REINHOLD ENVIRONMENTAL Ltd.

2012 APC Round Table & Expo Presentation

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Bag Life Optimization Through Testing

Presented At:

2012 APC Roundtable
Baltimore, Maryland

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Introduction

- Bag Test Methods & Value
- Causes of Premature Bag Failure
- Fabric Selection Considerations
- Importance of Fabric & Bag Specifications
- Quality Assurance/Quality Control
- Bag Monitoring Programs
- Achieving Maximum Bag Life
- Broken Bag Impact on Compliance

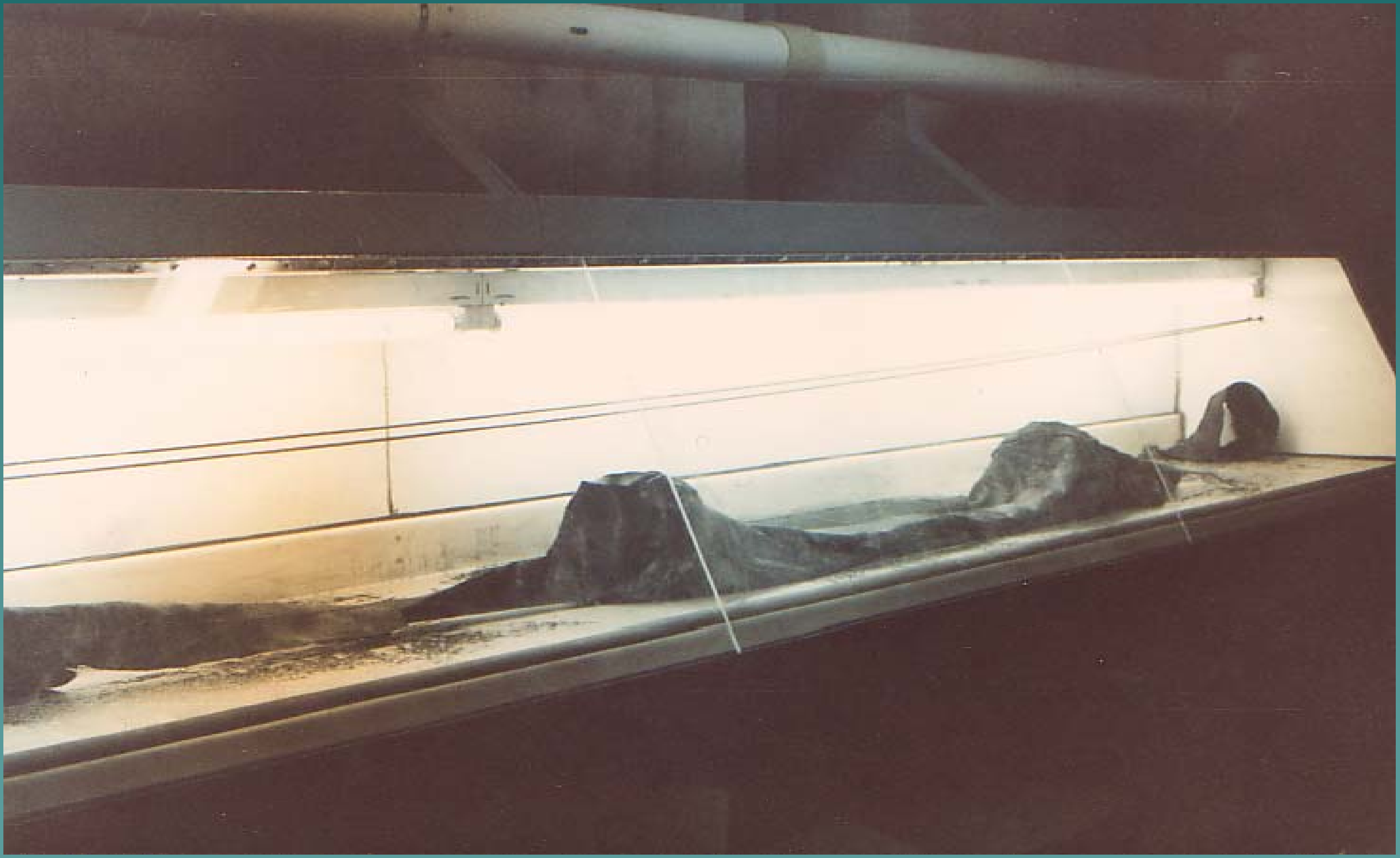
Reasons For Fabric Testing

- Quality Assurance
- Diagnostic Aid or Troubleshooting
- Fabric Monitoring
- Alternative Fabric Selection
- Research & Development
- Bag Replacement Timing

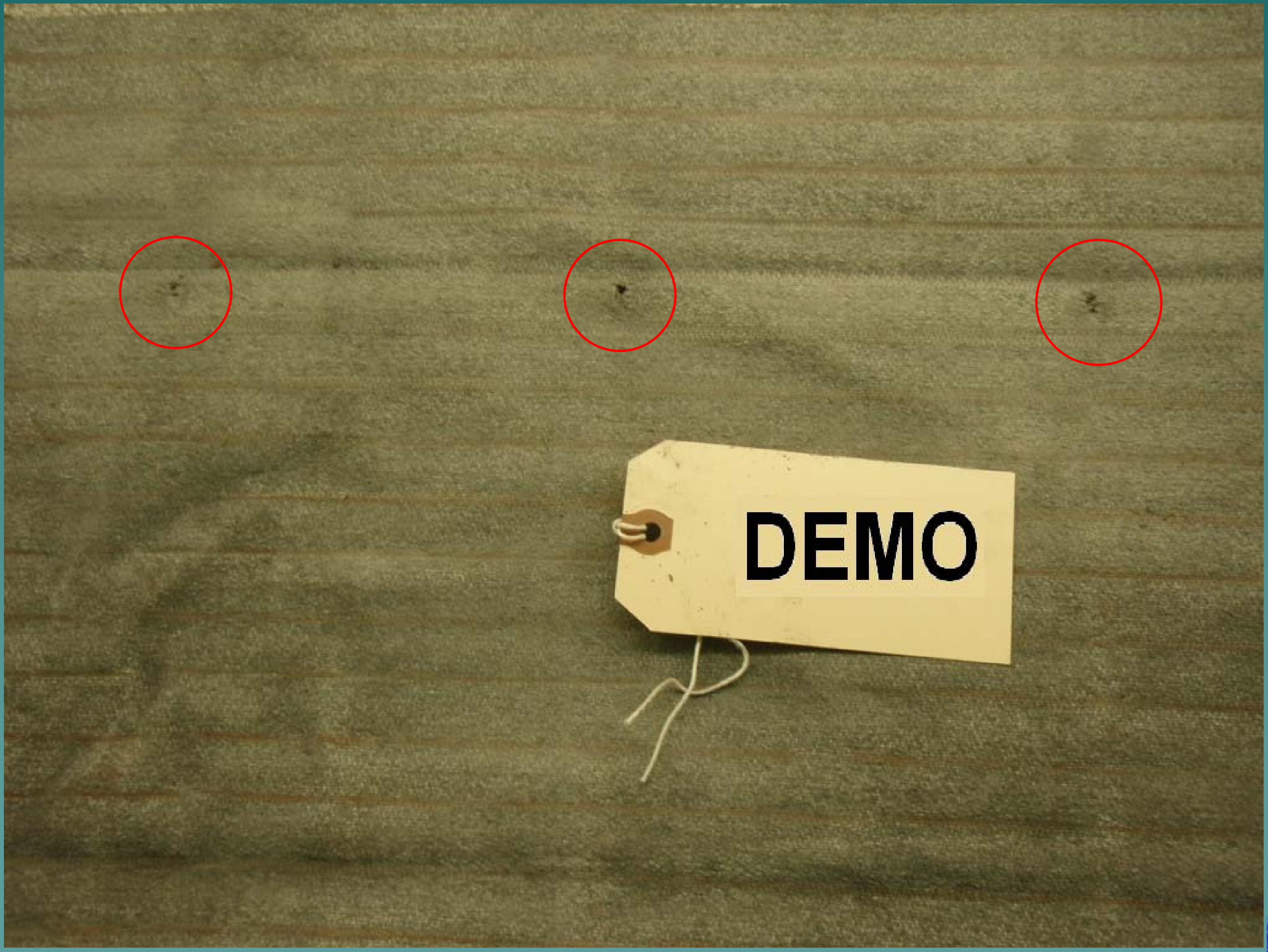
Standard Fabric Tests

TEST	METHOD
1. Weight	ASTM D3776
2. Construction	
2A. Yarn Count	ASTM D3775
2B. Type of Weave	ASTM D579
3. Thickness	ASTM D1777
4. Tensile Strength	ASTM D5035
5. Mullen Burst	ASTM D3786
6. Permeability	ASTM D737
7. Organic Content (LOI)	ASTM D4963
8. M.I.T. Flex	ASTM D2176
9. Filtration Performance	ASTM D6830
10. Water Repellency	ASTM D2721
11. Surface Resistance	STM 11.11
12. Volume Resistance	STM 11.12
13. Two-Point Resistance	STM 11.13
14. Fabric Thermal Stability (% Shrinkage)	Industry Standard

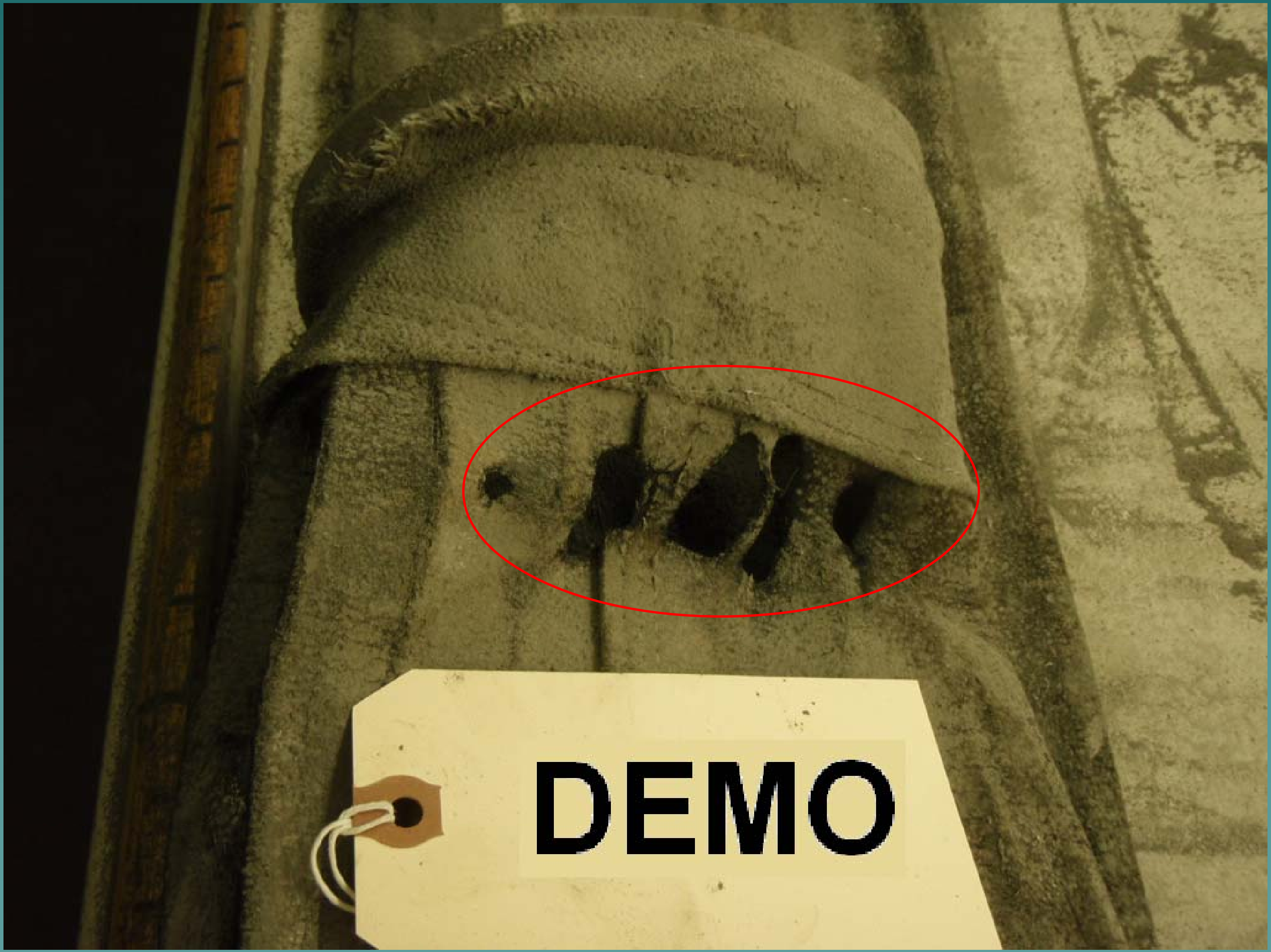
Visual Inspection



Pinholes



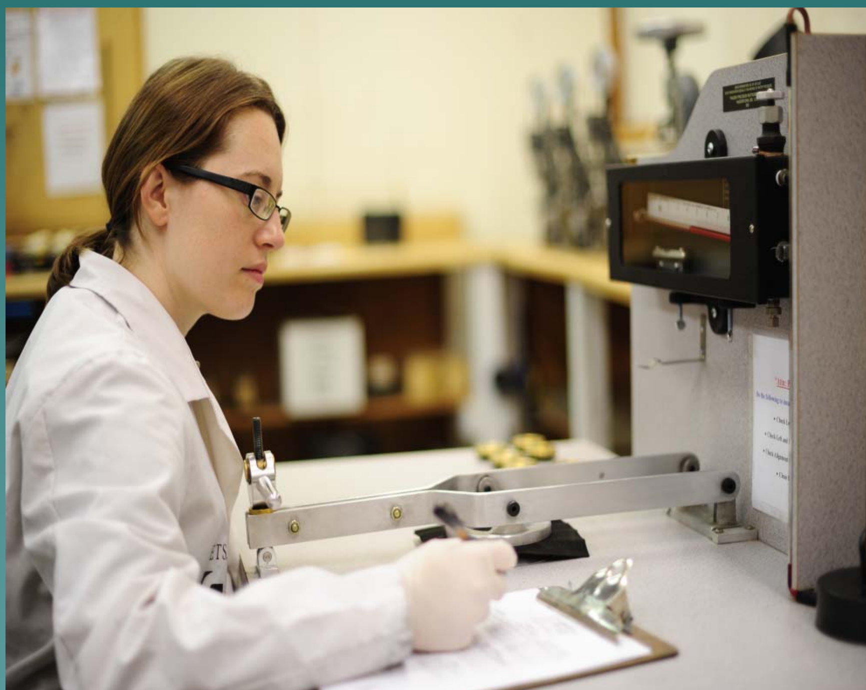
Dust Abrasion



Clean Side Contamination

Poor Seam Construction

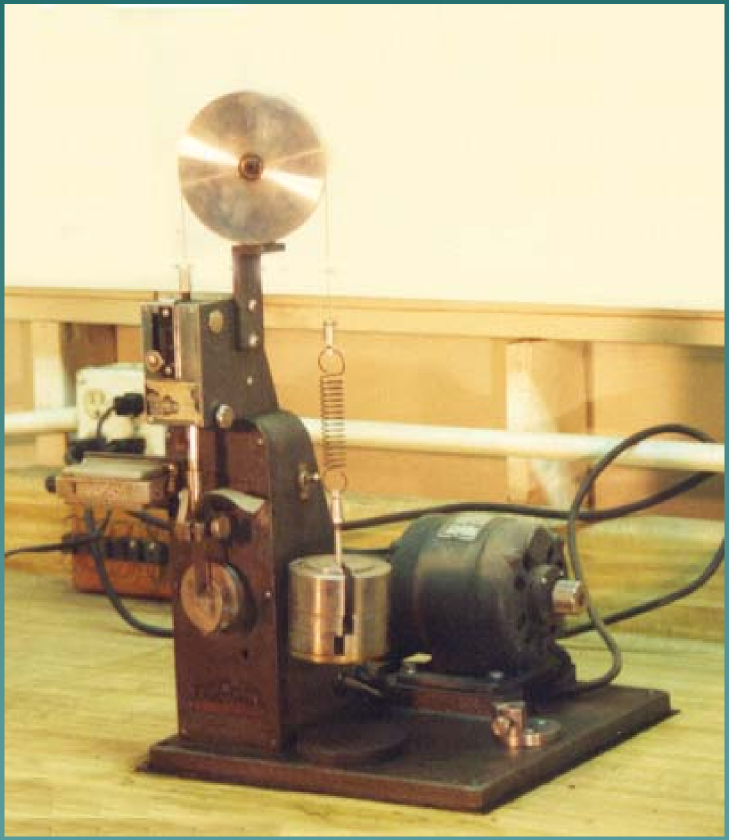
Permeability Test Method



- Frazier Permeability apparatus is used to determine air handling capability of filter media.
- Includes capability to measure air flow over a wide (0-20” w.g.) differential pressure.
- Ambient to 400 °F temperature range.
- Non-destructive manner.

M.I.T. Flex Endurance Test

- Primarily measures relative value of fiberglass fabric weaves and finishes to withstand self abrasion from flexing by measuring the number of flex cycles necessary to break a fabric sample.



Tensile Test Method

- Provides stretch, elongation, and tear data for fabrics.
- Measures relative strength of warp and filling yarns in fabric samples.

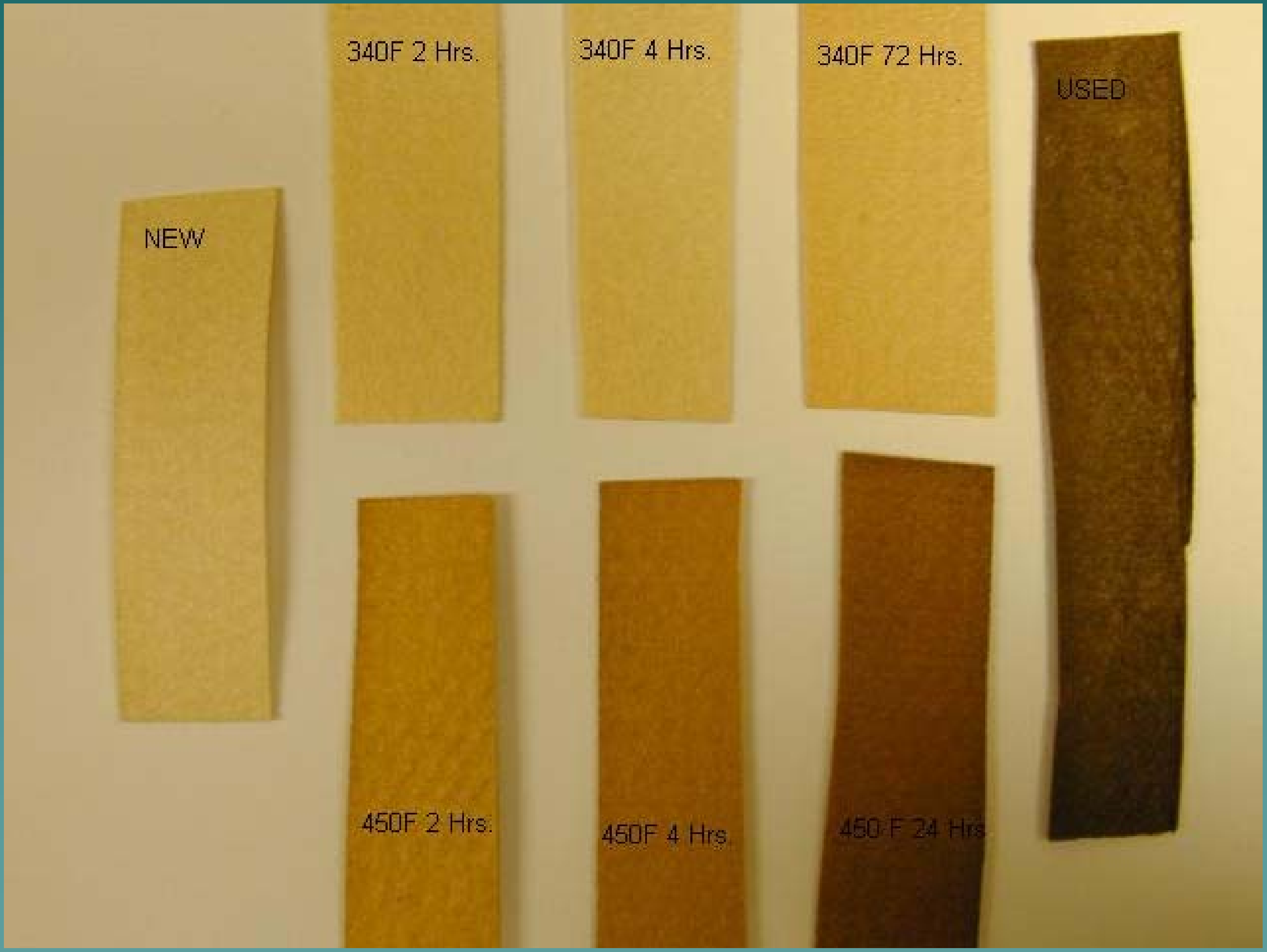
Mullen Burst Test Method

- Shows the relative total strength of fabrics to withstand severe pulsing or pressure.
- Fabric strength is measured by determining the difference between the total pressure required to rupture the specimen and the pressure required to inflate an expandable diaphragm.

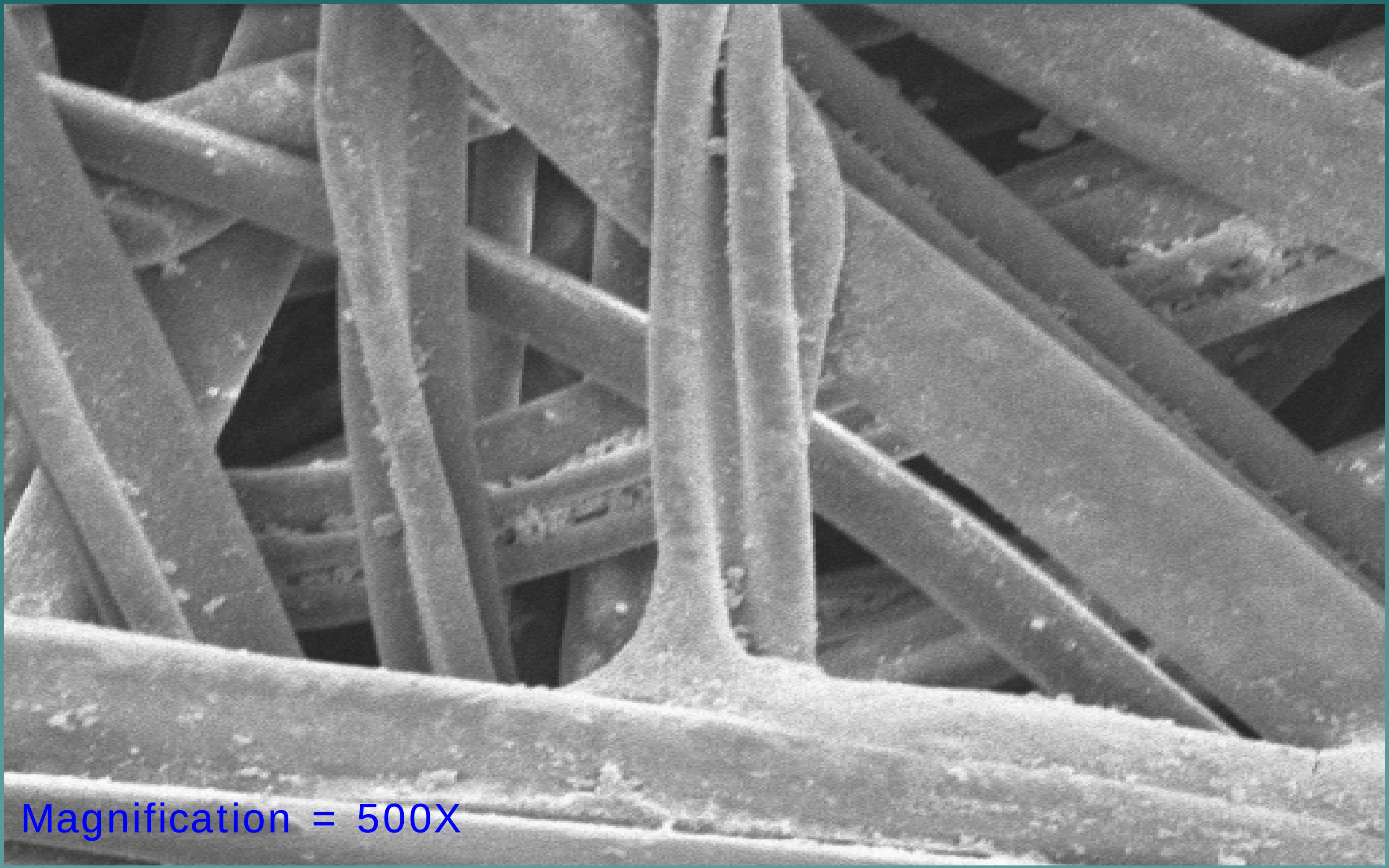
Microscopic Analysis

- Aides in determining causes of bag deterioration and bag blinding.

PPS Felt at Specific Temperatures



SEM Photomicrograph

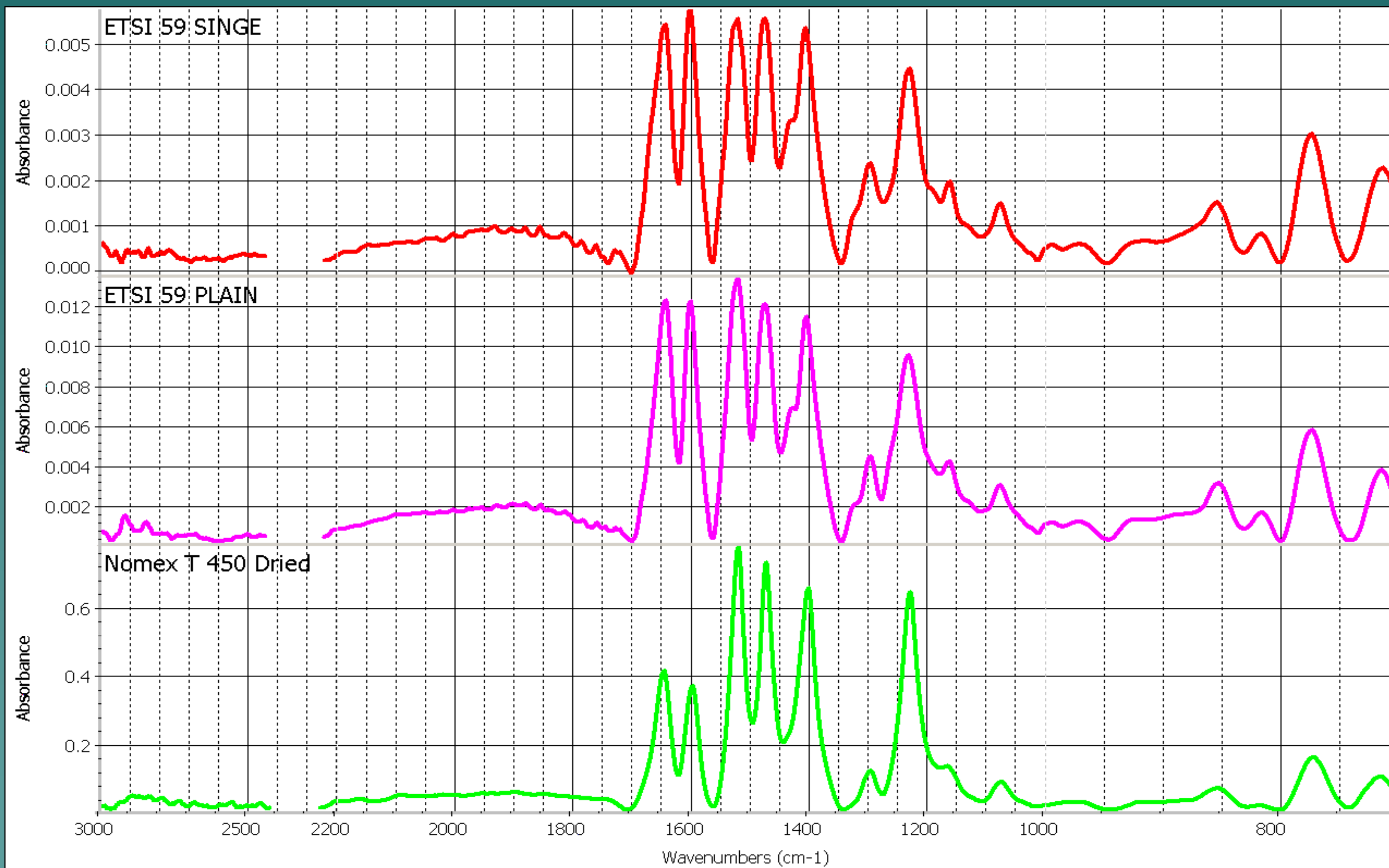


P-84 Felt Fabric

Chemical Analysis

- Used either to predict or determine what effect on-stream conditions would have on the performance of a bag.

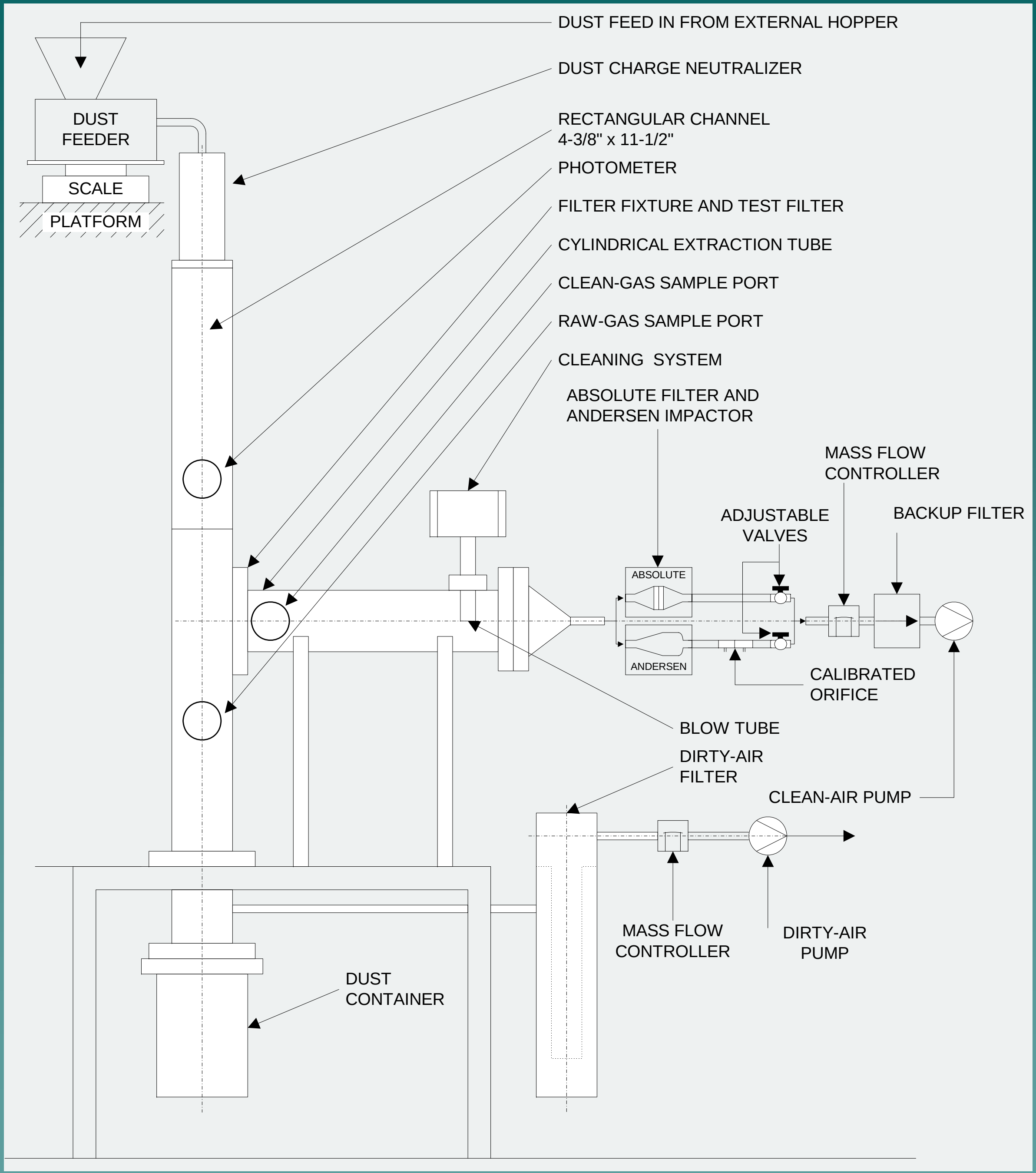
Fiber Identification by FTIR



Filtration Performance Test Apparatus

- Outlet Particle Concentration, $PM_{2.5}$
- Outlet Particle Concentration, Total Mass
- Average Residual Pressure Drop
- Initial Residual Pressure Drop
- Filtration Cycle Time
- Number of Filtration Cycles
- Mass Gain of Test Filter

ETS-FPTA Schematic



Bag Monitoring With Stream Time

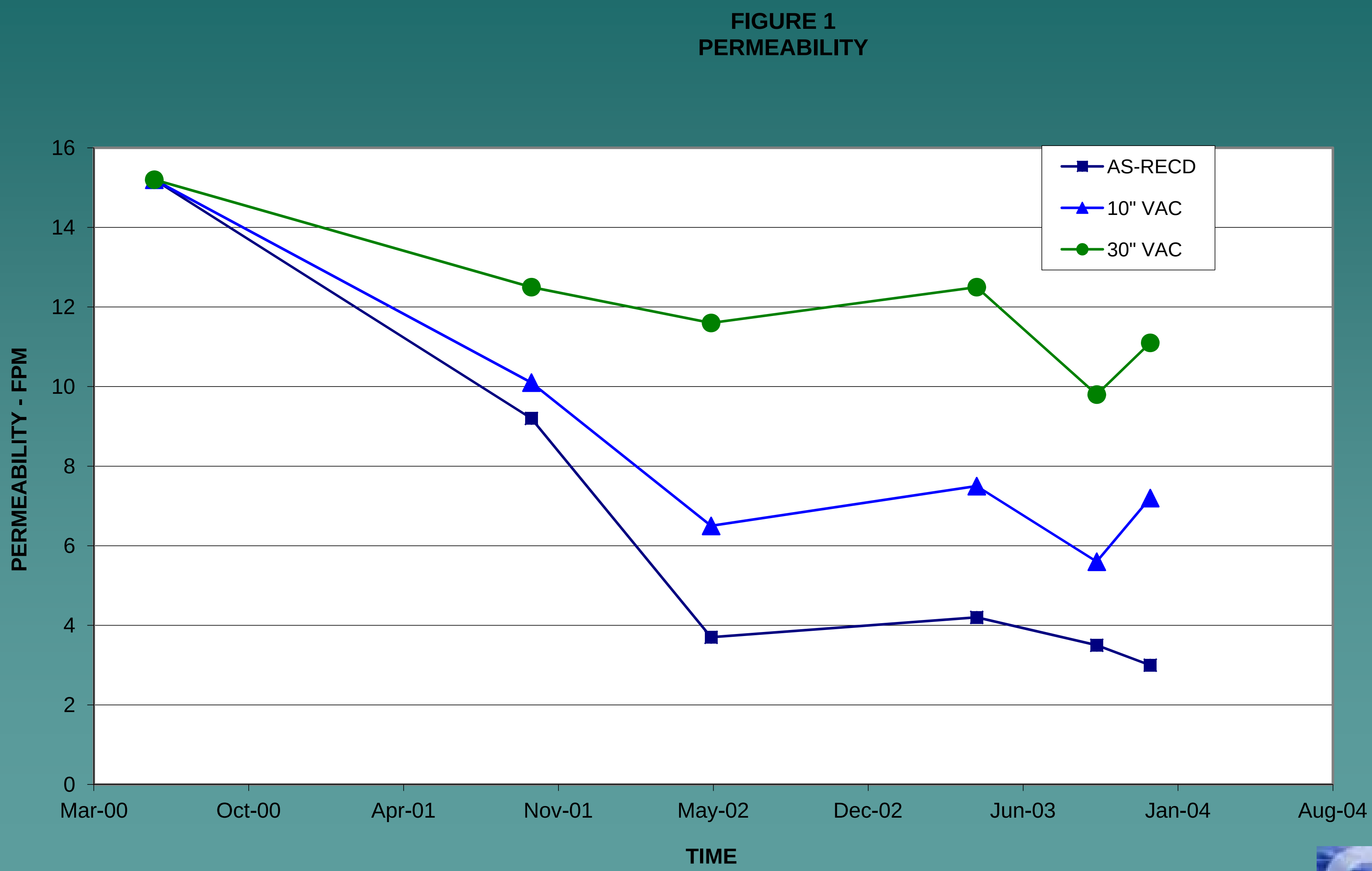
Fabric Type A

Bag Status	Tensile (lb/in)		Flex (#cycles)		Burst (psi)	Permeability (FPM)	
	Warp	Fill	Warp	Fill		Dirty	Clean
New	232	226	3100	778	405	68	68
4-wk	117	57	550	68	209	10.9	83

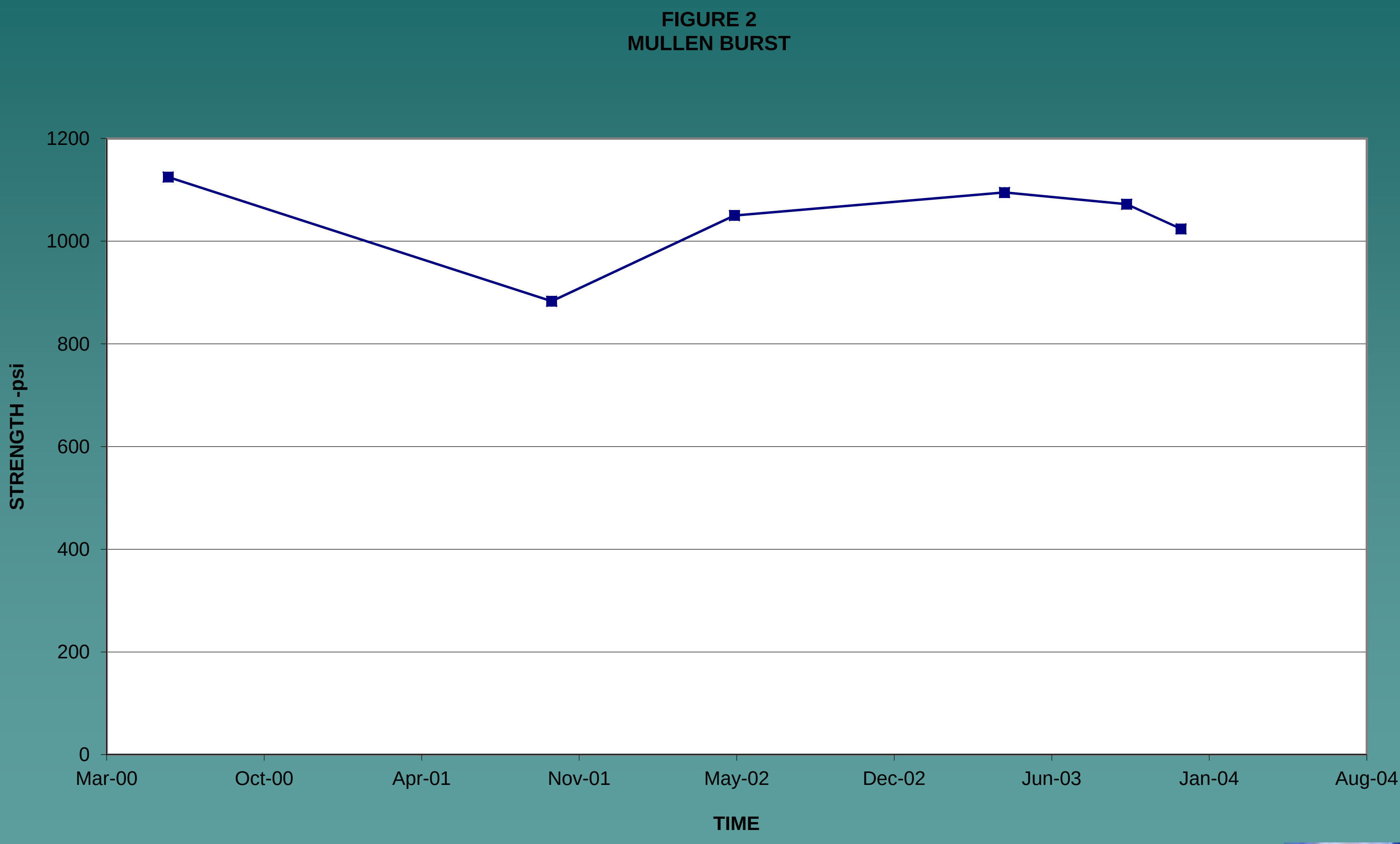
Fabric Type B

New	123	109	> 50,000	> 50,000	307	37.2	37.2
4-wk	101	81	> 50,000	> 50,000	263	10.8	36.2

Bag Monitoring



Bag Monitoring



Bag Monitoring

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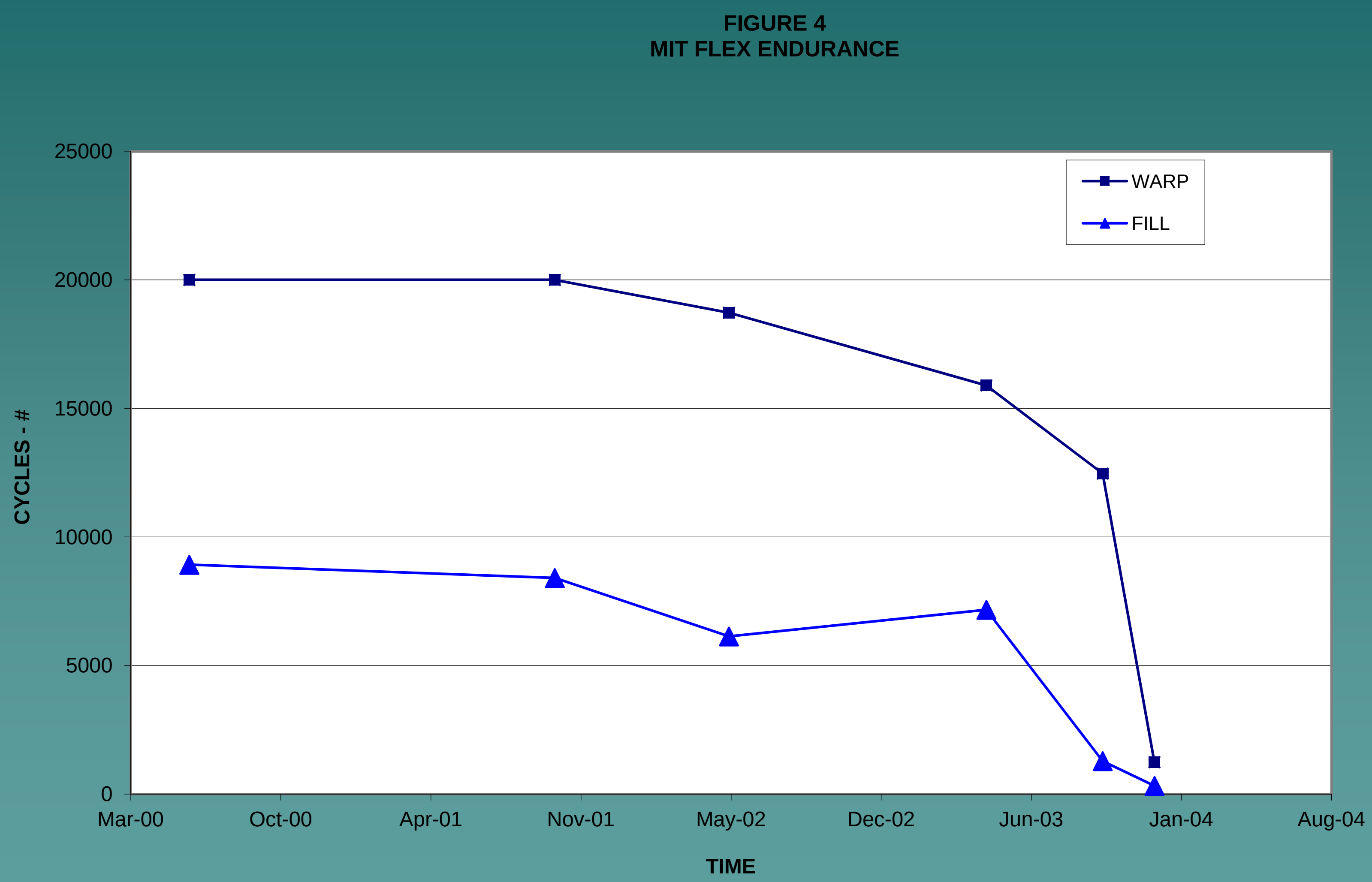
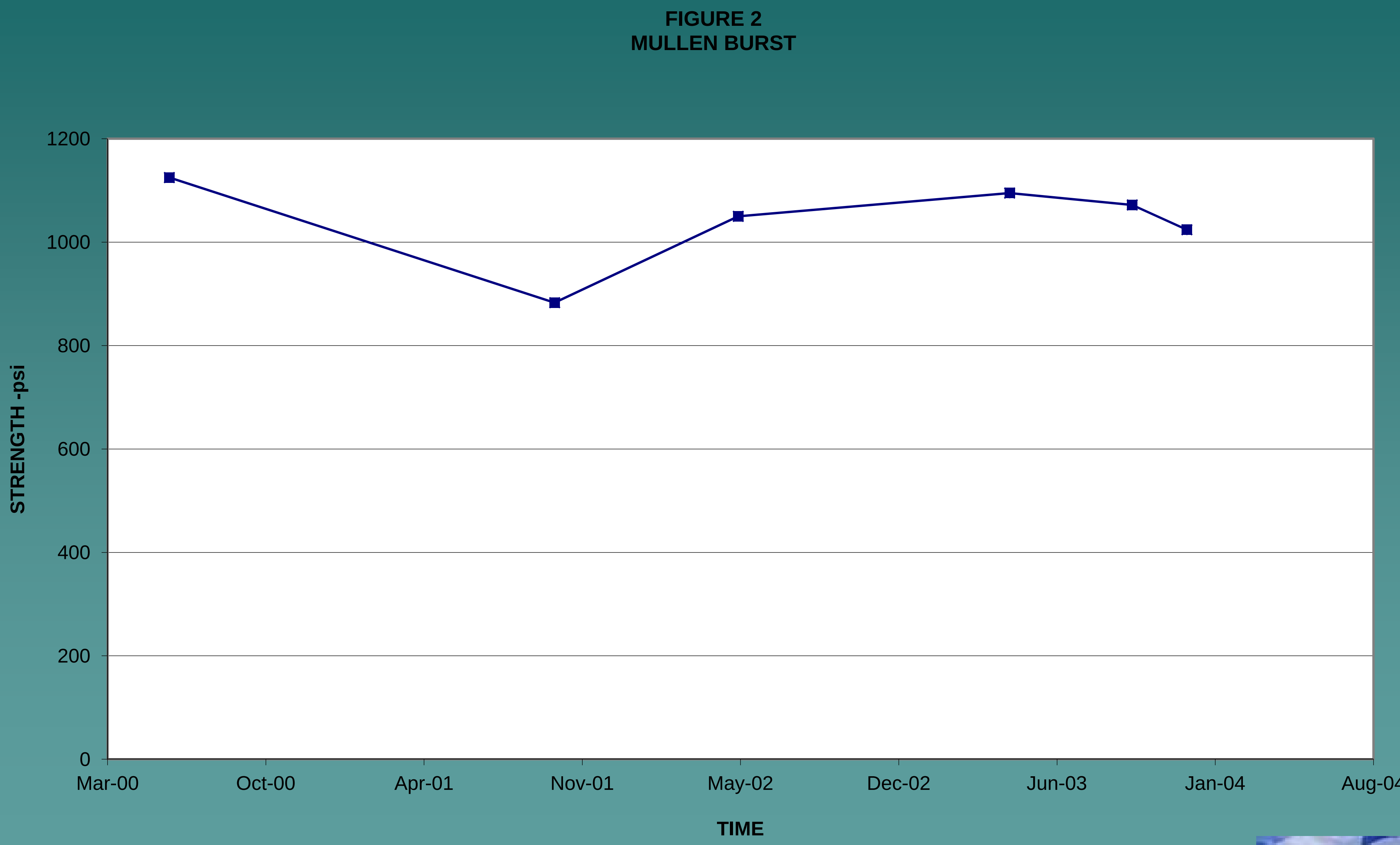


Alternative Fabric Study



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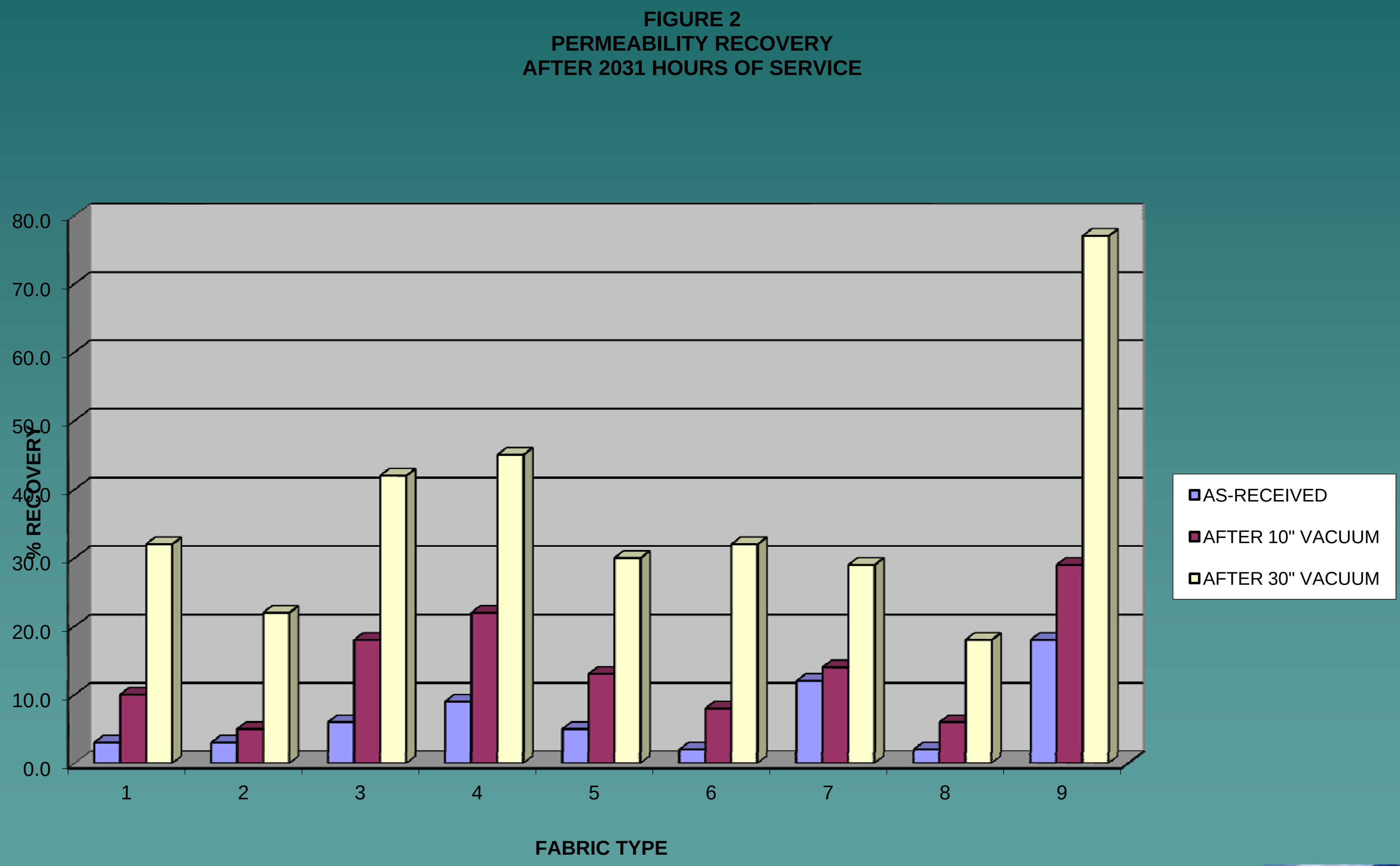

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Premature Bag Failure:
Factors Effecting Bag Life (PJ & RA)

- Design and Manufacturer
- Installation
- Gas Flow
- Gas Temperature
- Gas Acidity
- Dust Loading & Particle Size/Shape
- Cleaning Intensity/Frequency/Duration
- Bag Tension - Bag/Cage Fit
- Adjacent Bag Life

Premature Bag Failure: Causes

- **Mechanical**
  - Dust Abrasion
  - Over Cleaning
  - Bag Tension
  - Adjacent Bag
- **Thermal**
  - Excessive Temperature
  - Dew Point
- **Chemical**
  - Acids
  - Alkalies
  - Condensation (Organics, Acids, Water)

Premature Bag Failure: Typical Causes of Pulse Jet Bag Failures

- Dust on "clean side" – accelerates bag-to-cage wear
- High velocity dust abrasion - Bottom of bag
- Chemical attack from flue gas contaminants coupled with acid dew point excursions
- Bag-to-cage abrasion - Bad fit, poor design, damaged cage
- Bag-to-bag abrasion - Too close, bent cages, high can velocity
- Mechanical abrasion in top 1/3 of bag - misaligned Venturi or pulse pipe
- Process upset conditions - Fabric temperature capability exceeded; particulate is introduced to blind or attack the fabric

Premature Bag Failure: Typical Causes of Reverse Air Bag Failures

- High velocity dust abrasion - Inside bottom of bag
- Chemical attack from flue gas contaminants coupled with acid dew point excursions
- Bag-to-bag abrasion - Low tension, too close, stretching, misaligned support racks
- Bag-to-metal abrasion - Interference with walls or support structure
- Improper bag to thimble attachment - Results in high velocity leakage path
- Process upset conditions - Fabric temperature capability is exceeded; particulate is introduced to blind or attack the fabric
- Accidents - Fires or explosions
- Improper bag fabrication or incorrect design

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Fabric Selection Considerations

Gas Stream
- Temperature
- Moisture
- Chemistry
- Dust Loading

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

Dust Characterization
- Abrasiveness
- Stickiness
- Explosiveness
- Flammability

Other
- Membrane
- Coatings/Treatment
- Scrim
- Hardware
- Blends

Design: Key Issues

- Full process description affecting inlet gas (Vol., Temp., Chem., dust loading – high, low & normal)
- Baghouse specs (G/C, flow distribution
- Bag Spec - Devil in the details (e.g. shrinkage)

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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

Filter Bag Specification
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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”

QA/QC Program:
Typical Components

- What should be done in a typical QA/QC program for BFPs?
  - 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 & cap mate
  - Cage Fit

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

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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**

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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 - 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 baghouse and bags is a must.

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2012 Annual A&WMA Conference

FUTURE BOILER MATS REGULATIONS & BAGHOUSE EMISSION CONCERNS

San Antonio, Texas
June 2012

John McKenna, Christina Clark (ETS, Inc.)
Louis Theodore (Theodore Tutorials)

Typical Causes of Bag Failures

- High G/C Abrasion
- Metal-to-Cloth Abrasion
- Bag-to-Bag Abrasion
- Inlet Velocity Abrasion
- Chemical Attack
- High Temperature Excursion
- Accidents
- Upset Conditions (e.g., boiler tube leaks)
- Thread Mismatch
- Cuff Mismatch

Bag Failure Model Derivation and Additional Illustrative Examples

- Theodore, L.; Reynolds, J. Effect of Bag Failure on Baghouse Outlet Loading, JAPCA, Pittsburgh, PA, pp 870-2, August 1979.
- Theodore, L. *Air Pollution Control Equipment Calculations,* (adapted from) John Wiley & Sons, Inc.: Hoboken, N.J., 2008.

Bag Failure Model

Number of Broken Bags for Code Allowable Emissions

Code	Allowable Emissions (grains/acfm)	Number of Broken Bags Before Out of Compliance
Current	0.012	9.2
Possible Future	0.0012	0.92
Possible Future	0.0005	0.38

Summary and Conclusions

- How stringent future particulate emission codes will become is an open question.
- While not perfect – there is a model for outlet emissions which tells us that a very limited number of broken bags will put a baghouse out of compliance.
- The filter media has emission control capability well beyond current codes.
- The focus going forward will be bag detailed specification, QA/QC, monitoring, and baghouse PM, plus rapid response remediation.
- Ultimately the future may call for implementation of automated individual bag closure/capping.

THANK YOU FOR LISTENING

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