REINHOLD ENVIRONMENTAL Ltd.

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2018 APC-WASTEWATER/ PCUG CONFERENCE

Fabric Filter 101

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Fabric Filter – How Does it Work?

Fabric Filter Disadvantages

- Fabric Attack
- Temperature Limitations
- Pressure Drop Run Away
- Some Fabrics Burn
- Fabric Replacement Dirty

Fabric Filter Principal Advantages

- High Efficiency
- Dry Process
- No High Voltage
- Minimum Corrosion
- Less Sensitive
- All Capacity Ranges
- Modular Maintenance

Fiber Mfg.

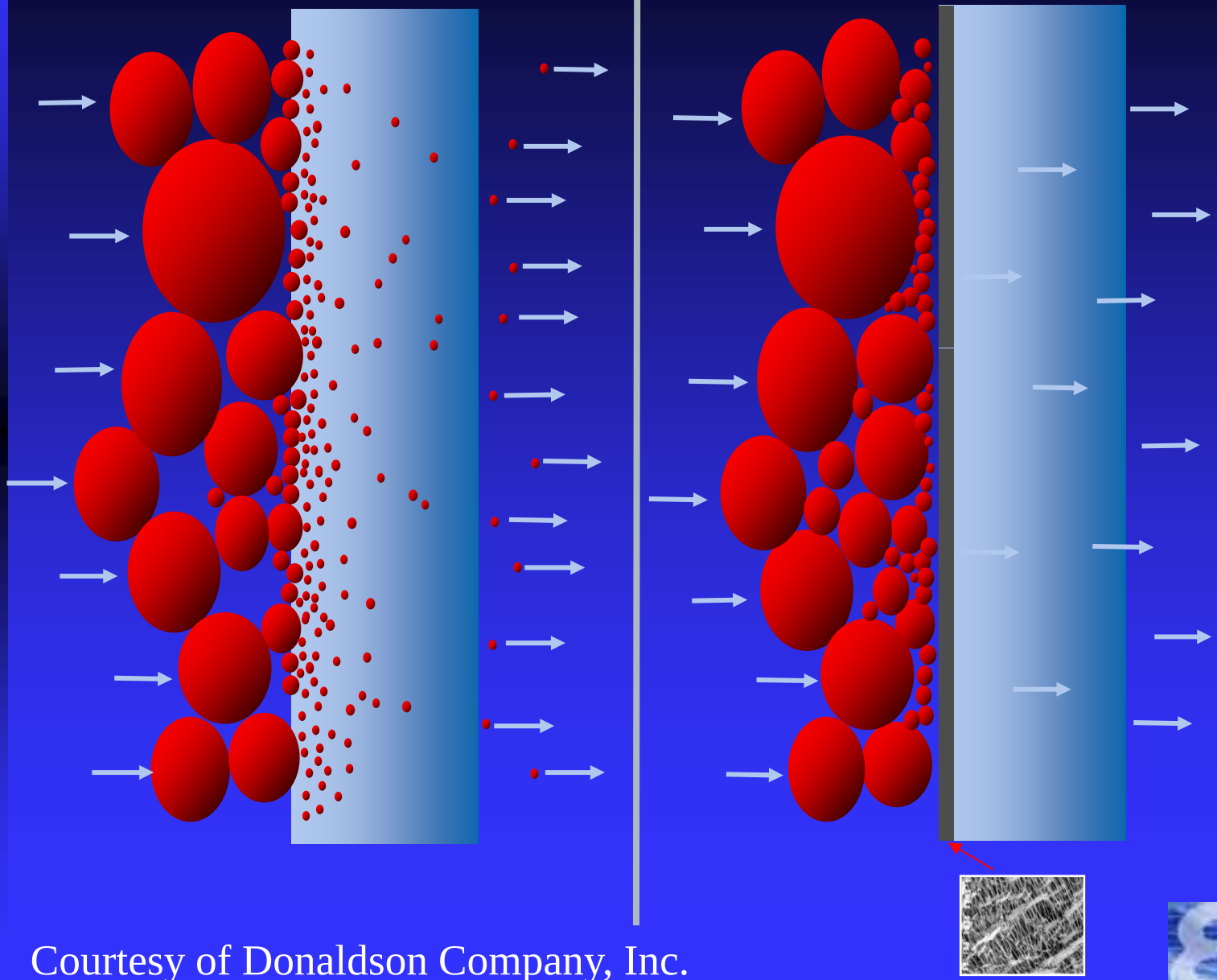
Fabric Mfg.

Bag Mfg.

Cage Mfg.

Baghouse Mfg.

Depth Filtration - Surface Filtration



Courtesy of Donaldson Company, Inc.

Fabric Filter Categories

- Capacity
- Filtering Temperature
- Operating Duty

Needs Dictated By Specific Application

- Cleaning Method
- Filter Media
- Filtering Gas Flow Direction

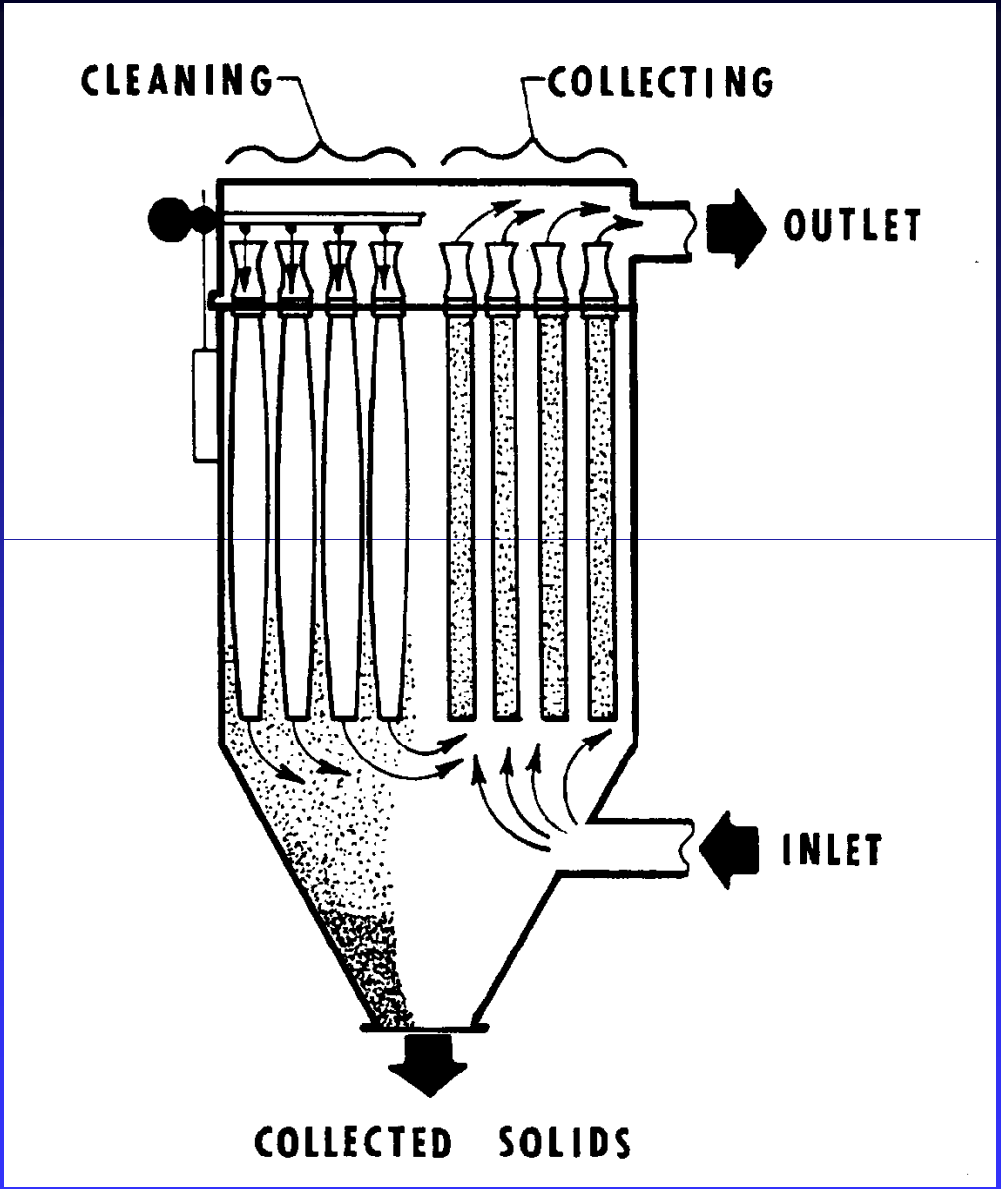
Options

Cleaning Methods

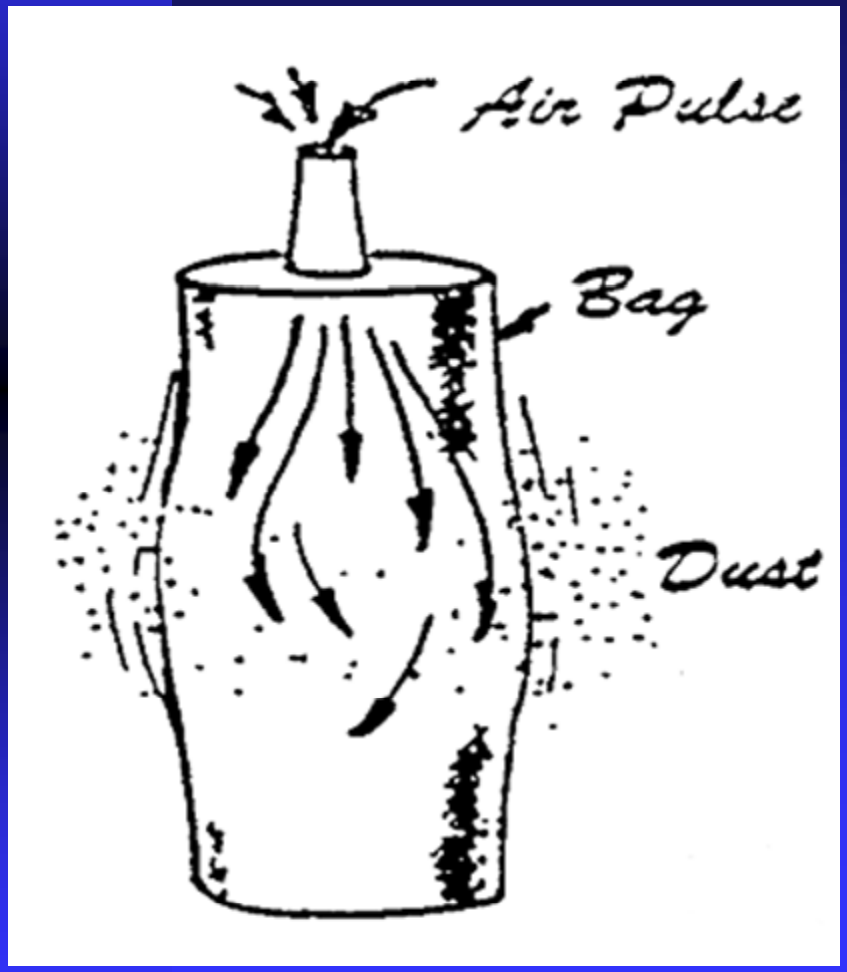
- Pulse Jet
- Reverse Air
- Shaker

Pulse Jet

- On-stream Cleaning
- Collecting Dust Simultaneously



Pulse Jet Cleaning

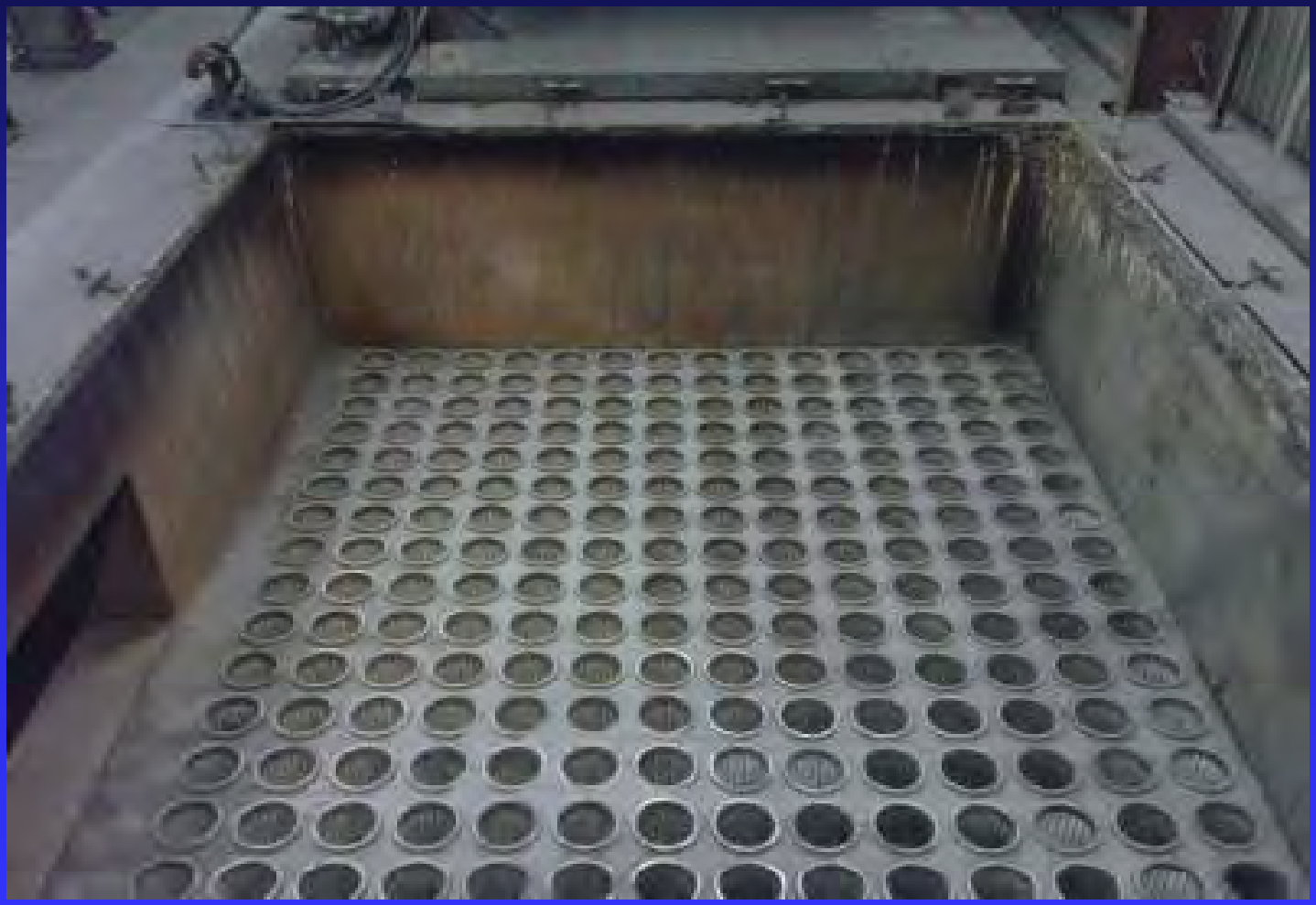


- Outside Collection
- Medium - High G/C Ratios
- Felted Filter Media and Woven Fiberglass (ePTFE membrane increasingly being used)
- Continuous Operation
- Automatic Cleaning
- Small - Large Volumes
- On-Line Cleaning - Most Applications
- Often No Compartmentalization- For Smaller Units
- Bag Access From Top of Collector

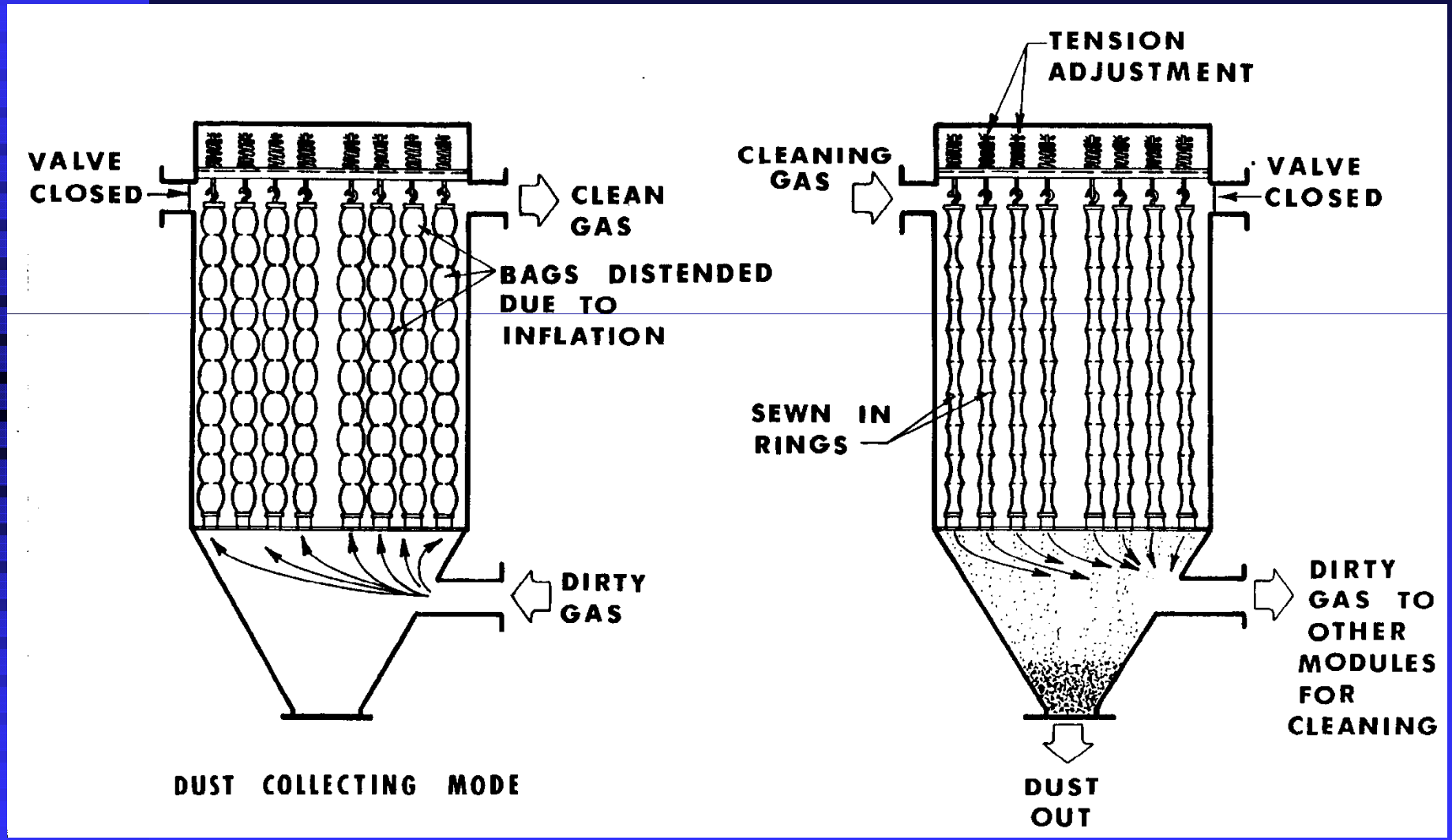
Pulse Jet Cleaning Parameters

Energy Source:	Low, Intermediate & High Pressure Compressed Air
Typ. Cleaning Initiation:	Timed or ΔP ΔP Trigger Typ. 5.0 - 7.0 in. H_2O Cleaning Activated If > 72 hrs.
Motion:	Air Bubble Travels Down Bag Bag Distends From Cage
Mode:	On-Stream: One Row/Pulse Off-Stream: One Compartment
Bags:	4½ - 6” Diameter 8’ - 32’ Length
Bag Support:	1, 2 and 3 Piece Cages ¼” - ½” Pinch

Pulse Jet Tubesheet



Reverse Air


VALVE CLOSED
CLEAN GAS
BAGS DISTENDED DUE TO INFLATION
DIRTY GAS
DUST COLLECTING MODE
TENSION ADJUSTMENT
CLEANING GAS
VALVE CLOSED
SEWN IN RINGS
DIRTY GAS TO OTHER MODULES FOR CLEANING
DUST OUT

Reverse Air Cleaning - Parameters

Energy Source:	Low Pressure, High Volume Fan
Cleaning Frequency:	30 Min. – Several Hours
Duration:	10-30 Seconds & Settling Time
Motion:	Gentle Collapse of Bag/Cracking Dust Cake Reverse Flow of Cleaning Air - (1.2 x Volume)
Mode:	Off-Stream
Bags:	8” - 12” Diameter 22’ & 30’ Length Anti-Collapse Rings
Bag Tension:	2 lbs./inch of Bag Circumference 50-80 lbs.

Gas-To-Cloth Ratio

$$G/C = \frac{\text{Gas Volume}}{\text{Cloth Area}}$$

Gross and Net G/C Ratios

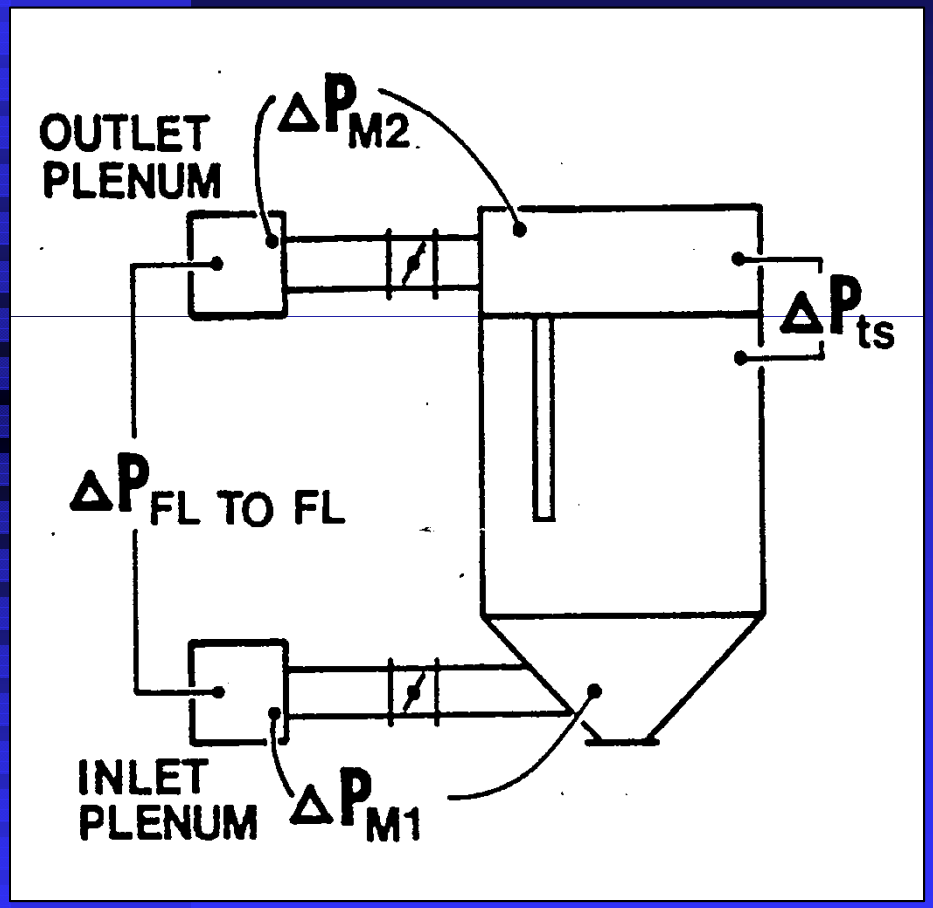
$$\text{Gross G/C} = \frac{\text{Total Inlet Gas Volume}}{\text{Total Cloth Area in Collector}}$$

$$\text{Net G/C} = \frac{\text{Total Inlet Gas Volume}}{\text{On Stream Cloth Area}}$$

What is Pressure Drop?

- Differential pressure, Delta P, or ΔP
- Resistance to airflow through media
- Lost energy required to move air through media
- The higher the ΔP, the more energy (fan horsepower) required to maintain design airflow rate through fabric filter
- Lower ΔP over filter's life reduces energy costs of operating the overall dust collection system

Definition of Pressure Drop Terms



Flange-to-Flange – Total baghouse pressure drop

Tubesheet – Consists of the residual fabric, dust cake, and new dust accumulated since the last cleaning

Residual – Tube sheet pressure drop just after cleaning

Mechanical – Pressure drop across ductwork, dampers and the plenums

Baghouse Selection Process

- Review Dust Source Operation
- Define Emission Problem
- Select Cleaning Method
- Size Collector
- Select Filter Media
- Identify Materials of Construction
- Identify Auxiliary Equipment Needs

Essential Information Required

- Description of Application
- Gas Inlet Volume
- Gas Inlet Temperature
- Gas Moisture Content
- Gas Acid Content
- Description of Dust

Other Information Desired

- Available Space
- Other Equipment in Dust Collection System
- System Operating Pressure
- Existing Utilities
- Additional Comments

Fabric Selection Considerations

Gas Stream

- Temperature
- Moisture
- Chemistry
- Dust Loading

Dust Characterization

- Abrasiveness
- Stickiness
- Explosiveness
- Flammability

Fabric

- Filtration Performance
- Temperature Max
- Release Properties
- Pressure Drop
- Life/Durability
- Costs

Other

- Scrim
- ePTFE Membrane
- Coatings/Treatment
- Hardware
- Fiber Blends

Fabric Selection Chart

Fabric	Max Continuous Temp	Surge Temp.	Acid Resistance	Fluoride Resistance	Alkali Resistance	Flex Abrasion Resistance	Relative Cost*
Cotton	180 °F	200 °F	Poor	Poor	Good	Very Good	0.3
Wool	200 °F	230 °F	Good	--	Poor	Fair	--
Polypropylene	200 °F	200 °F	Excellent	Poor	Excellent	Very Good	0.4
Homopolymer Acrylic (PAN)	257 °F	284 °F	Good	--	Fair	Good	0.6
Polyester	275 °F	300 °F	Fair	Poor to Fair	Fair	Very Good	0.4
Basofil®/ Melamine	375 °F	-- °F	Good	--	Excellent	--	--
PPS	375 °F	425 °F	Good	Good	Very Good	Very Good	1.0
Nomex®/ Aramid	400 °F	425 °F	Poor to Fair	Good	Good	Excellent	0.9
P-84®/ Polyimide	400 °F	500 °F	Fair	Fair to Good	Fair	Good	1.7
Teflon®/PTFE	450 °F	500 °F	Excellent	Excellent	Excellent	Fair	4.7
Glass Felt	500 °F	550 °F	Good	Poor	Fair	Fair	1.6
Woven Fiberglass	500 °F	-- °F	Fair to Good	Poor	Fair to Good	Fair	0.8

*Relative Cost – PPS Pulse Jet Bag 5”∅ x 10’ Long

Fabric Selection Process

All Fabric Options

Key Decision Factors

- Filtration & Temperature

Remaining Options

Other Decision Factors

- Purchase Price & Bag Life & Pressure Drop

Cost Analysis

Final Selection

Design: Key Issues

- Full Process Description Affecting Inlet Gas (volume, temperature, chemistry, dust loading – high, low & normal)
- Baghouse Specs (G/C, flow distribution)
- Bag Specification – Devil in the details (e.g. shrinkage)

Importance of Fabric & Bag Specifications

- Spec is the basis for the QA/QC
- The details & comprehensive breadth are critical
- Without the spec there can be no recourse
- Drawings & quantitative acceptable tolerances are required

Custom Filter Bag Specifications

- Selection
  - Select the proper media for inlet gas & process conditions.
- Specification
  - Bag drawings include material, dimensional, and fabrication specifications. Minimal acceptance levels including permeability, strength, and shrinkage.
- Design
  - Bag and cage fit as well as baghouse design specifications can be provided.

QA/QC Program: Purpose and Description

- To insure a new bag set conforms to a material and construction specification
- Primary focus on specifying and testing of fabric durability & mechanical performance
- Verification of filtration & pressure drop performance
- Prevent contamination of “clean side”

Product Malfunctions/Quality Issues

- Several players on the Swiss national soccer team had jerseys torn in a match against France at 2016 European Championship
- Puma's analysis showed that there was 1 batch of material where yarns had been damaged during the production process, leading to a weakening in final garment

- The case of a torn shirt does not stop the game
- A similar hole in a fabric filter bag could lead to dust on the "clean side" and ultimately destroy a full bag set

QA/QC Program: Typical Components

- What should be done in a typical QA/QC program for Fabric Filters?
  - Dimensional and construction inspection of prototype & production of bags to verify product specifications
  - Lab validation of mechanical & physical properties of fabric
  - Filtration performance testing

Bag Quality Control Program

Fabric

- Construction
- Tensile
- Permeability
- Mullen Burst
- MIT Flex Endurance
- Finish
- Filtration Performance
- Fabric Thermal Stability (% Shrinkage)
- Organic Matter (LOI)

Thread

- Material
- Strength

Hardware

- Caps
- Rings
- Bands

Bags

- Inspect for general quality of workmanship
- Length as fabricated
- Length under tension
- Cuff to thimble and cap mate
- Cage Fit

Why Do Third Party QA/QC?

- Ensure bags you receive meet specifications
- Reduce downtime
- Maximize your bag life
- Improve bag set quality
- Unbiased representation
- Provide documentation in case of litigation

QA/QC Program: Initial Installation of Bags

- The bag set is the most important item in the baghouse
- The entire bag set and associated hardware must be properly installed and is key to successful operation
- Inspect all system components thoroughly before installation and again prior to initial start-up for compliance to specifications and for correct assembly
- Retensioning of RA bags very important

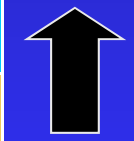
Bag Installation Oversight

Bag Monitoring Program: Purpose and Description

- To determine the retention of strength and flow characteristics of a bag set with on-stream time.
- Used as an aid in determining the useful life and scheduling the replacement of a bag set.
- Diagnostic tool in assisting the client or his agent in troubleshooting a baghouse.

Bag Monitoring Program: Example

UNIT 1	
1-13	1-14
1-11	1-12
1-9	1-10
1-7	1-8
1-5	1-6
1-3	1-4
1-1	1-2



6 mo.	Initial Test	3 bags
1 yr.	2nd Test	3 bags
18 mo.	3rd Test	3 bags
2 yr.	4th Test	3 bags
30 mo.	5th Test	2 bags
33 mo.	**	4 bags
36 mo.	**	4 bags

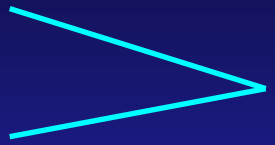
** When fabric deterioration accelerates increase testing frequency to every 3 months with four bags per pull/test

Test Bag location random – never same hole

Each program is custom designed

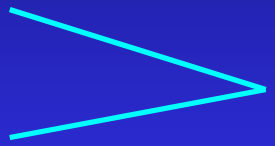
Short Bag Life

Physical Failure
or
Plugged Fabric



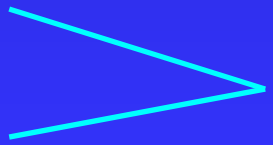
Inspection
and
Maintenance

Site Specific
or
General Problem



Inspection
and
Failure Log

Mechanical Wear
Thermal Attack
Chemical Attack



Lab Tests

How Do I Achieve Maximum Bag Life?

- **SELECTION –** Select media for the inlet gas constituents & process operation.
- **SPECIFICATION –** Specify filter media, thread, bag and hardware.
- **QUALITY ASSURANCE/QUALITY CONTROL –** QA/QC program to insure what is delivered meets the spec.
- **INSTALLATION –** Oversee the installation of the bags and perform leak tests.
- **BAG MONITORING –** Test periodically. Increase frequency if strength or permeability decline steeply.
- **IDENTIFY & CORRECT –** Immediately fix any leaks or high ΔP.

Preventing the dust from entering the "clean side" of the fabric filter and the bags is a must.

Successful Operation

- Routine Inspection
- Preventive Maintenance
- Quick Response to Malfunctions
- Data Monitoring and Management

Baghouse Troubleshooting

Behavior and Performance

- Understanding
- Monitoring
- Diagnosing
- Integrating
- Remedying

Key Troubleshooting Tools

- Monitors/Recorders for Key Parameters
  - Opacity or Equivalent
  - Flange-to-Flange DP
  - Compartment DP
  - Gas Flow Rate (Indication)
  - Gas Temperature
  - Cleaning System Parameters
- Bag Analysis
- Computerized Parameter Monitoring System
- Fluorescent Dye/Black Light

Key BH Troubleshooting Principles

- Dichotomy: Simple, Yet Complex
- No Single Parameter Tells All
- Data Needs to be Integrated
- Problems Cascade More Problems
- Evaluate Big Picture
- Include Process Conditions/Changes
- Consider All Options Initially

General Steps to Problem Solving

- Define Current Operating Parameters and Compare them to Design and Baseline Values
- Establish Historical O&M Events Prior to Discovery of Problem
- Test Bags
- Inspect Baghouse
- Establish and Conduct Experiments and Evaluations
- Symptom → Cause → Remedy

Why Evaluate?

- Emission Limit Failures
- Short Bag Life
- High Bag Cost
- High or Unstable Pressure Drop
- High Maintenance

Best Practices

- Design Critical Aspects
  - G/C Ratio
  - Bag-to-cage fit
  - Selection of fabric suitable for dust particle size dist.
- Prestartup
  - QA/QC of fabric, bag dimensions, thread, etc.
- Startup
  - Critical that all installation is proper
  - Early leak testing critical
  - Any dust on clean side removed
- Initial Operation
  - Establish effective operation & recordkeeping, establish baseline performance & data records

Best Practices (continued)

- Operation
  - Do not reuse rusted cages
- Maintenance
  - Never use hopper as storage vessel (note the impact on hopper velocity due to volume reduction)
  - As soon as dust emission detected, it must be addressed and fixed (clean the tubesheet)
  - A preventive maintenance program is a must
- Recordkeeping
  - Once 3 months of successful operation is demonstrated, a detailed record of any upsets is needed and compared with successful operation

Thank You

Questions

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