Worldwide Pollution Control Association

IL Regional Technical Seminar

September 13-15,2011

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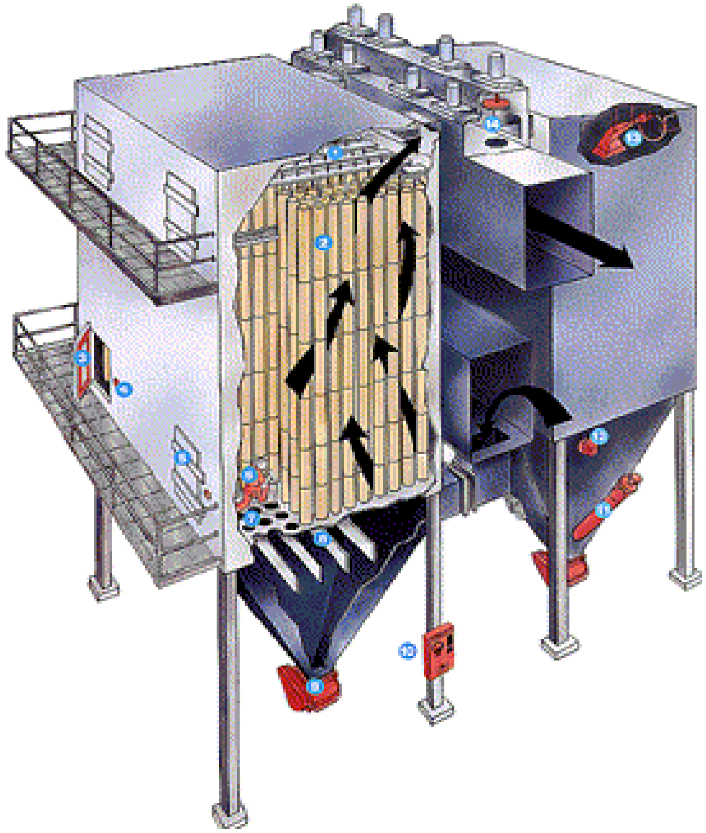
WPCA Regional Technical Seminar

Planning and Executing the Refurbishment of Coal-Fired Boiler Bag Houses



Tim Stark
GE Environmental

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Bag house refurbishment
Background

- Fabric filters are becoming more common as the primary particulate removal device serving a coal-fired utility
- Fabric filters are capable of achieving consistent high efficiency removal of fine particulate
- The filter bags, however, must be maintained to retain performance
- This presentation outlines the process of accomplishing a filter bag change out

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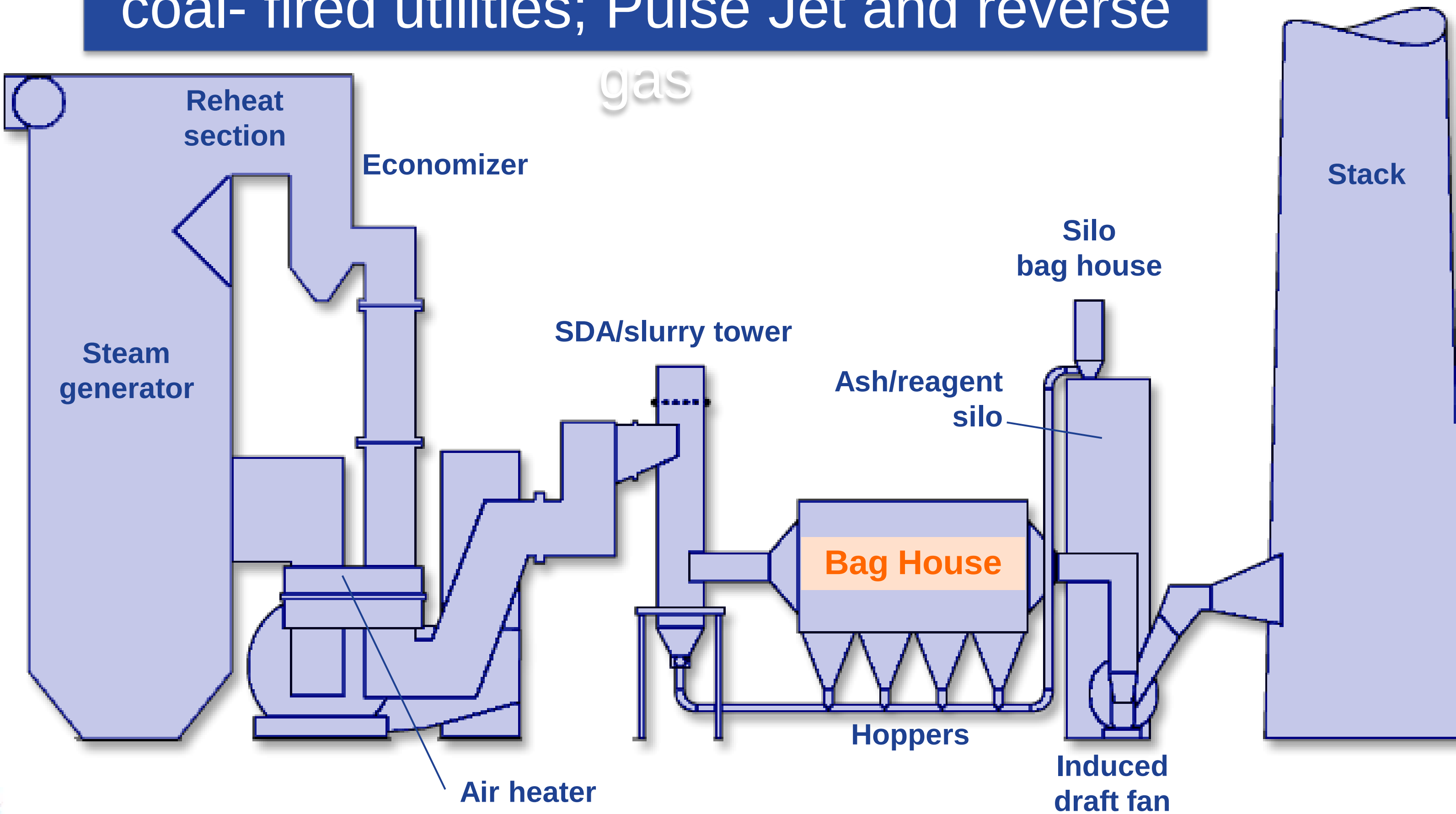
Bag house refurbishment

Typical flow diagram

Two major types of bag houses serve coal- fired utilities; Pulse Jet and reverse gas



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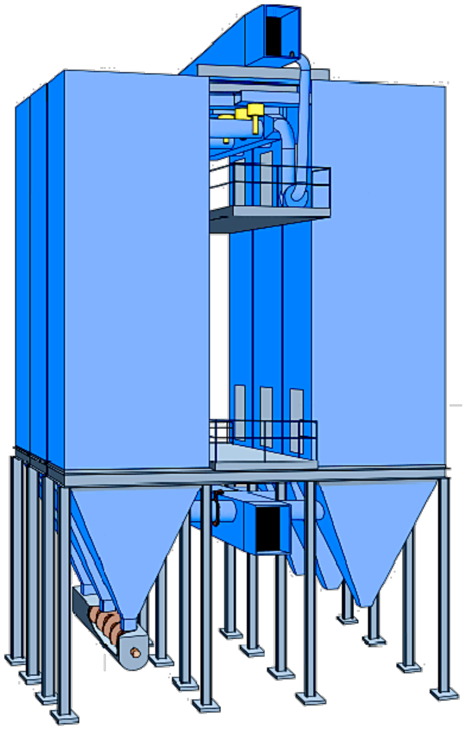
Bag house refurbishment

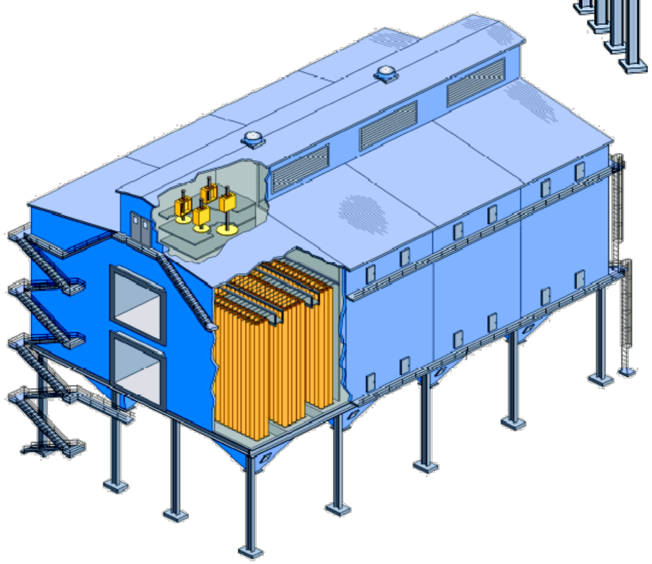
Reverse gas fabric filter

Historically, 95% of applications utilized reverse gas collector designs

Typical configuration:

- Woven fiberglass bags
- 2:1 (fpm) Air-to-Cloth Ratio (ACR)
- 11.5" x 30' filters (29 cm x 9 m)
- 4 – 10 year filter life
- Large footprint housing
- Off-line cleaning





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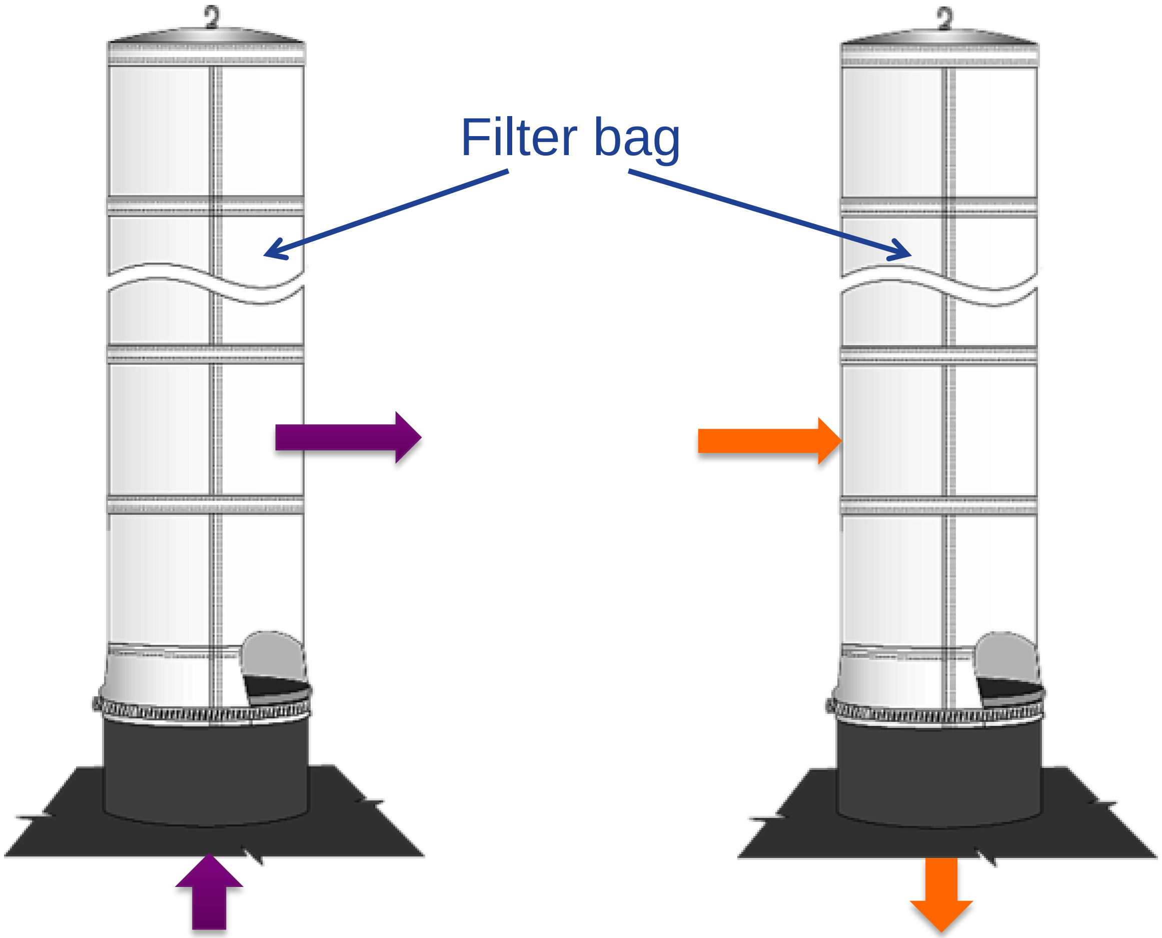
Bag house refurbishment

Reverse gas fabric filter



Normal flow

Reverse flow

Tension assembly

Bag house refurbishment
Pulse Jet fabric filter

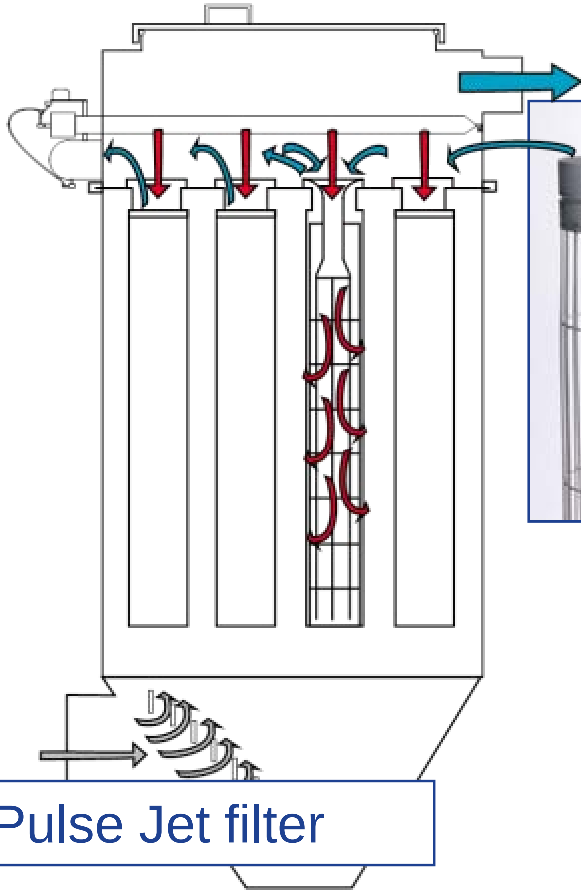
Most new installations use Pulse Jet technology

Typical configuration

- Needle felts (acrylic, PPS, P-84), woven fiberglass and pleated filter elements
- 2.8 – 3.5 (fpm) Air-to-Cloth Ratio (ACR)
- 6” x 24’+ (15 cm x 730 cm)
- 3 – 5 year filter life
- Smaller housing footprint
- Typically on-line cleaning

Bag house refurbishment

Pulse Jet fabric filter



Pulse Jet filter

Cages

Pleated elements

Filter bags

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Bag house refurbishment

What drives the need for a bag change?

Ideally, filter bags should be changed at the end of their useful life

Multiple factors impact bag life:

- Gas temperature
- Dust loading
- Flow velocity and uniformity
- Cleaning cycles endured

Increasing rate of failure is an indication of bags reaching end of useful life

Bag house refurbishment
Outage planning decisions

Multiple decisions must be made prior to initiating a bag change outage:

- Will bag change occur on-line or off-line?
- What is start date and duration of outage?
- Will change out be contracted or handled in-house?
- Is configuration of bag, and if applicable, cage known?
- Does a purchasing specification for labor/materials exist?
- What receiving and staging areas can be dedicated?
- How does a bag change out integrate with other outage activities?
- Are existing confined space entry and LOTO procedures adequate?
- Is internal condition of bag house known?

Answering the questions minimizes surprises

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Bag house refurbishment

Why is outage planning critical?

Estimated price off-line 500 MW boiler bag change out:

Pulse Jet: $1.2 to $1.8 million installed

Reverse air: $1.0 to $1.25 million installed

Filter bag replacement is the highest bag house maintenance cost

Bag house refurbishment
Change out approach

Primary decision: on-line or off-line change out?

- The bag change out can occur while the boiler is shut down
- If sufficient and compartmentalization and isolation exists, the change out can occur while the boiler is on-line
- If not then bags must be changed out off-line
- There are advantages and disadvantages of both approaches

Bag house refurbishment

Change out off-line

Pros

- **Speed** – Access to all compartments at the same time
- **Safety** – No challenges with radiant temperature from other compartments or potential gas stream leaks
- **Thoroughness** – Simultaneous leak testing and pre-coat of entire system with ability to start-up and shut-down fans
- **Control** – Ability to control airflow through entire system at even loading during start-up
- **Predictability** – Improved bag life predictability with all filters having same start-up date
- **Uniformity** – Unit starts up at overall lower pressure drop, allowing less cleaning required to maintain pressure drop

Cons

- **Time** – Outage sufficient for completion of entire unit; lost production

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Bag house refurbishment

Change out on-line

Pros

- **Time** – No boiler shut down required
- **Staging** – Minimize challenge associated with staging materials for several compartments

Cons

- **Safety** – Potential issues with compartment isolation and heat
- **Non-Uniform** – Uneven loading to compartments with new filters leading to possible bleed-thru/blinding
- **Velocity** – Potential high velocity leading to abrasion issues in newly re-bagged compartments
- **Duration** – Slower schedule, takes longer to complete entire unit
- **Start-Up** – Challenge to properly leak test and pre-coat individual compartments

Bag house refurbishment
Change out mode decision

Basis for decision

- Reverse gas versus Pulse Jet
- RA typically conducive to on-line change out
- Pulse Jet must have sufficient A/C to accommodate operation with one or more compartments off-line
- Compartments must be capable of being isolated from heat and process gas
- Relative cost of each option
- Time available for change out

Bag house refurbishment

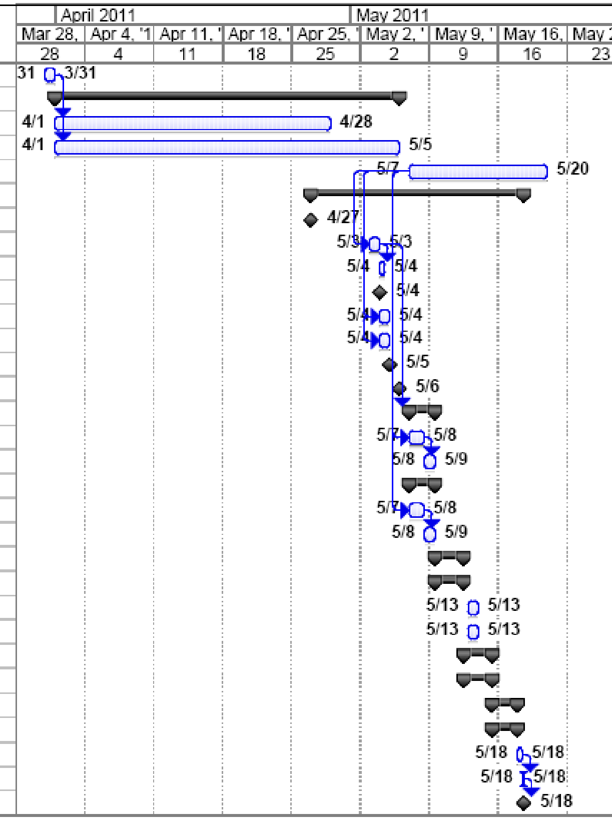
Phases of change out

Pre-Outage → Outage → Post-Outage

Inspect	Clean	Pre-coat
Plan	Remove	Start-up
Purchase	Position	Monitor
Schedule	Install	Sample
Receive	Verify	Test
Stage	Leak test	Inspect
	Demobilize	Record

Boiler Refurbishment
Unit #
Project # 10000XXXX

ID		Task Name	Duration	Start	Finish	Resource Names
1		Receive PO	1 day	Thu 3/31/11	Thu 3/31/11	
2		**Manufacturing**	**35 days**	**Fri 4/1/11**	**Thu 5/5/11**	
3		Bags (4 weeks ARO)	4 wks	Fri 4/1/11	Thu 4/28/11	
4		Cages (5 weeks ARO)	5 wks	Fri 4/1/11	Thu 5/5/11	
5		Outage	2 wks	Sat 5/7/11	Fri 5/20/11	
6		***Installation / Services schedule Unit 2***	***21.75 days***	***Wed 4/27/11***	***Wed 5/18/11***	
7		Supplies Shipment Arrival	0 days	Wed 4/27/11	Wed 4/27/11	
8		*Crew Travel/ Mobilization*	*1 day*	*Tue 5/3/11*	*Tue 5/3/11*	
9		Site Safety / Prep Site	0.5 days	Wed 5/4/11	Wed 5/4/11	
10		Rental Equipment Delivery	0 days	Wed 5/4/11	Wed 5/4/11	
11		Bag and cage delivery	1 day	Wed 5/4/11	Wed 5/4/11	
12		Stage bags and cages	1 day	Wed 5/4/11	Wed 5/4/11	15 person team
13		Crane arrival on-site	0 days	Thu 5/5/11	Thu 5/5/11	
14		Dumpsters arrival on-stie	0 days	Fri 5/6/11	Fri 5/6/11	
15		**Compartment 1 Refurb**	**2.75 days**	**Sat 5/7/11**	**Mon 5/9/11**	**9 person team**
16		Remove blowpipes / filters / cages	1.5 days	Sat 5/7/11	Sun 5/8/11	
17		Install filters/ cages / blowpipes	1.25 days	Sun 5/8/11	Mon 5/9/11	
18		**Compartment 2 Refurb**	**2.75 days**	**Sat 5/7/11**	**Mon 5/9/11**	**9 person team**
19		Remove blowpipes / filters / cages	1.5 days	Sat 5/7/11	Sun 5/8/11	
20		Install filters/ cages / blowpipes	1.25 days	Sun 5/8/11	Mon 5/9/11	
21		**Compartment 3 Refurb**	**2.75 days**	**Mon 5/9/11**	**Thu 5/12/11**	**8 person team**
24		**Compartment 4 Refurb**	**2.75 days**	**Mon 5/9/11**	**Thu 5/12/11**	**9 person team**
27		Bag and cage delivery	1 day	Fri 5/13/11	Fri 5/13/11	Logistics Crew
28		Stage bags and cages	1 day	Fri 5/13/11	Fri 5/13/11	15 person team
29		**Compartment 5 Refurb**	**2.75 days**	**Thu 5/12/11**	**Sun 5/15/11**	**9 person team**
32		**Compartment 6 Refurb**	**2.75 days**	**Thu 5/12/11**	**Sun 5/15/11**	**9 person team**
35		**Compartment 7 Refurb**	**2.75 days**	**Sun 5/15/11**	**Tue 5/17/11**	**9 person team**
38		**Compartment 8 Refurb**	**2.75 days**	**Sun 5/15/11**	**Tue 5/17/11**	**9 person team**
41		Visolite testing	0.5 days	Wed 5/18/11	Wed 5/18/11	4 person team
42		Neutralite Injection	0.25 days	Wed 5/18/11	Wed 5/18/11	4 person team
43		Demobilization of crew	0 days	Wed 5/18/11	Wed 5/18/11	



Task		Rolled Up Task		External Tasks	
Progress		Rolled Up Milestone	◇	Project Summary	
Milestone	◆	Rolled Up Progress		Group By Summary	
Summary		Split		Deadline	⇩

GE Energy
BHA Group Inc

Bag house refurbishment

Pre-change out activities

Pre-outage activities

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Bag house refurbishment
Basic material procurement

Pulse Jet	Reverse air
Filters	Filter bags
Cages (100% or spares)	Tensioning (100% or spares)
Door seal	Door seal
Labor	Labor
Pulse valve/solenoid parts	Clamps if required
Leak detection materials	Leak detection materials
Pre-coat	Pre-coat

- Depending on outage needs, additional equipment such as cranes, air compressors, welders, scaffolding, and ventilation may be required
- Lead time of purchased and rented material must meet outage schedule

Bag house refurbishment

Pre-outage Inspection

- Outage duration and staffing is based on assumed productivities
- Productivity is directly impacted by the internal condition of the equipment
- To minimize “surprises,” inspecting the bag house or at least a small number of compartments is recommended
- A pre-outage inspection can identify:
  - Filter bag “stuck” on cage
  - Corroded blow pipes connections
  - Accumulation of particulate
  - Damage to tube sheet
  - Corrosion damage to access doors
  - How many people fit into a compartment
  - Other issues that require lead time to address

Bag house refurbishment

Clean air plenum access-space restrictions

Pre-outage inspection can identify access limitation

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Bag house refurbishment
Clean air plenum access

What equipment is necessary to lift hatches and material?

Bag house refurbishment

Pulse valves and solenoids

Prior to outage, identify faulty diaphragm and solenoid valves

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Bag house refurbishment

Ash accumulation

Look for ash buildup

Bag house refurbishment
Ash accumulation

Clean up before installation can begin

Bag house refurbishment
Blow pipe corrosion

Corrosion can cause blow pipe connections to seize

Bag house refurbishment

Door seal

Pre-outage inspection helps identify extra work scope and materials

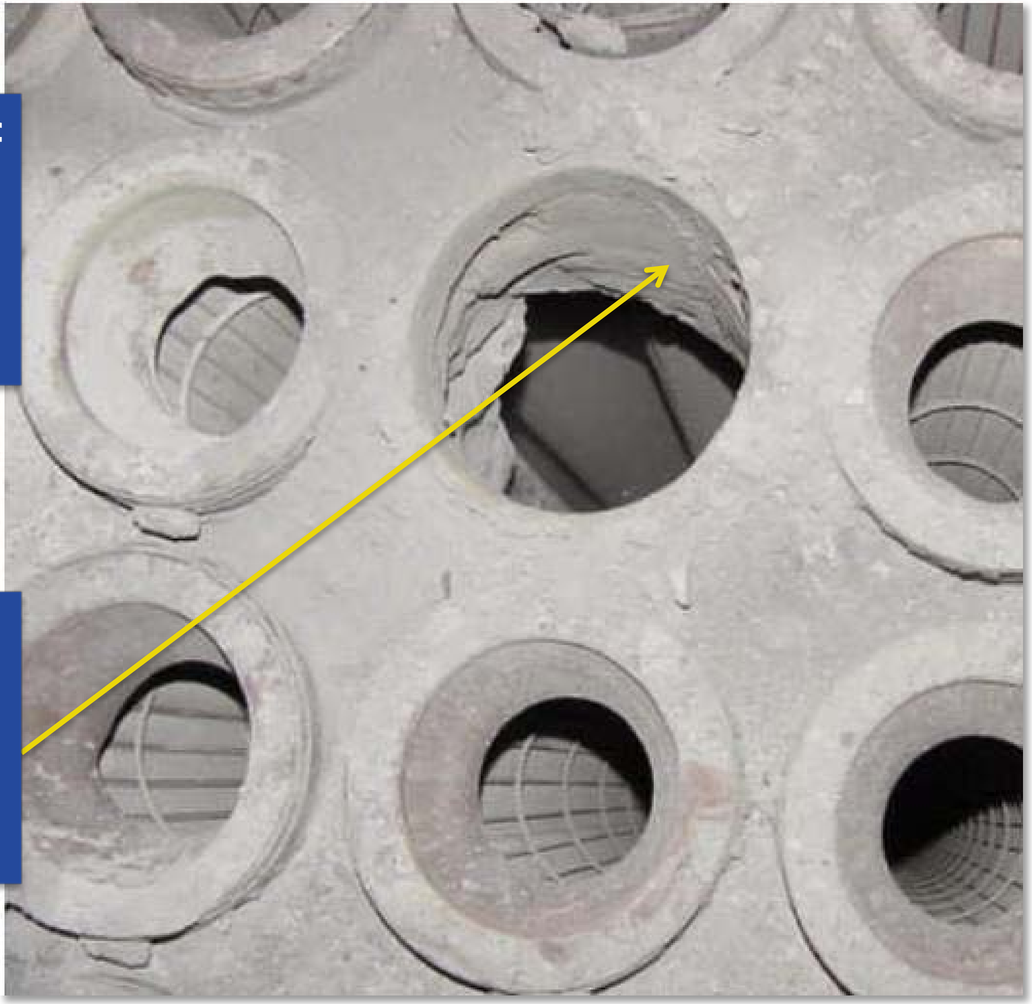
Leakage at access doors causes corrosion

Bag house refurbishment

Know what is in store for the crew

Deposits on bottom of tube sheet hamper bag removal

Unknown conditions can destroy outage schedules



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Bag house refurbishment

Have you considered the weight of the filter bag?

Dirty filter bags may weigh several times more than a clean filter bag

Reverse gas fiberglass filter bag 12” diameter x 35’ long	Filter Weight
New filter bag	16 lbs.
Dirty Bag - SCR Offline	35-45 lbs.
Dirty Bag - SCR Online	55-100 lbs.
Dirty Membrane Bag - SCR On or Off	20 lbs.

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Bag house refurbishment

Pre-outage inspection

Inspection findings should be documented to identify:

- Repair work scopes
- Material necessary for repairs
- Need for “sucker” truck or other cleaning equipment
- Condition of tube sheet
- Available area for staging material near tube sheet
- Location of damaged bags
- Ease of access to platforms and doors

When documented, the inspection findings can be incorporated into the project scope of purchase specification

Bag house refurbishment

Outage activities

Outage activities

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Bag house refurbishment

Hopper clean out

Hoppers should be cleaned out and the outlet plugged to exclude debris

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Bag house refurbishment
Position material

Bag house refurbishment

Staging new materials

To expedite outage, stage material near work station

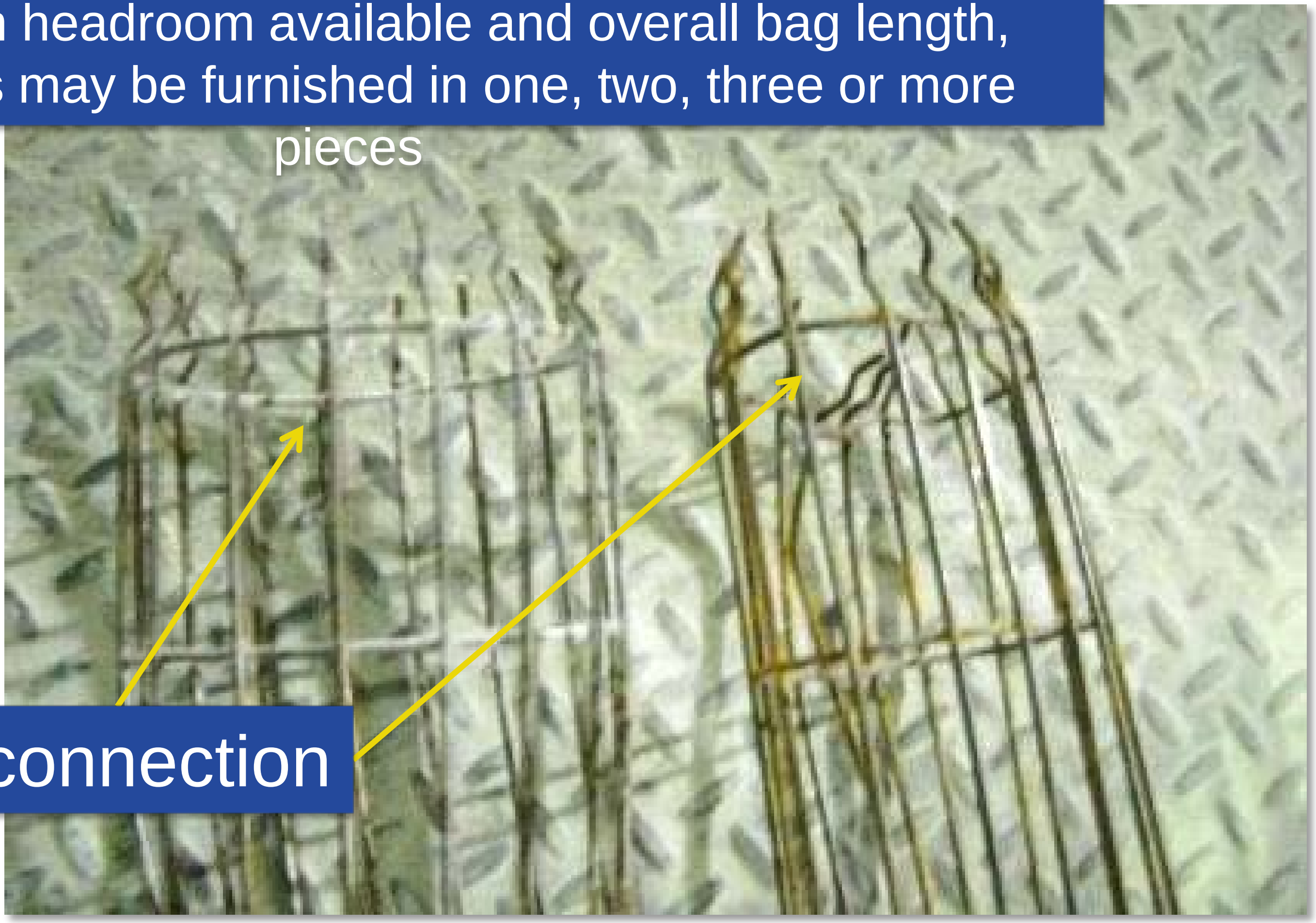
Bag house refurbishment
Filter/cage removal

At the beginning of an outage, bags and cages are removed from the tube sheet

Bag house refurbishment

Two-and three-piece cages

Depending on headroom available and overall bag length, support cages may be furnished in one, two, three or more pieces



Used cage connection

Bag house refurbishment
Bag disposal

Used filters are placed in bags for disposal

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Bag house refurbishment
Bag disposal chute

Chute emptying directly into dumpster minimizes handling

Bag house refurbishment

Installing new filters

Staging boxes of bags

Bag house refurbishment

Lifting filter bags (reverse gas)

Bag house refurbishment

Fitting bag bottom and applying clamp

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Bag house refurbishment
Tightening bottom clamp

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Bag house refurbishment
Tensioning R/A filter bags

Bag house refurbishment
Tube sheet replacement


If extensive tube sheet damage is noted during inspection, it can be replaced during outage

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Bag house refurbishment
Leak testing bag installation

Prior to releasing a compartment, the filter bag installation shall be leak tested

A leak test will identify:

- Damaged bags
- Tube sheet leaks
- Loose clamps
- Improperly installed filter bags

Problems identified can be repaired before the compartment is turned back over to operations

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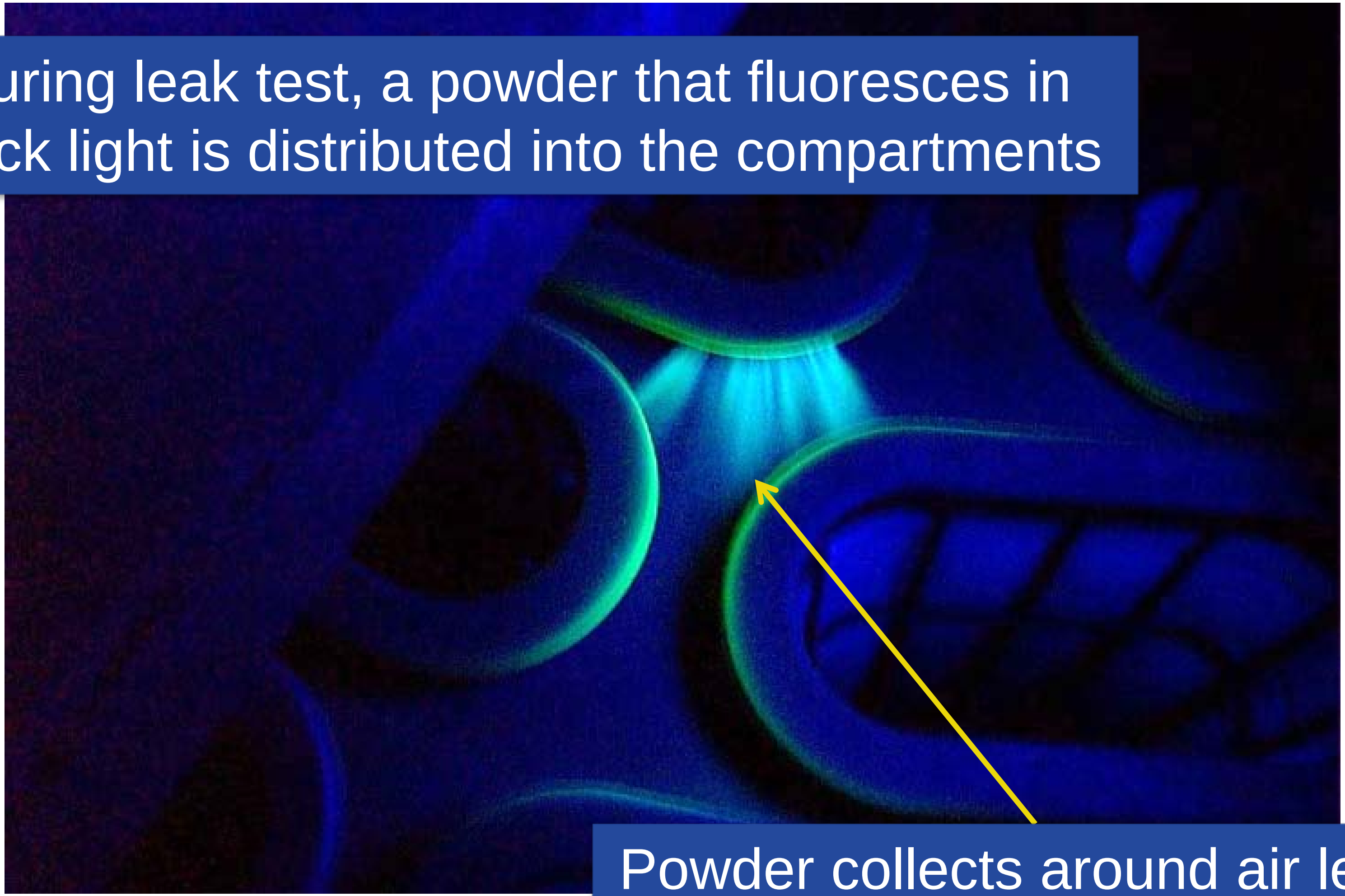
Bag house refurbishment

Leak testing bag installation

During leak test, a powder that fluoresces in black light is distributed into the compartments



Powder collects around air leaks

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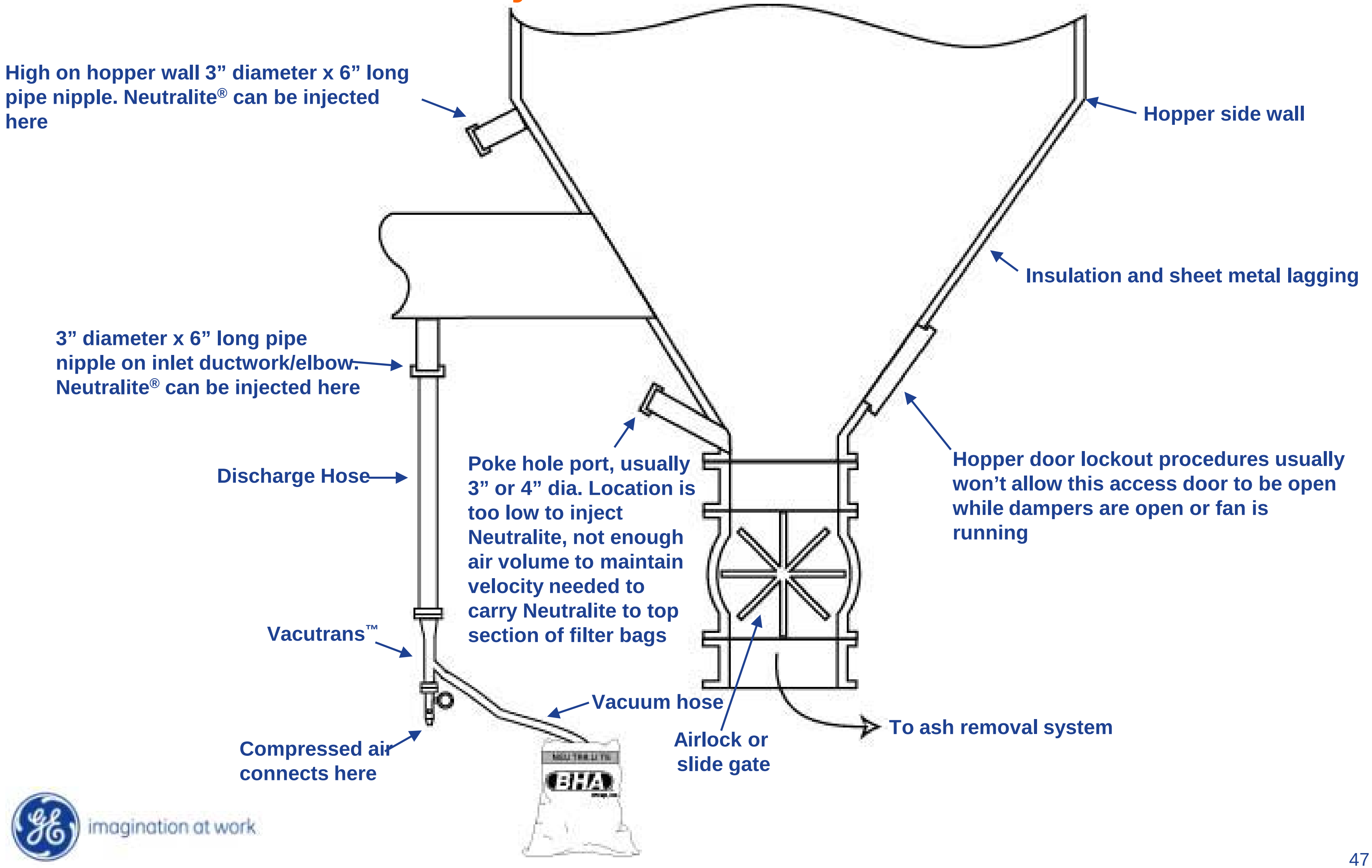
Bag house refurbishment
Leak testing bag installation

- Shut off cleaning system
- Energize fan
- Inject leak test powder (~1lb. per 1000 sq. ft. of cloth)
- Shut off fan after powder has chance to disperse (varies)
- Enter compartment and inspect with black light
- Mark and map defects observed
- Repair and repeat

Bag house refurbishment

Pre-coat/leak test injection



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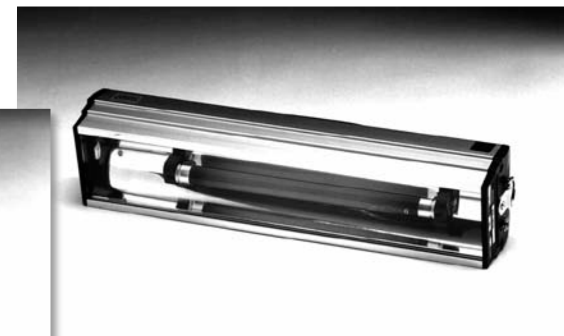
Bag house refurbishment

Leak testing bag installation

GE Visolite® colors:

GREEN | ORANGE | PINK | YELLOW

Recommend purchase of at least two colors of leak test powder. Re-testing can then be performed using a different color



A variety of light sources are available

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Bag house refurbishment

Start-up procedure

GE Energy

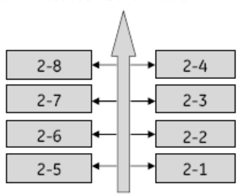
8800 East 63rd Street
Kansas City, Missouri 64133
USA

T 800 821 2222
T 816 356 8400
F 816 353 1873

Brayton Point Station Dry Scrubber System/Operation Procedures document for "SYSTEM STARTUP procedures".
This document describes the recommended startup procedure for Unit 2 PJFF only.

General Information

There is no alternative flue gas path from the boiler except through the pulse-jet fabric filter (PJFF). Flue gas from the SDA is ducted to the PJFF which evenly distributes flow to eight (8) compartments as shown in illustration 1 shown below:



Flue gas path (Illustration 1)

Each compartment contains 1,040 filter bags manufactured from polyphenylene sulfide (PPS) fabric laminated on the collection surface with GE Preveil™ ePTFE membrane.
The filter bags are cleaned by using a reverse pulse of intermediate pressure (35 psig) compressed air at 150-200 ms on-time. To do so, compressed air is delivered to four (4) isolatable pulse air headers per compartment. Each header supplies air to 13, 3.0" double diaphragm pulse valves which are activated by a pilot solenoid valve and control air supply to a pulse manifold pipe. Each pipe delivers pulse air to twenty (20) filter bags within each compartment through holes in the bottom of the pipe. The reverse pulse of air dislodges the accumulated filter cake from the filter bags, and particulate falls to the hopper.

Precoating and Re-Coating Procedures

Initial Precoating

Since the system will start-up with natural gas, the materials used for approved precoating ... e dew point is crossed during startup, protecting the filters. Refer to ... es for amount and various methods on injection.
... of filtration media which will require a total of 13,117 lbs. of GE ... initial precoating. Once the approved precoat material is introduced ... should not be turned off or compartments isolated in order to hold ... ion surface of the bags for a period of 24 hours.

... ed to be turned off after the initial startup, **flyash** is an acceptable ... coating of the filter bags. PJFF Unit 2 will require 65,584 lbs. (32.8 ...

... oad out trucks should be utilized.
... t for precoating or re-coating is 50% of average operating gas ... 300,000 ACFM for Unit 2).
... equirement for either the initial precoating or subsequent re-coating

... ith only the Neutralite pre-coat is expected to be very low in the 1" ... ange across the individual compartments. This is completely

... it online from a cold start, only 25% of the PJFF (2 compartments) ... xample, compartments 2-4 and 2-8 can be used for startup. If an ... eeds to be added, please consult with the GE technical advisor. ... p utilizing natural gas firing typically take 12 – 16 hours. Because ... is reduced, flue gas velocities through the PJFF unit are reduced. ... mpartments were in service, it would take additional time for the ... ature. This would result in compartments operating a considerable ... dew point. Bringing several compartments online at different ... ent temperatures being brought up more quickly and subsequently ... t quickly. This minimizes the amount of condensation that occurs, ... rs, support cages, and structural metal parts.

... Refurbished Compartments
... outlet dampers.
... ng system should remain off for all compartments, including the ... nts until the differential pressure (ΔP) across the compartment has ... nd the inlet ... ... nts have ...

3. The allowable volumetric flue gas flow rate, as measured at the stack, is limited based upon the number of compartments online (inlet & outlet dampers fully open). These limits are shown in Table 1. Unit load should be reduced as necessary to remain at or below these limits.
4. Bring the pulse-jet cleaning system online for each newly bagged compartment when ... dampers are fully open, and the ΔP across the compartment tube ... eeds 4.0" w.g.

Additional Guidelines

... ent ΔP exceeds 4.0" w.g. across a newly bagged ... d the minimum damper open times ... elapsed, additional compartments can be brought on-line ... he compartment ΔP drops below 4.0" w.g. across all newly ... ed compartments ... not elapsed the inlet damper to the compartment ... ding a compartment ΔP of 4.0" w.g. should be ... essively closed until the compartment ΔP is at or below ... VG.

... ximum Flue Gas Flow vs. No. Of Online Compartments

...ments Online ... Dampers Full ...n)	Maximum Allowable Flue Gas Flow Measured In The Stack (ACFM)
	1,100,000
	962,000
	825,000
	687,500
	550,000
	412,500
	275,000

Additional Information

... rate in any one newly bagged compartment is limited to ... This value was established to keep the air-to-cloth ratio and ... at or below system design parameters. ... espond to GE Energy's Performance Warranty

... "w.g. difference in differential pressure between the individual ... p and system (measured inlet to outlet across the PJFF) pressure

... JFF unit cleaning system be controlled by pressure drop. Refer to ... t Fabric Filter (PJFF) Operation/Pulse Air Cleaning System".

3

Document the start-up procedure to be applied

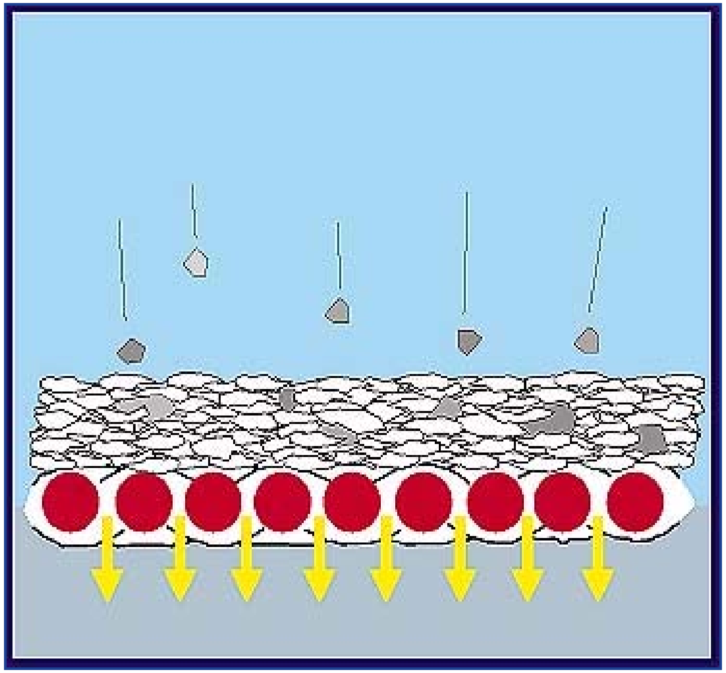
Bag house refurbishment
Start-up procedure

High level start-up guidelines:

- Build up initial dust cake (pre-coating)
- Preheat compartments
- Restrict airflows (balance dirty/clean compartments)
- Lockout cleaning cycle (initially)
- Stabilize process and release normal cleaning

Bag house refurbishment

Pre-coating filter bags



It is recommended to pre-coat new filter bags prior to introducing flue gas.
The pre-coat shall:

- Exhibit a wide range of particle sizes
- Contain a range of particle shapes
- Build to a uniform coat
- Present a neutral pH?
- Create a porous dust cake

Effective pre-coat ensures acceptable gas flow, protects bags from moisture, hydrocarbons, and initial blinding

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Bag house refurbishment

Start-up procedure

After pre-coating

- The cleaning system should be locked out to keep the initial dust cake in place until the desired differential pressure is achieved
- Monitor the DP at both flanges and tube sheet
- Cleaning prematurely will re-expose the new fabric to the gas flow, creating the potential for blinding and bag damage
- Cleaning system can be released when the desired pressure differential is achieved

Bag house refurbishment
Start-up procedure

If possible start up the boiler on natural gas

Preheat the equipment on start-up fuel to minimize thermal shock to the mechanical and structural components of the system, and to ensure gas stream temperatures are above moisture and acid dew point prior to venting to the collector.

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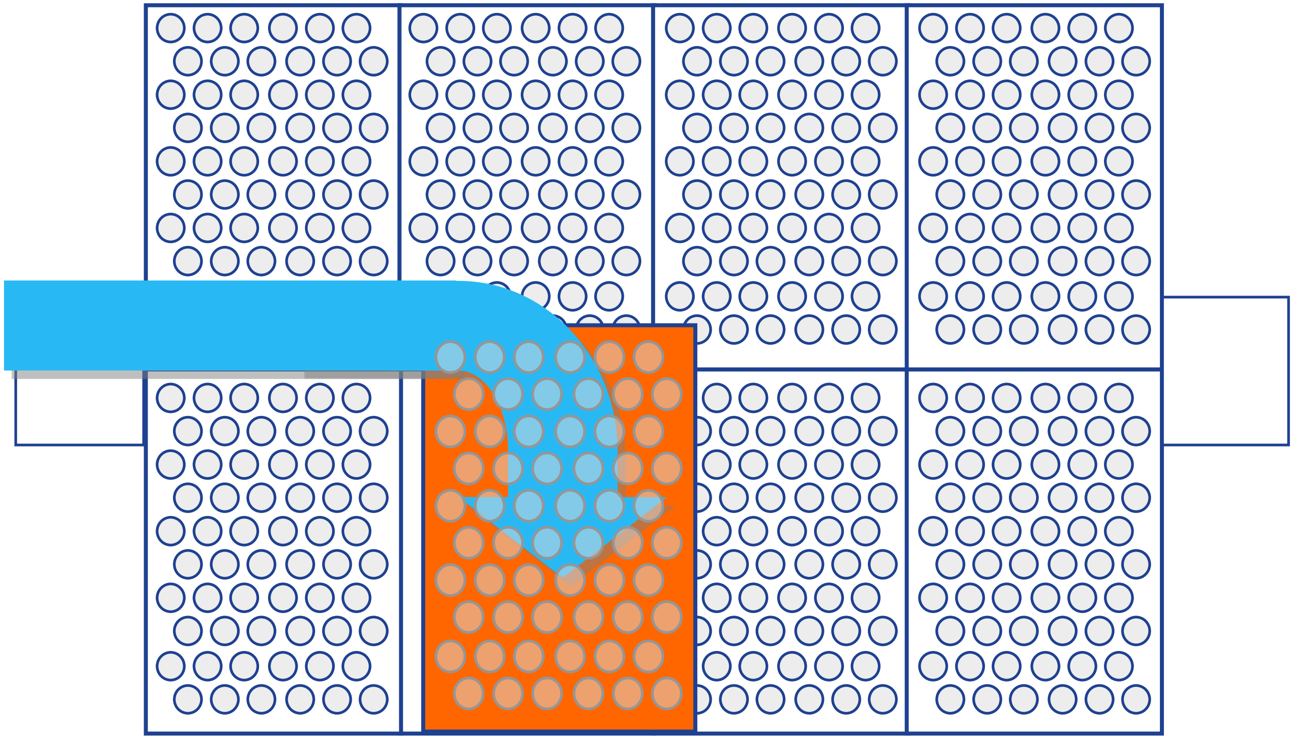
Bag house refurbishment

Why balance flow?
Compartment change out



After bag change out, new filter bags offer less resistance to gas flow, compared to used bags

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Bag house refurbishment

Why balance flow?

- Field testing shows clean filter media accepts 20 to 50 cfm gas flow per square foot area
- Dirty filter media with dust cake accepts gas flow in the range of 5 to 10 cfm per square feet area
- Based on this difference, the clean filter bags will treat about three times more gas than dirty media
- Potential for blinding of bags, scouring, and bag to bag abrasion damage
- Increasing pressure loss to the clean compartments, or the entire bag house with clean media, will minimize potential for damage

Bag house refurbishment
Restrict initial gas flow

Pulse Jet system	
Damper setting	Operating period
10%	12 hours
25%	6 hours
50%	6 hours
Reverse gas system	
Damper settings	Operating period
20%	12 hours
40%	6 hours
70%	6 hours

Not critical how, just that flow is restricted to clean compartments on start-up

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Bag house refurbishment

Post-outage activities

Post-outage activities

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Bag house refurbishment
Post-outage activities

Post outage activities should be focused on preserving the bag change out investment

Some typical activities are:

- Inspections
- Bag testing
- Monitoring
  - Emissions
  - Pressure drop
  - Cleaning interval

Bag house refurbishment

Post-outage activities

Inspections

- Each compartment should be inspected regularly to identify changes in condition
- Inspection shall reference bag installation date
- Establish tube sheet template for recording inspection observations
- Inspections should identify location of failed bags or components
- Location of defects can help characterize the nature of the problem

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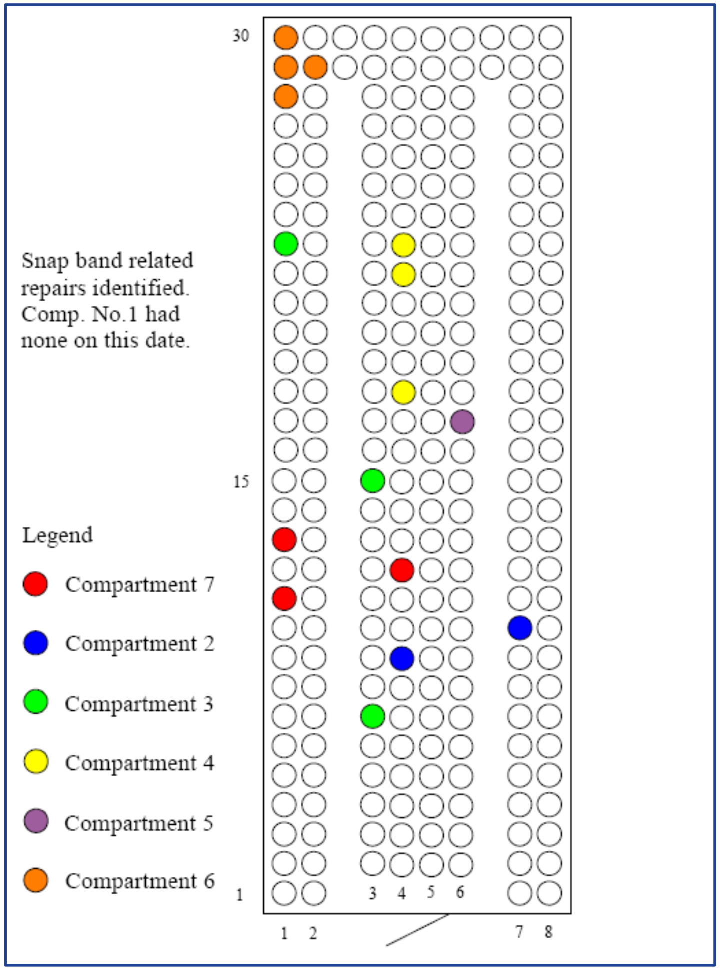
Bag house refurbishment
Post-outage activities



Tube sheet templates record location of defect and inspection findings for future reference

Bag house refurbishment
Post-outage activities

Bag testing

- Filter bag testing can identify cause for failures and provide indication of remaining useful life
- Samples of damaged filter bags should be tested
- On an annual basis, it is recommended to test a sample of operating filters

Typical properties tested are:

- Permeability
- Burst strength
- Flexural strength

Bag house refurbishment
Post-outage activities

Bag testing

- Bag test results provide useful data when compared against baseline data
- Gathering bag test data for new filters and periodically thereafter provides an indication of the rate at which physical properties are degrading
- Test data obtained for failed bags provides insight into the failure mechanism
  - Chemical
  - Thermal
  - Mechanical

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Bag house refurbishment
Post-outage activities

Monitoring

- Overall emissions should be monitored, but individual compartment data may be more meaningful

Overall emissions can be evaluated for:

  - Absolute emission level
  - Changes in emissions over time
  - Variations in emission during cleaning
- Individual compartment emission data helps focus inspection and monitoring activities
- Problems associated with overall gas or temperature distribution can be identified using compartment specific data

Bag house refurbishment

Summary

- Filter bag replacement represents a major expense
- Proper planning minimizes surprises and extended outages
- Inspections performed prior to outages provide invaluable planning data
- Leak testing ensures that the installation was performed correctly
- Care must be exercised during start-up to avoid damage to clean filters
- Long-term management through inspections, bag testing, and monitoring will help extend the change out investment

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Bag house refurbishment

Q&A

Thank you for your time

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Bag house refurbishment

Fabric characteristics and suitability for power generation applications

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

* Sensitive bag-to-cage fit

** Fair with chemical or acid-resistant finishes

*** Must oversize bag for shrinkage for temperatures above 450°F (232°C)

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Bag House Refurbishment

Abrasion failure: Bottom of filter bags located directly in line with inlet gas stream

Excessive movement of filters causing bag-to-bag abrasion

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