bags that are currently in service, causing potential damage early in the bag’s life.
PJFF Theory

- Filters out particulates
- Filter cake on bags contributes about 20% of SO$_2$ reduction

\[ SO_2 \rightarrow SO_3 \rightarrow HCl \rightarrow HF \rightarrow \text{"Clean Gas"} \]
Unprotected new fabric interstices work like miniature venturis to accelerate airflow through the fabric, causing particulate impingement.
Initial dustcake requirements:

1. Porous, ensuring high airflows
   A. Range of particle sizes
   B. Varying particle shape
2. Provide a uniform coat. (1/16” to 1/8”)
3. Material should be neutral (pH).
4. Safe to handle.
New fabric protection & porosity

Unprotected

Protected

Embedded Particles in Interstices

Artificial Dustcake
Pre-coat injection

High on hopper wall 3” diameter x 6” long pipe nipple. Neutralite® can be injected here.

3” diameter x 6” long pipe nipple on inlet ductwork/elbow. Neutralite® can be injected here.

Discharge Hose

Vacutrans™

Compressed Air Connects Here

Vacuum Hose

Poke hole port, usually 3” or 4” dia. Location is too low to inject Neutralite, not enough air volume to maintain velocity needed to carry Neutralite to top section of filter bags.

Hopper Side Wall

Insulation and sheet metal lagging.

Hopper door lockout procedures usually won’t allow this access door to be open while dampers are open or fan is running.

To ash removal system.

Airlock or slide gate.
Apply Pre-coat Material into Hopper Door
Startup Pre-Coated Bags

• Season Bags
• 2 pounds on a 10 Meter x 150 mm Bag

• Material
1. Limestone
2. Fly ash
3. Aluminum Silicate
4. Diatomaceous earth
Apply Pre-coat Material into Hopper Door
Apply Pre-coat Material into Hopper Door
LEAK DETECTION
Purpose

- Identify holes in filters
- Check for proper installation
- Detect structural air leaks
Key information

• Clean Air Plenum Access
• Cloth Area
• Injection Location
Injecting Leak Detection Powder

**Inlet Ductwork/Elbow**
(May inject Visolite® here)

**Poke hole port**
usually 3”- 4” dia.
(This location is too low to inject Visolite®)

**Hopper Door**
(This location is not recommended for Visolite® injection)

3”- 4” dia. pipe nipple x 6”
with female quick
(May inject Visolite® here)

To Ash Removal System
Keys to successful test

- Shut off cleaning system
- Fan in operation
- Inject powder (1lb per 1000 sq ft of cloth)
- Shut off Fan after sufficient time for powder to disperse
- Test with light
BHA Visolite® Leak Detection System

Powder collects around air leaks
Options:

BHA Visolite® colors:

GREEN   ORANGE   PINK   YELLOW

Monochromatic lights:
Startup

- Preheat hopper with heaters 24 hours prior to startup
- Close all doors
- Verify Pulse Jets are operational
- Monitor Temperatures & DP
PJFF Overview Screen
PJFF Control

- PJFF starts cleaning when the baghouse differential pressure exceeds the “start” setpoint. Stops cleaning when the dP drops below the “stop” setpoint.
PJFF Control – Groups

- Whole baghouse doesn’t clean at once!
- Cycles through pulse headers in “groups”.

![Diagram of PJFF Control Groups](image-url)
PJFF Control - Pulse Air Header Sequencers

- One sequencer for each header.
- The DCS gives the sequencer a command to start firing pulse valves when it is time to clean.
- Two valves per header pulse at the same time.
- 30 valves on a header, so it takes 15 pulses to complete a header.
- Pulses are 10 seconds apart.
- The last pulse valve on a sequencer sends a “sequencer complete” signal back to the DCS.
PJFF Control

- Once all 5 headers in a group say they are complete, the DCS moves on to the next group.
- Just because a group is “ready”, doesn’t mean it is pulsing!
Monitoring the System

- Usually, not much to look for.
- BUT – If a pulse valve sticks open or pulse header air supply line ruptures:
  - Typically the PJFF air compressor pressure indication will drop a few psi and become erratic.
  - If the leak is bad enough, the pulse headers will stop firing due to low pulse header pressure. This is VERY BAD because differential pressure can rise rapidly without cleaning at full load!
Hunting a Bag Leak

- Typically, an opacity spike will occur when the leaking bag is pulsed.
Hunting a Bag Leak

- Trend data showed this leak was likely in PJFF-A, group B.
Hunting a Bag Leak

- The location of the leak can be quickly narrowed down to a particular compartment header.
- After the offending group is identified:
  - Manually pulse each of the headers in the group one at a time and wait for an opacity spike to occur.
Hunting a Bag Leak

- The header of the leaking bag is found!
- So, we’ve got it down to 500 out of a possible 22,000 bags.
- That’s still a lot of bags. What is the next step?
Hunting a Bag Leak

- The leaking bag can usually be identified easily once the compartment is locked out and entered. BUT – only if previous leaks in the compartment have been thoroughly cleaned up!
Repairing a Bag Leak

- The blow pipe is removed, the bag cage is pulled out, and the broken bag is extracted.
Repairing a Bag Leak

- This bag was damaged by rubbing against the compartment wall.
Repairing a Bag Leak

- The area is vacuumed up, a new bag is installed, and the cleaned and inspected cage is re-inserted.
Bag Leaks – Final Thoughts

- Bag leaks are relatively painless to identify and correct – IF opacity spikes are checked regularly and compartments are thoroughly cleaned when bags are replaced.
- Flue gas velocity in the compartments is very low. The ash path from bag to outlet damper won’t just sweep itself clean – it must be vacuumed.
Questions?
Bag Attachment to Tubesheet
**Bag Cages**

Process gas flows from the outside to the inside of the filter bags. Bag cages are installed inside each bag to prevent their collapse during operation.
Pulse Valves and Pilot Solenoids

- Compressed air is sequentially discharged to each blowpipe through a pilot controlled pulse valve. The pulse valve is a double diaphragm valve. The pulse valve is controlled using a normally closed electrically operated solenoid air valve.
10 meter Filter Bags

Surface Area -

8,704 filter bags
10 - meter length?

10 – Acres

435,600 ft²