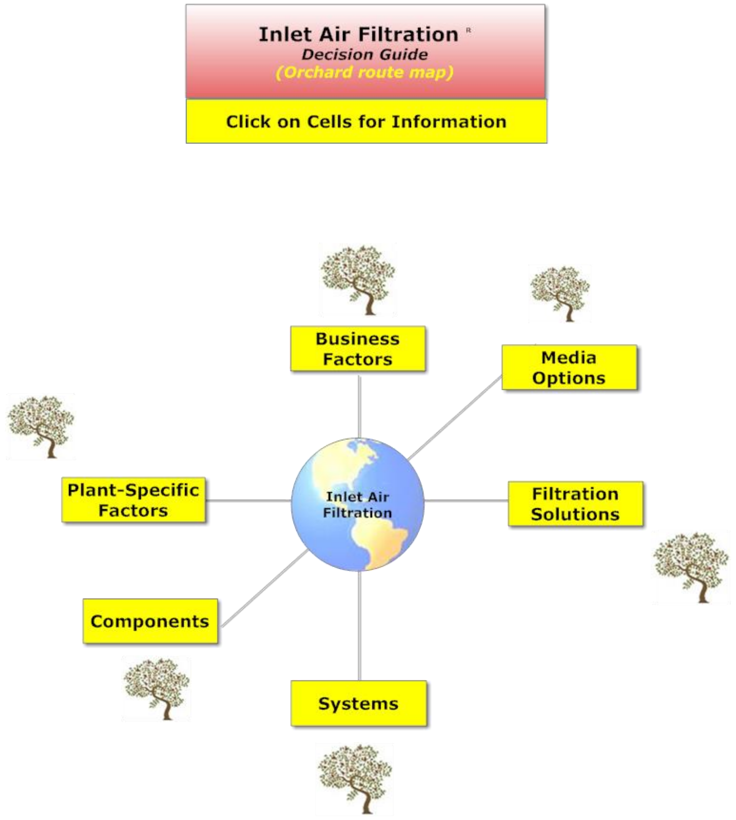
Filters and Media
Route Map and Summary

Gas Turbine Air Treatment Decision Guide

Media options

- Non woven

- Woven glass
- Membranes
- Ceramic
- metallic



I. Fiber and Media Choices

Subject	Slide Contributor	Relevant decision
Overview of Media Options	McIlvaine	What factors should be considered in selecting the filter media?
Efficiency Levels	Mcilvaine	What are EPA, HEPA and ULPA filters?
Efficiency Levels	Gore	What are the differences between high and very high efficiency filters? (2 slides)
Air Filter Standards	Freudenberg	What are the EN779, Ashrae and ISO standards applicable to air intake filters? (2 slides)
Media Selection	Hollingsworth & Vose	**What factors should be considered in selecting the filter media?** (6 slides)
Combo vs Synthetic or Glass	Midwesco	How does the performance of a synthetic/glass combo filter compare to other media?
Expanded Metal & Plastic	Dexmet	How can expanded metal and plastic media be used in gas turbine applications?
Nanofibers	Lydall	What are the benefits of nanofibers?

Overview of Filter Media Options

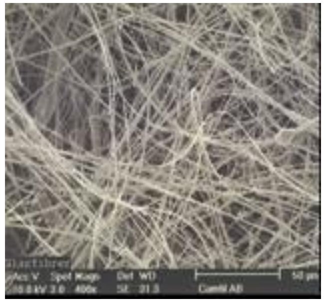
Two primary types of media are available:

- Synthetic, typically with coarser fibers
  - 3.0 to 4.0 µm diameter
- Glass, typically extruded to a smaller fiber diameter
  - 1.0 to 1.3 µm diameter
  - Higher dust holding capacity
  - Stiffer fibers, able to resist higher pressure drops and last longer

Fiber selection criteria:

- Efficiency rating
- Fiber size, diameter
- If synthetic, which resins

Synthetic Media



Glass Media

Three Levels of High Efficiency

The three common types of high efficiency filters are EPA, HEPA, and ULPA, defined as follows:

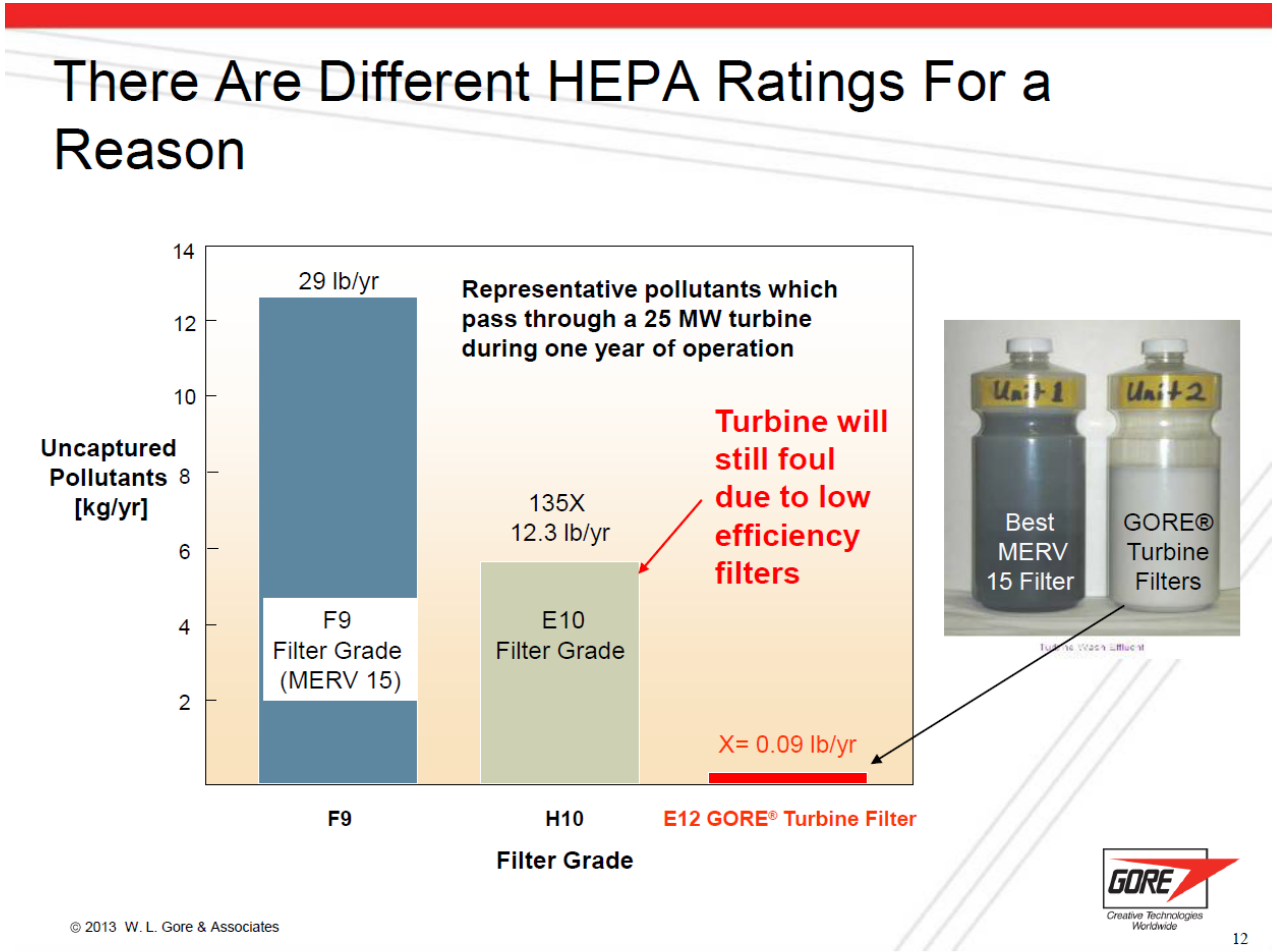
- EPA filters have a minimum efficiency of 85% for removal of 0.3 µm diameter or larger particles
- HEPA (High Efficiency Particulate Air) filters have a minimum efficiency of 99.97% for removal of 0.3 µm diameter or larger particles
- ULPA (Ultra Low Penetration Air) filters have a minimum efficiency of 99.9995% for removal of 0.12µm diameter or larger particles

Differences Between High and Very High Efficiency Filters (Gore)

Filter Classifications

			Ventilation	Ventilation	Cleanroom
Filter Class	**Efficiency**	**Particle Size**	**EN779**	**ASHRAE 52.2**	**EN1822** 2005/2009
Fine Filters	80% ≤ E_m ≤90% E1 < 75%	0.4µm/ 0.3-1.0 avg.	**F7**	**MERV 13**	
	80% ≤ E_m ≤95% 75% ≤ E1 ≤85%	0.4µm/ 0.3-1.0 avg.	**F8**	**MERV 14**	
	95% ≤ E_m 85% ≤ E1 ≤95% 95% < E1	0.4µm/ 0.3-1.0 avg.	**F9**	**MERV 15**	
EPA/HEPA Filters	>85%	MPPS		**MERV 16**	**H10/E10**
	>95%	MPPS			**H11/E11**
	>99.5%	MPPS			**H12/E12**

Make Sure to Use Relevant HEPA Rating (Gore)



Air Filtration Standards (Freudenberg)

EN779: 2012 supersedes 2002.

Europe use EN779 (Fine filters) & EN1822 (EPA)

North America: Ashrae 52:2 (MERV) & DOP

Rest of the World is a mixture of both standards.

Japan: JIC

New ISO test protocol dedicated to rotating equipment is a worldwide standard. (Different to old EN779 which was based on HVAC filter testing).

Air Filtration Standards (Freudenberg)

ISO / FDIS 29461 -1:2011 (E) ISO/TC 142/SC WG9
Air intake filter systems for rotary machinery

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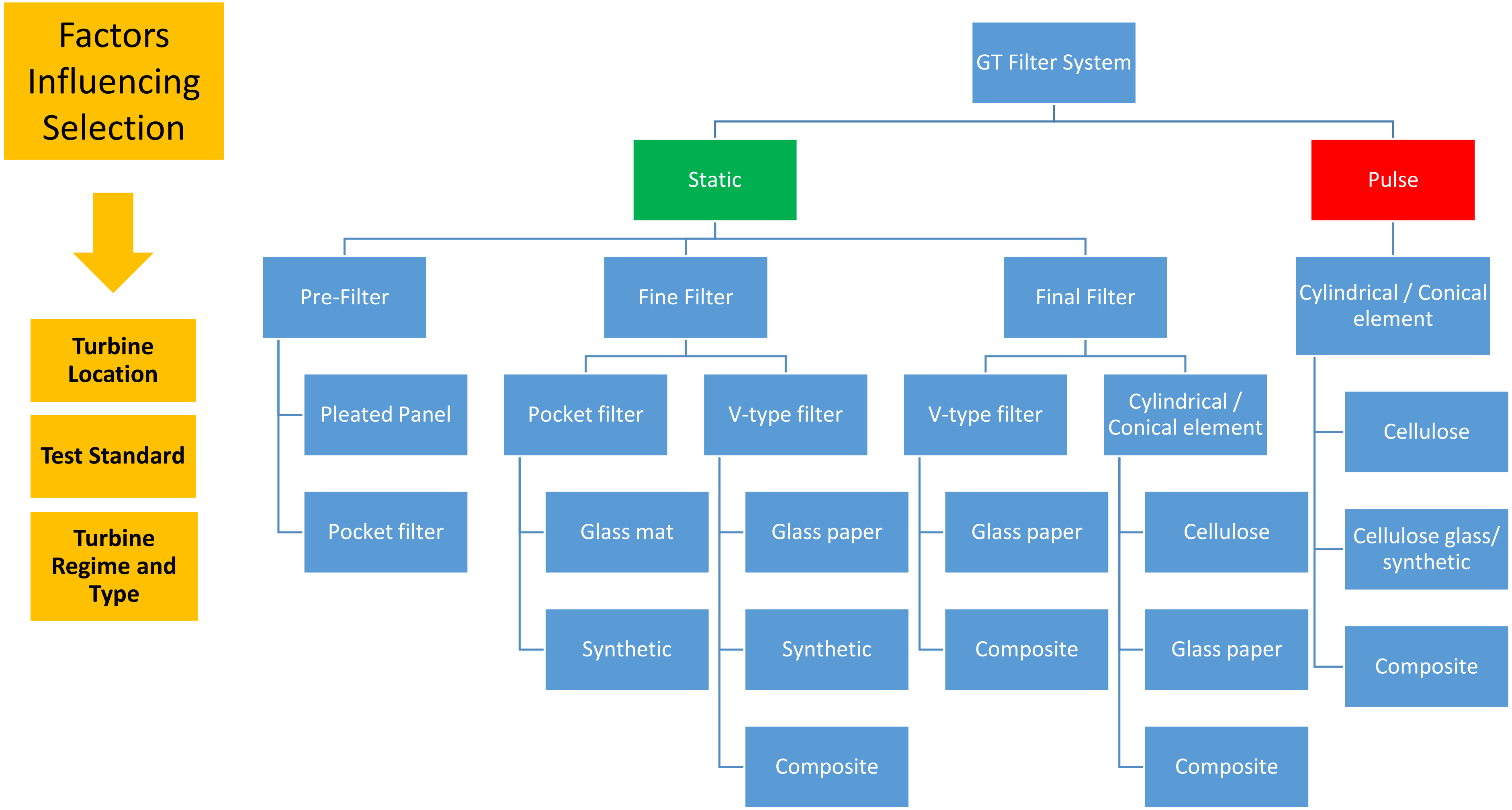
- Part 1: Test method and classification for static filter elements. *(Introduction of a discharge test ,minimum 04.um percentages & higher final differential pressure limits).*
- Part 2: Test method and classification for cleanable (Pulse Jet) filter <u>systems</u>

  (draft being reviewed)
- Part 3: Integrity testing (environmental conditions, mechanical strength).
- Part 4: In-Situ testing – real operating performance.
- Part 5: Marine and Off-shore - (*draft being compiled)*
- Part 6: Cartridge testing method for individual cartridges. (d*raft being compiled*)

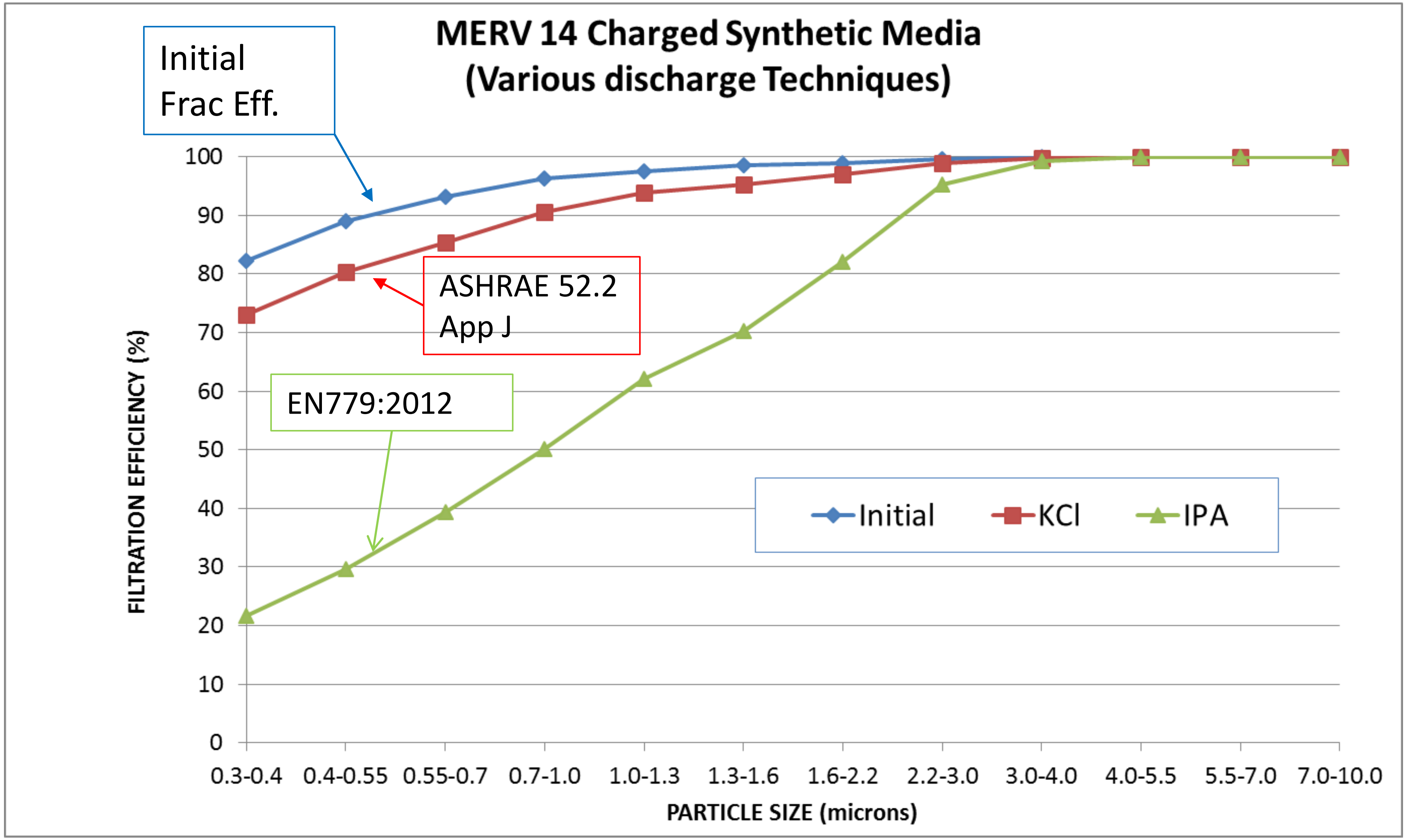
Media Selection = f(Filter System, Element type) (Hollingsworth & Vose)



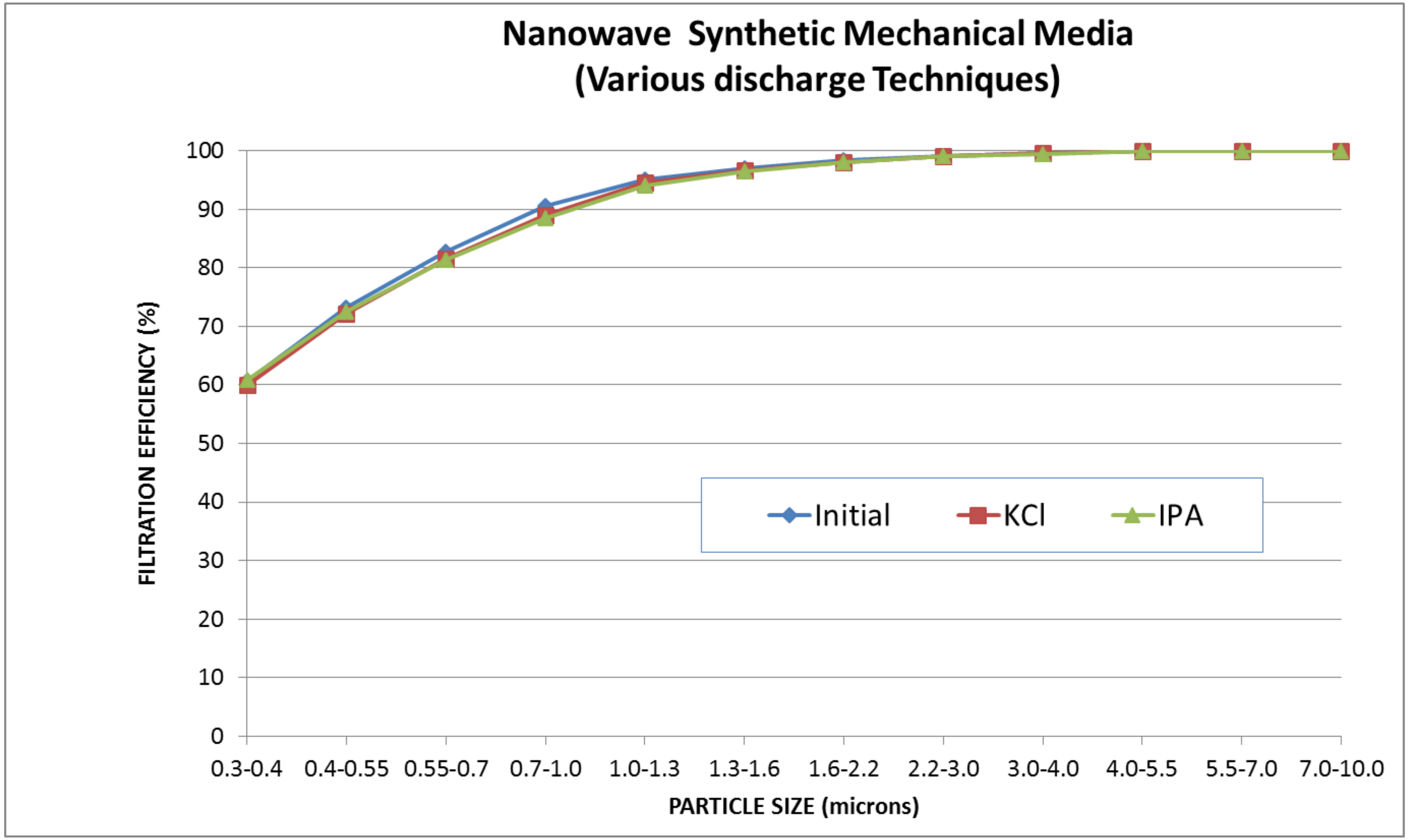
Test Standard to be Considered (Hollingsworth & Vose)

- Mechanical vs Charged Media
  - There are major differences in the test – and classification systems of standards and their revision
    - ASHRAE 52.2 : 2007 or 2015, Appendix J
      - Discharging is not mandatory and has no effect on classification
    - EN779 : 2002 or 2012
      - 2002: discharged value is reported but has no effect on classification
      - 2012: discharging is mandatory for F7 – F9 and influences classification

HVAC – Discharge Impact of Charged Media (Hollingsworth & Vose)

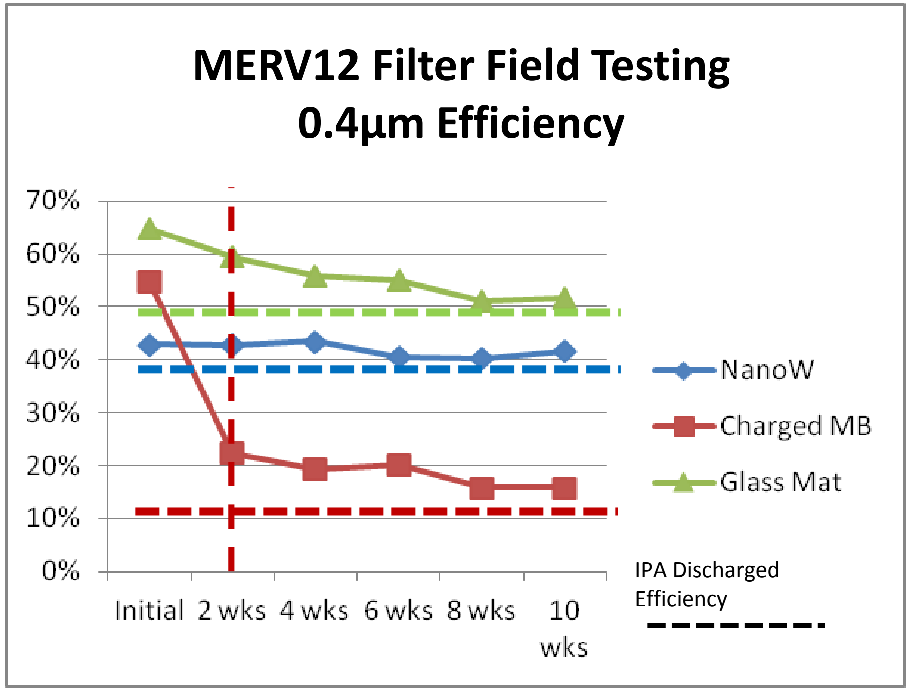


Discharge Characteristic of Mechanical Media
Wet laid glass and NanoWave®
(Hollingsworth & Vose)

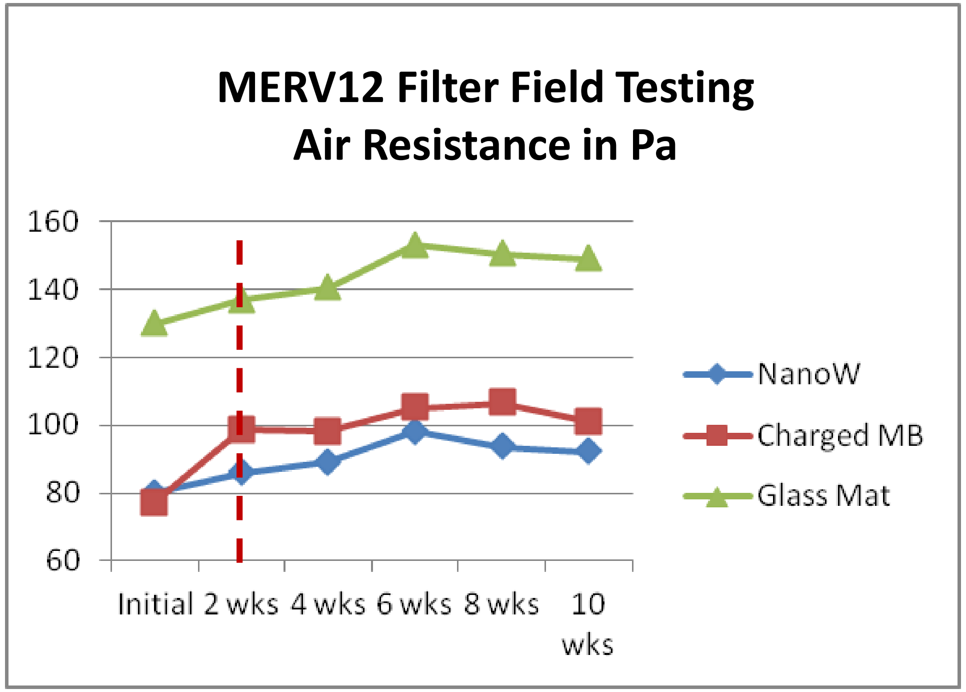


Evolution of Filter Performance (Hollingsworth & Vose)

Rapid Loss of 0.4µm Efficiency



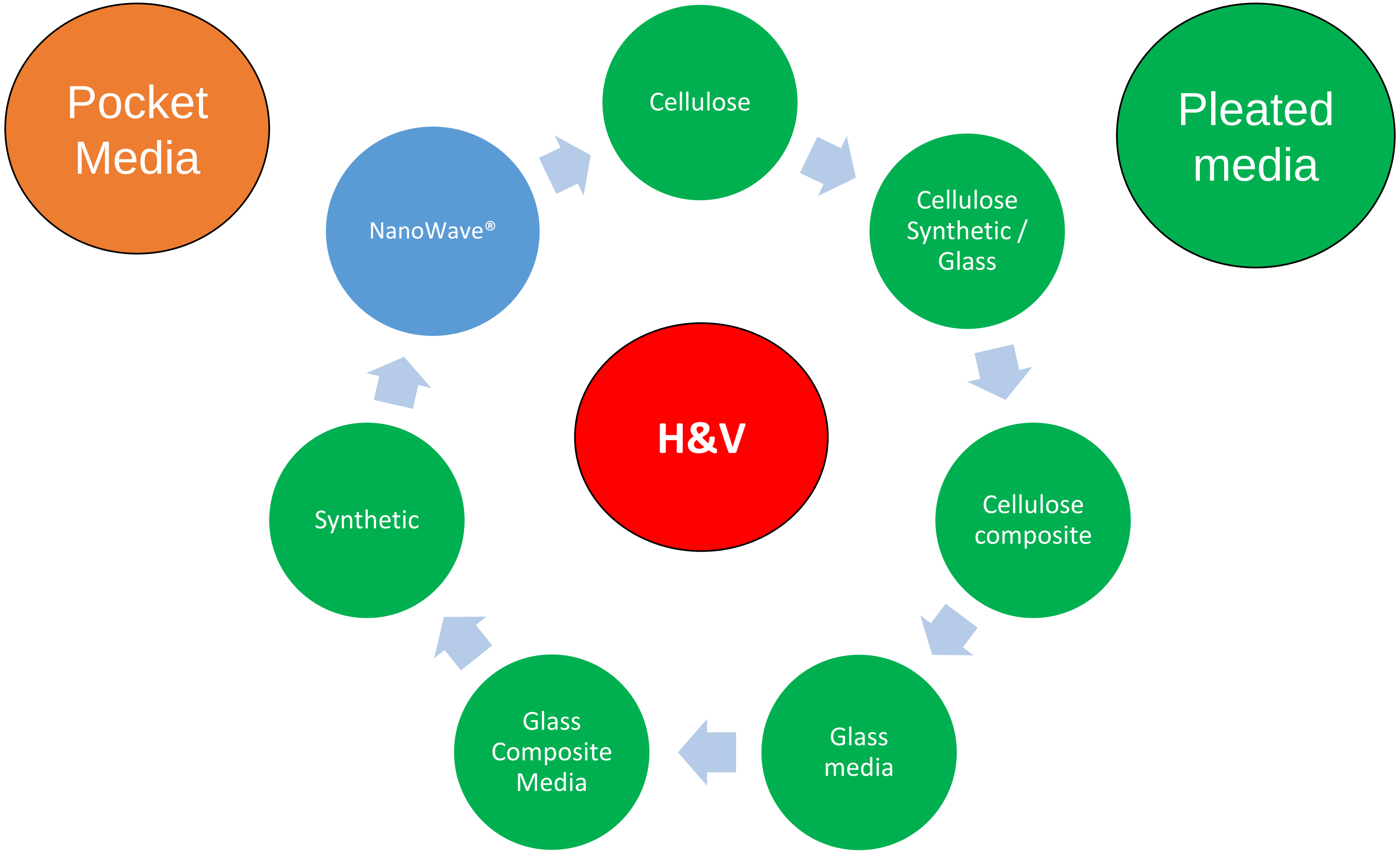
Increased Air Resistance in 2 weeks



- **Charged media can rapidly lose all performance**
- **IPA discharge simulates real life**

- **Charged synthetic media quickly increases air resistance**
- **High air resistance and energy usage**

H&V Media Selection for GT (Hollingsworth & Vose)



Polymer Group Gas Turbine Media

Everist™ high efficiency filtration media

outperforms traditional mechanical and synthetic composite media

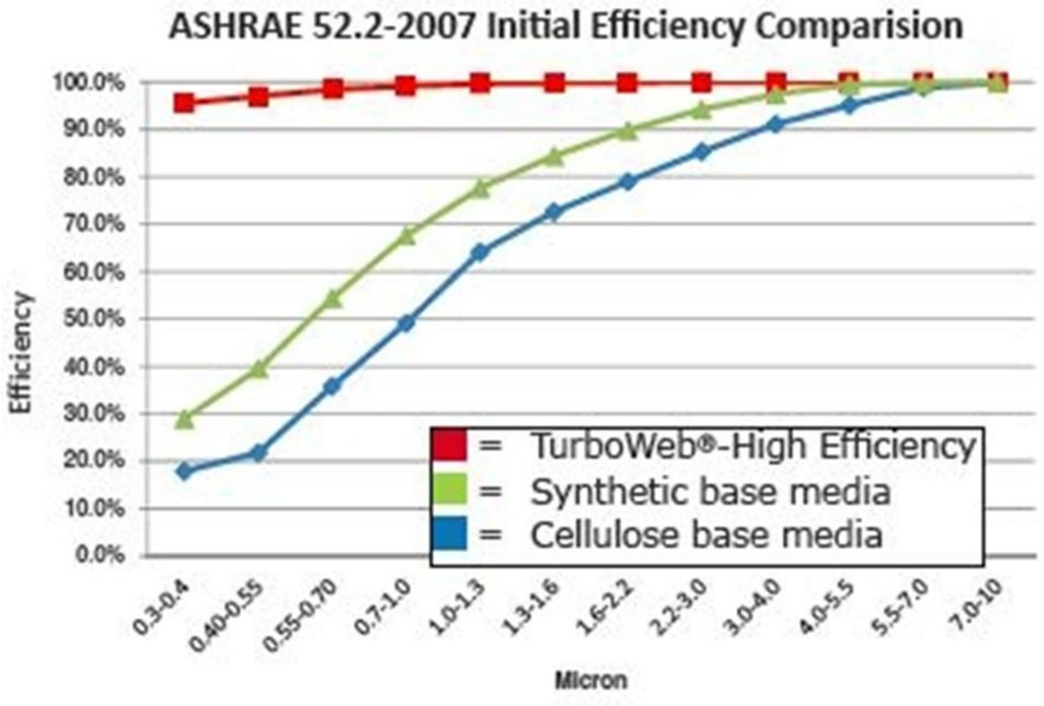
meets all demands put forward by gas turbine manufacturers

- ❖ Nanofiber-based technology
- ❖ Enhanced Efficiency
  - Everist media provides a higher initial efficiency and the same mechanical efficiency as glass, while providing the same initial efficiency and a higher discharge efficiency vs. synthetics
- ❖ Low Pressure Drops
  - The nanofiber-based technology in Everist media provides half the pressure drop of glass media and is similar to electrostatically-charged synthetics.
- ❖ Excellent Dirt Holding Capacity
  - PGI's Everist media doubles the dirt holding capacity of synthetic composites and has a similar capacity to glass
- ❖ Best-in-Class Processing
  - Everist media pleats on both rotary and blade pleaters and can be sonically welded
- ❖ High Durability and Sustainability
  - This new technology is both more durable than glass and greener than traditional media

TurboWeb™ Filter Compared to Other Media (Midwesco)

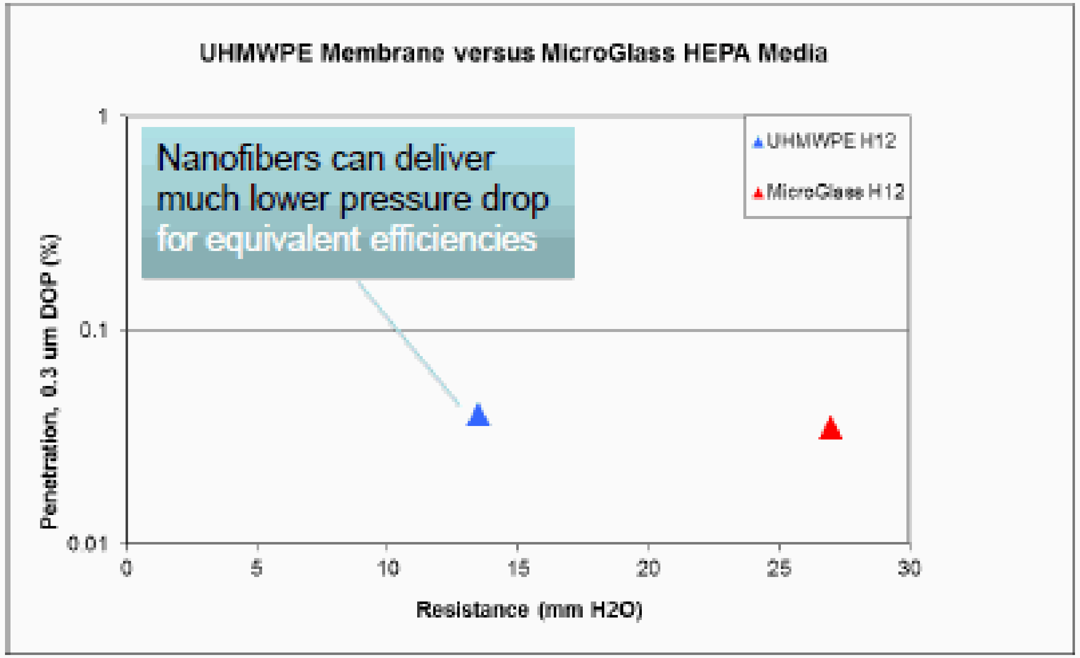
TurboWeb™ is a 3 layer ultra-high efficiency media.

- Layer 1: Proprietary high efficiency laminate
- Layer 2: Special treatment to resist moisture and salt from entering the media
- Layer 3: 100% synthetic



Nanofibers (Lydall)

Nanofibers: Energy Reduction Possibilities



* The efficiency ratings for this test used 0.3 micron DOP particles on a TSI Model 8160 automated test stand on flat sheet media samples at 5.33 cm/second.

Lydall Gas Turbine Filter Media Simplified Decision Matrix

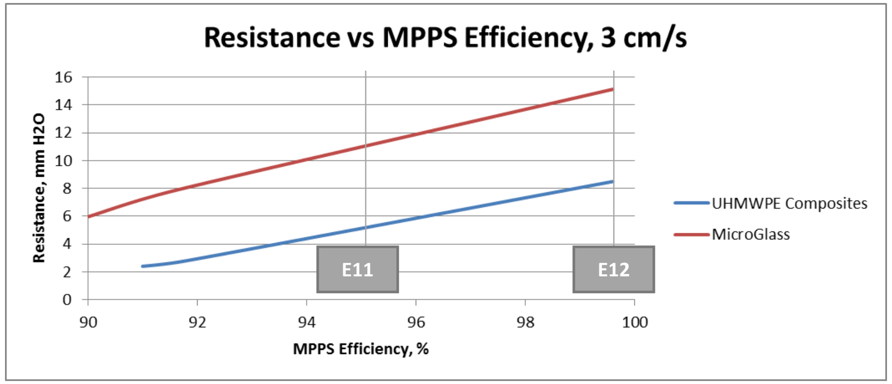
Solution	Technology	Filtration Efficiency				Cleaning Mode		Filtration Mechanism		Water Resistance	Oil Management
		MERV 11-15 F6-F8	MERV 16 F9	E10	E12	Pulse	Static	Mech.	Charged		
Arioso Composites	Membrane Composites		+	+	+	+	+	+		+++	+++
LydAir MG ASHRAE	MicroGlass	+	+				+	+		+	+
LydAir MG HEPA	MicroGlass			+	+		+	+		++	++
LydAir SC	Synthetic Composite	+	+			+	+		+	+	++
LydAir MB	Meltblown	+	+				+		+	+	++

Note: Lydall Lamination Technologies and multiple Functional Support Layers are available for use with all product families.

Gas Turbine Air Inlet Filtration: Membrane Composite Considerations

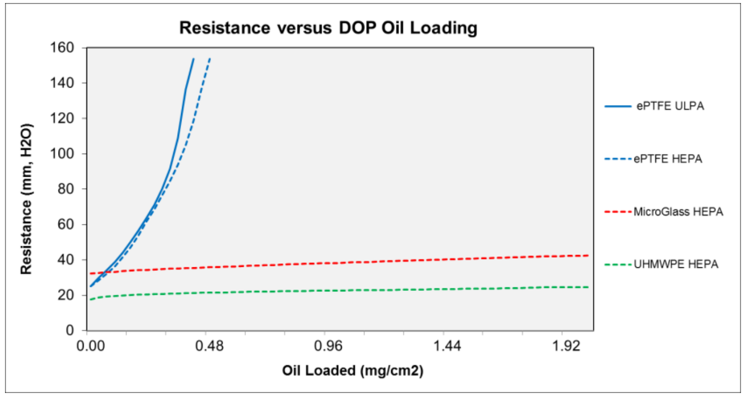
Mechanical Filtration Efficiency

Tests at design velocity to prove E10 to E12 performance



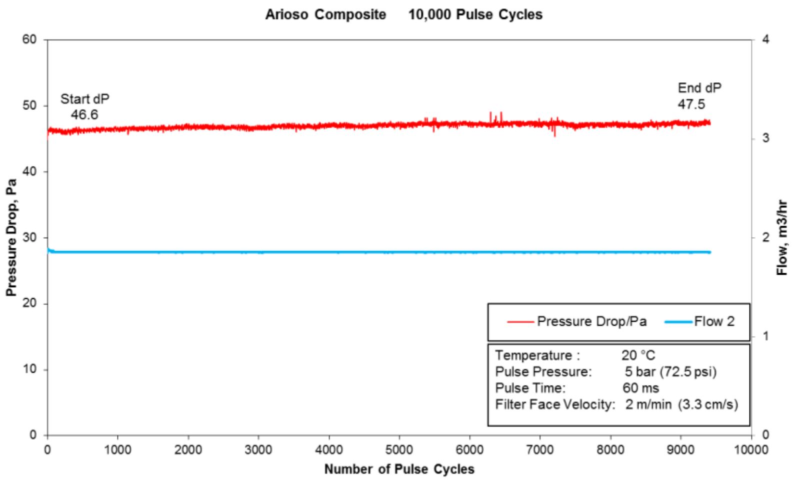
Oil & Hydrocarbon Management

Oil loading to simulate oily/hydrocarbon environments



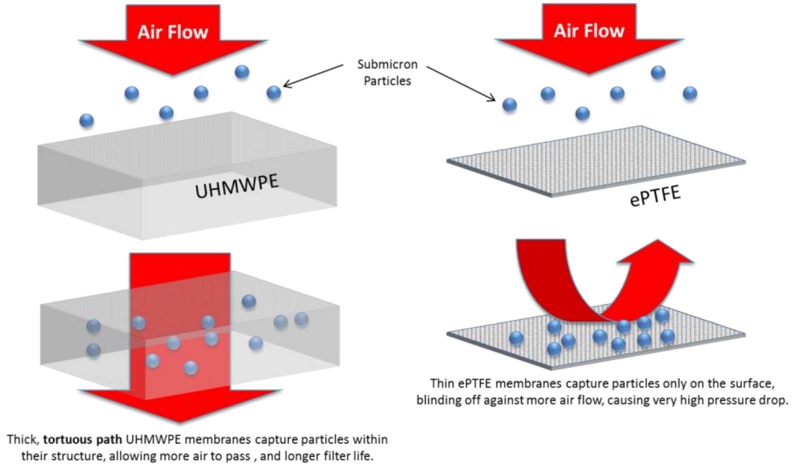
Designs for Pulse or Static Operation

Pulse testing to validate durability and dust release



Filter Life

Depth loading membranes, versus surface loading



Decision Route – Fibers and Media

Webinars

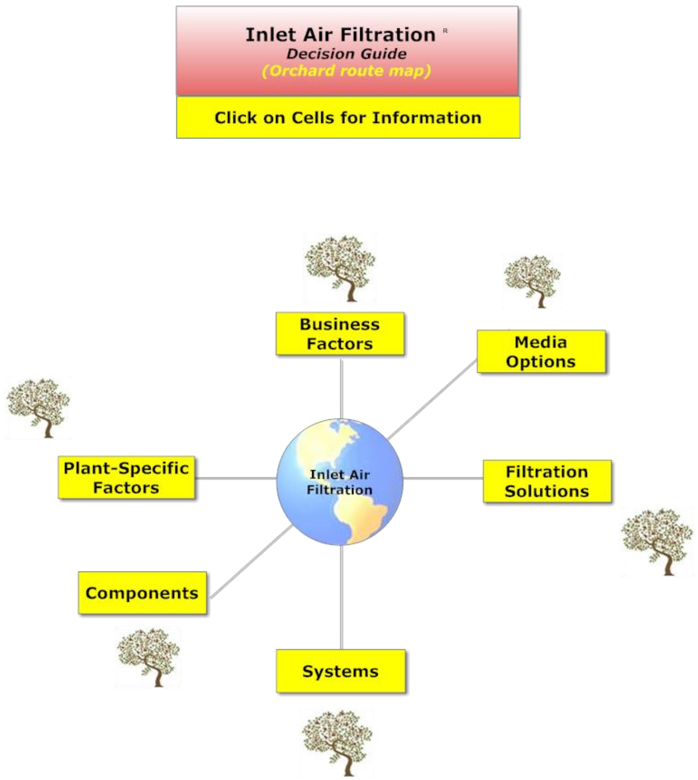
Date	Recording Title
February 5, 2015	**Gas Turbine Regulatory Drivers** 120 minutes
May 15, 2014	**Gas Intake Filters: HEPA or Medium Efficiency** 101 minutes

InterWebViews™ (Free)

Date	Topic

Search Category	Key Words
By Product	Air Filter Air Intake House
By Company	Dexmet, Hollingsworth & Vose, Lydall, Midwesco
By Topic	Efficiency

Filter Choices



II. Filter Choices #1 - Performance

Subject	Slide Contributor	Relevant decision
Performance Criteria		
Pressure Losses	Southwest	What filter designs provide acceptable pressure losses?
Problems with Particulates	Mcilvaine	How can air inlet systems be designed to address corrosion, erosion or fouling issues?
Problems with Particulates	Clarcor	How can air inlet systems address fouling? (4 slides)
Problems with Moisture	Nederman	How should a filter house be designed to address moisture issues?
Problems with Moisture	Freudenberg	How can air inlet systems be designed to address moisture issues? (3 slides)
Options for Snow and Ice	GE	What options are most effective in dealing with snow and ice?

High Efficiency Filter Pressure Losses (Southwest)

- In order to achieve the high filtration efficiency, the flow through the filter fiber is highly restricted which creates a high pressure loss, unless the face velocity is kept low.

- The initial pressure loss on high efficiency filters can be up to 1-in. H_2O (250 Pa) with a final pressure loss in the range of 2.5-in. H_2O (625 Pa) for rectangular filters and 4-in. H_2O (2000 Pa) for cartridge filters.

- High efficiency filters used with gas turbines have pleated media that increase the surface area and reduce the pressure loss.

Filter Performance: Problems with Particulates

Corrosion

- Loss of material caused by a chemical reaction between machine components and contaminants, which can enter the gas turbine through the gas stream, fuel system or water/steam injection system.
- Salts, mineral acids, elements such as sodium, vanadium, and gas, including chlorine and sulphur oxides in combination with water, can cause corrosion.

Erosion

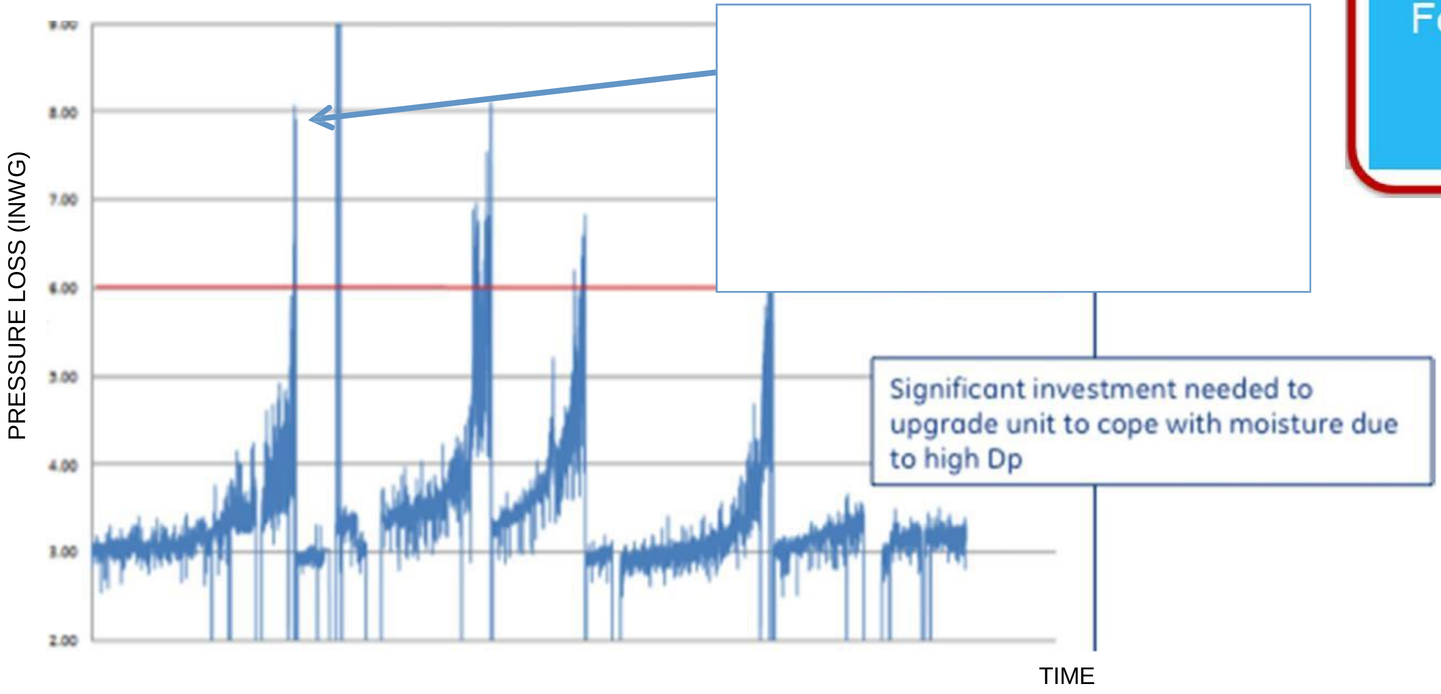
- Erosion is the abrasive removal of material by hard particles suspended in the gas stream.
- Particles causing erosion are normally 10 microns or larger in diameter. Particles with diameters between 5 and 10 microns fall in a transition zone between fouling and erosion.
- Erosion damage increases with increasing particle diameter and density, flow turning and gas velocity, and with decreasing blade size.
- Turbine and compressor manufacturers minimize erosion by increasing trailing edge thickness, installing field replaceable shields and using improved alloys.
- Nevertheless, they all recommend fine inlet filtration to prevent hard particles from entering the turbines.

Fouling

- Fouling is the adherence of particles and droplets to the surface of the turbomachine blading. This degrades flow capacity and reduces efficiency in a short period of time.
- Fouling can normally be reversed by cleaning, but it often requires downtime. Fouling is a serious problem, particularly in the oil and gas industry where sticky hydrocarbon aerosols are universally present.
- Traditionally, no accommodation has been made in designing turbines to tolerate deposition tendencies of particulate-laden gas streams. Although the deposition trajectories can be predicted for some turbine blades, the actual fouling is very much dependent on inlet gas cleanliness which varies unless it is controlled.

Two ways to stop fouling –

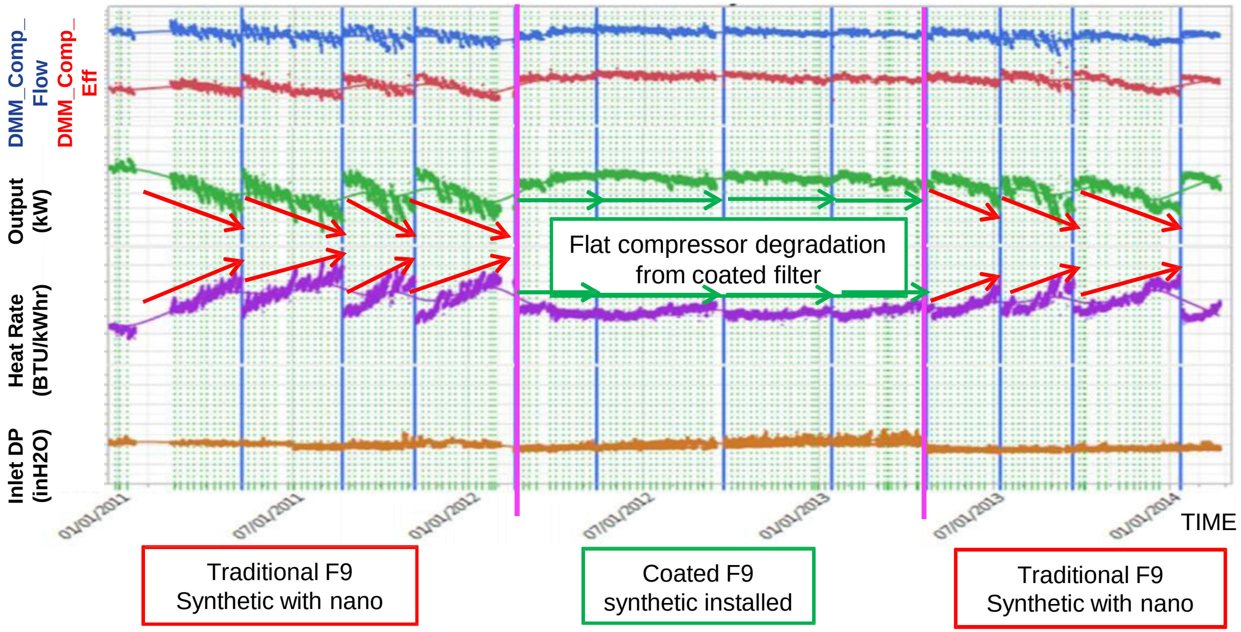
1. Stop fine (<1 micron) particulate reaching the GT
   - Use of high efficiency filters, typically E10 or above
   - EPA / HEPA alone only addresses dry contaminants
   - Filter likely to be more sensitive to moisture



Two ways to stop fouling –

2. Stop contaminants from sticking to the compressor blades
   - Sticky contaminants such as, salts and hydrocarbons etc. are much more likely to cause fouling by making the blades sticky which then enable them to foul with dry inert particulate.
   - Use of hydrophobic and advanced fibre coated filters can significantly reduce sticky contaminants getting to the GT

EXAMPLE



Industry trend *(Clarcor)*

The industry trend is for increased GT availability in all environments while using ever newer, more complex and sensitive gas turbines.

This results in a need for:-

1. Higher efficiency filters – Fine fibre (Nano)
2. Filters with longer life – Multi layer composites that are highly pleatable
3. Filters with predictable performance and no surprises – Advanced coatings with moisture management addressed that have been extensively tested in the real world
4. Robustly designed filters – Strong filter media

Challenges for the Nonwovens Industry

1. Higher efficiency (EPA / HEPA) media that is less sensitive to mist, fog or hydrocarbons especially when loaded in the real world
2. As 1 above specifically for surface loading media for pulse cleanable products
3. Proven through life (real world) hydrophobic properties
4. Synthetic media that truly holds or improves it's efficiency through real world loading
5. Longer life media
6. Higher strength media that can be pulsed
7. Focus on pleating, self supporting, corrugation etc.
8. Advanced fibre coatings

Essentially there is a growing need for cost effective, composite media using multiple non-woven and coating technologies in a single media available from multiple global locations

Superior filtration solutions to improve the quality of life.

Freudenberg Filtration Technologies.
Air filtration.

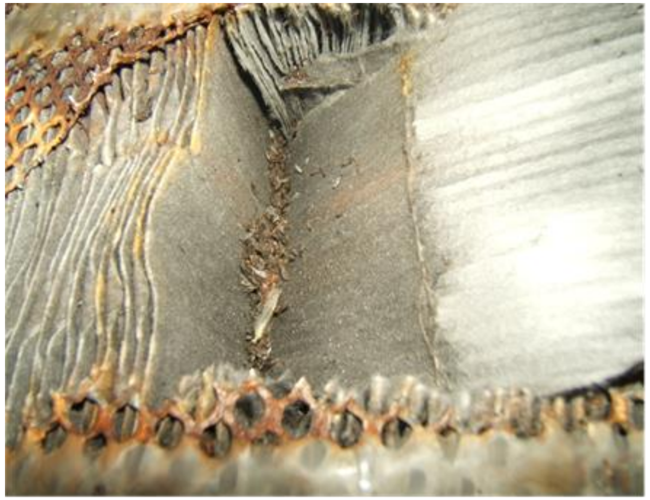
M. Garnett

28TH APRIL 2015

Industrial Air Filtration
Liquid Filtration
Automotive Filters
Human Protection
Engineering & Services

energy efficiency
performance

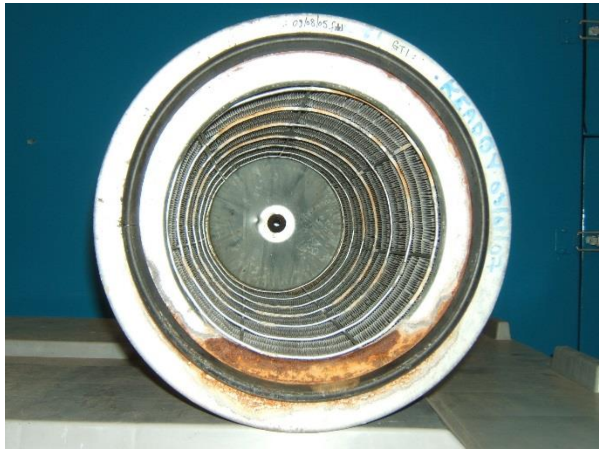
Consideration of the Condition of the Air Inlet Housing & Filters.

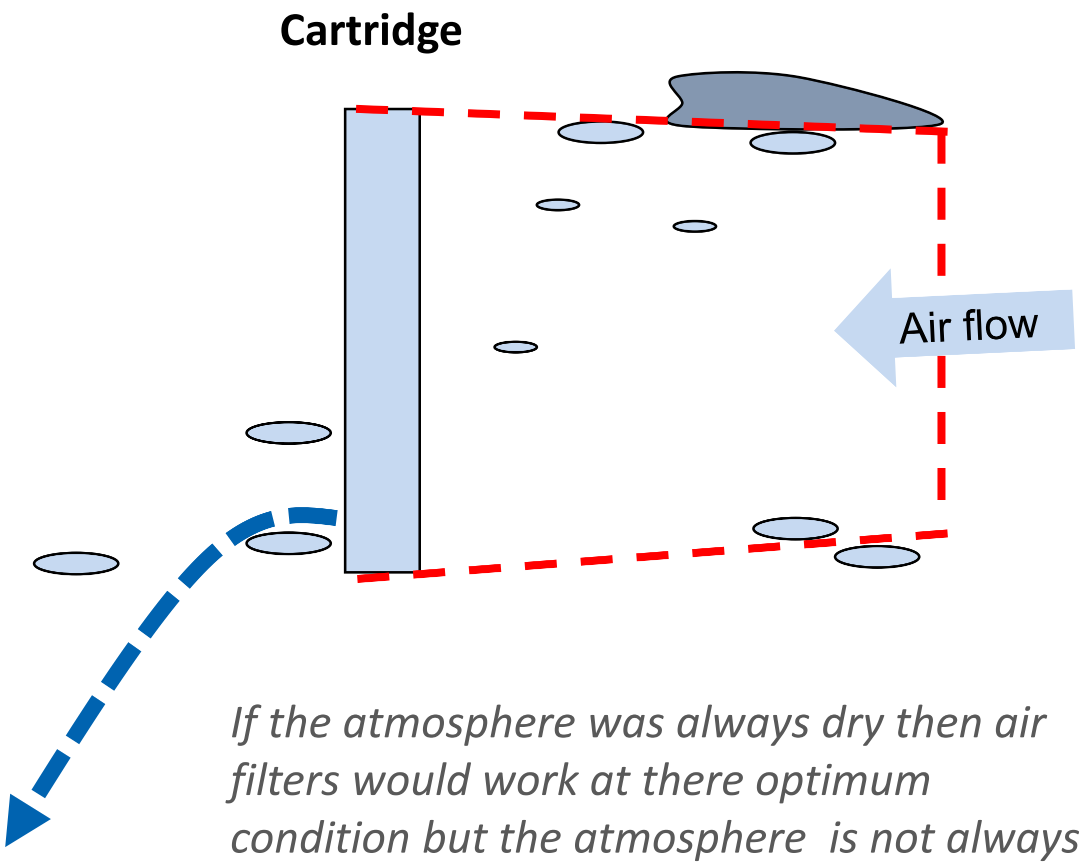







Particle Removal - Liquids - Single stage Filter Configuration





If the atmosphere was always dry then air filters would work at there optimum condition but the atmosphere is not always dry.

Options for Snow and Ice (GE)

Benefit	Snow Hood	Upflow Pulse	Inlet Heating
Effectiveness vs. Ice	-	0	+
Effectiveness vs. Snow	-	0	+
Cost	+	-	-

+ (Most favorable)
0 (Unbiased)
– (Least favorable)

II. Filter Choices #2 - Design Decisions

Subject	Slide Contributor	Relevant decision
Design Decisions		
Life Cycle Costs	Clarcor	What factors should be considered besides filter efficiency?
Life Cycle Costs	Southwest	What life cycle costs should be taken into account?
Static Design	Southwest	What shape and size of filter?
Self-Cleaning Filters	Southwest	How do self-cleaning filters work?
Pulsing for Constant Pressure Drop	Gore	What are the advantages of pulsing over static filters?
Pulsing to Eliminate Off-line Washes	Gore	What are the advantages of pulsing over static filters?
Static vs. Pulse	GE	Under what conditions are static and pulse filters most effective?

Evaluate Filters Based on Overall Performance – not just Efficiency

Filtration Efficiency's impact on compressor health-Filtration News, April 2015.

- Clarcor says that based on total performance, which includes turbine maintenance plus pressure loss and filter degradation. The EPA filter is not necessarily the best.

- Maintenance of long term turbine health can be offset by
  - Operational degradation
  - Higher dP spikes
  - Unpredictable end of life
  - Unplanned outages

Filter Life Cycle Cost Considerations (Southwest)

- Initial costs
  - Equipment (filters, filtration system, spares filters, instrumentation)
  - Installation and commissioning (labor, cost of installation equipment such as cranes)
- Energy costs (pulse system for self-cleaning filters)
- Operating costs (labor and inspections)
- Maintenance costs (replacing filters, repairs, and associated labor)
- Downtime (to replace filters, complete offline water washes, anything outside of normal shutdowns for other maintenance)
- Gas turbine effects (degradation, performance loss)
- Decommissioning and disposal (disposal of filters)

High Efficiency Static Filter Design (Southwest)

- There are many different constructions of high efficiency-type filters:
  - rectangular,
  - cylindrical/cartridge,
  - bag filters

- Rectangular high efficiency filters are constructed by folding a continuous sheet of media into closely spaced pleats in a rectangular rigid frame.
  - Rectangular filters are depth loaded; therefore, once they reach the maximum allowable pressure loss, they should be replaced.

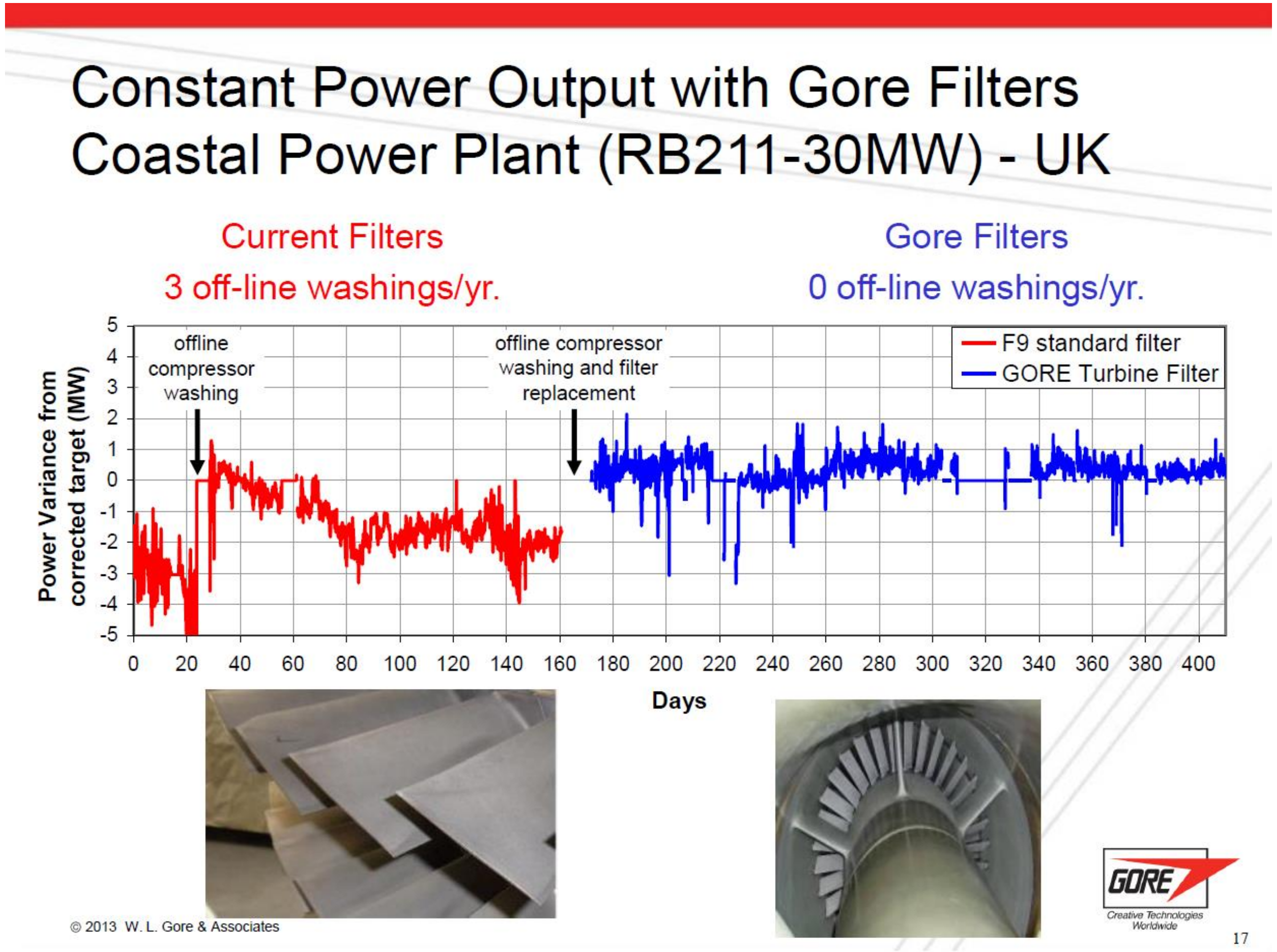
- Cartridge filters are also made up of closely spaced pleats, but in a circular fashion
  - Air flows radially into the cartridge
  - They can be installed in a horizontal or vertical fashion (hanging downward)
  - Cartridge filters can be depth or surface loaded

Self-Cleaning Cartridge Systems (Southwest)

Self-cleaning systems operate primarily with surface loaded high-efficiency cartridge filters.

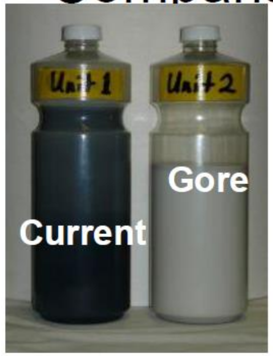
- Once the pressure loss reaches a pre-defined level, the filter is cleaned with air pulses.
- The pressure of the air pulses ranges from 80 to 100 psig (5.5 to 6.9 barg).
- A reverse jet of compressed air (or pulse) occurs for a length of time between 100 and 200 milliseconds.
- To avoid disturbing the flow, and to limit the need for compressed air, the system typically only pulses 10 percent of the elements at a given time.
- With this type of cleaning, the filter can be brought back to near the original condition

Pulsing Prevents Pressure Peaks (Gore)

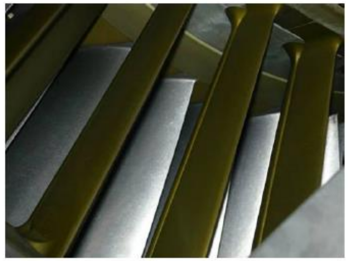


Pulsing Eliminates Off-line Washes (Gore)

Eliminating Off-Line Washes - Confirmed via Boroscope and Wash Water Comparison



End User	Off-line washes/yr with F–Class (MERV) filters	Off-line washes/yr after installing GORE® H12 Turbine Filters
Plastics Mfg. (coastal)	20	0
Brewery (coastal)	17	0
Food	26	0
University	7	0
Ceramics	52	0
Power (coastal)	3	0
Power - Refinery (coastal)	9	0



GORE
Creative Technologies Worldwide

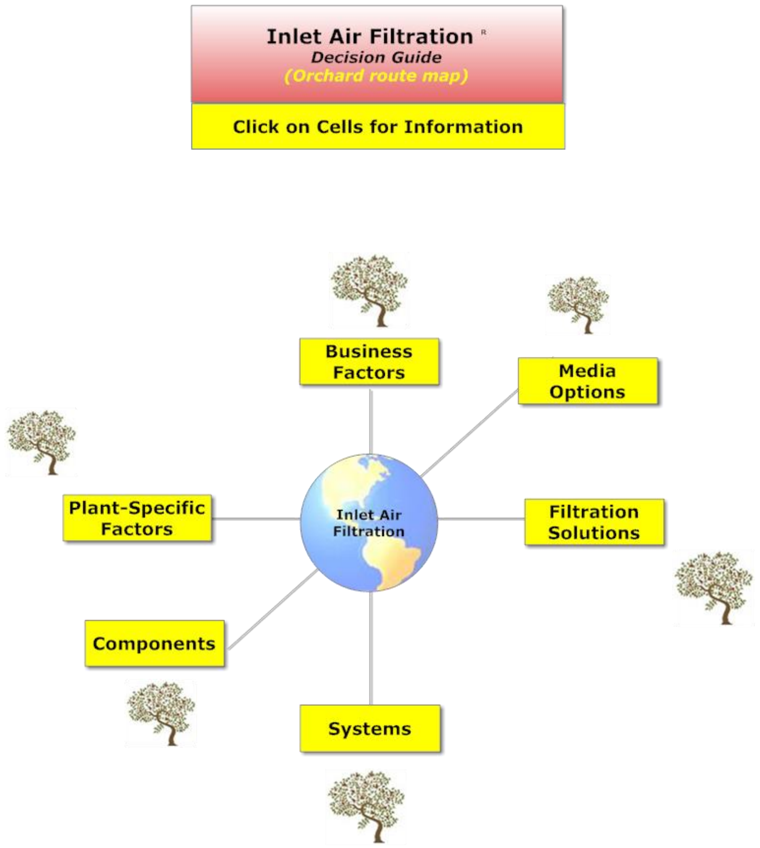
Static vs. Pulse Filter Options (GE)

Benefit	Static	Standard Pulse	Upflow Pulse
Initial dust efficiency	+	-	-
Filter life	-	0	+
Sensitivity to fog / mist	+	-	-
Compactness	+	0	-
Cost	+	0	-

+ (Most favorable)
0 (Unbiased)
– (Least favorable)

Filter systems

- Multi stage designs
- Pre filter options



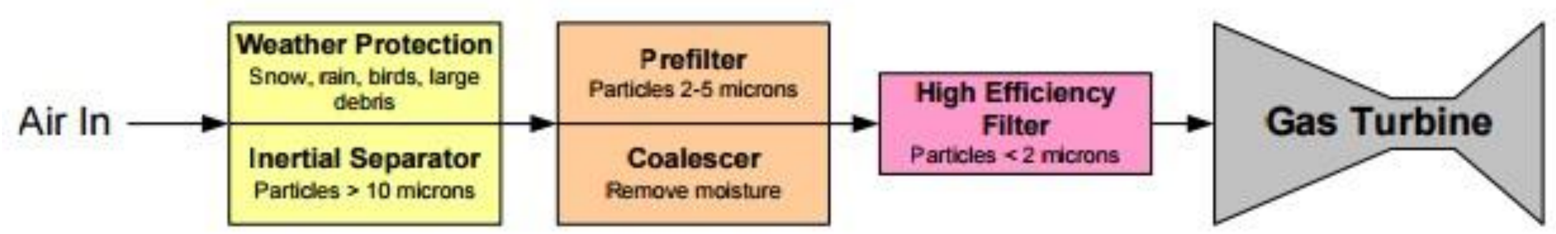
II. Filter Choices #3 - Multi-stage Designs

Subject	Slide Contributor	Relevant decision
Multi-stage Designs	Southwest	Will more than one type of filter be required?
Pre-filter Options	AAF	Why should pre-filters be used?
Pre-filter Options	AAF	Which option is best and when?
Cartridge/Pre-filter	Gore	Gore offers a cartridge filter with an integral pre-filter.

Multi-Stage Filtration Systems (Southwest)

Any gas turbine application typically needs more than one type of filter, and there are no "universal filters" that will serve all needs. So, two-stage or three-stage filtration systems are typically used.

- A weather louver can be used first to remove erosive contaminants, rain and snow.
- The second stage may be a low to medium performance pre-filter selected for the type of finer sized particles present, or a coalescer to remove liquids.
- The third stage is usually a high-performance filter to remove smaller particles less than 2 μm in size from the air.
- The arrangement will very based on site specific environmental considerations.



Pre-filter Options (AAF)

If a one-stage high efficiency filter is used, the build-up of large and small solid particles can quickly lead to increased pressure loss and filter loading.

Pre-filters are used to increase the life of the downstream high efficiency filter by capturing the larger solid particles.

- Therefore, the high efficiency filter only has to remove the smaller particles from the air stream which increases the filter life.

Pre-filters normally capture solid particles greater than 10 μm, but some pre-filters will also capture the solid particles in the 2 to 5 μm size range.

- These filters usually consist of large diameter synthetic fiber in a disposable frame structure.

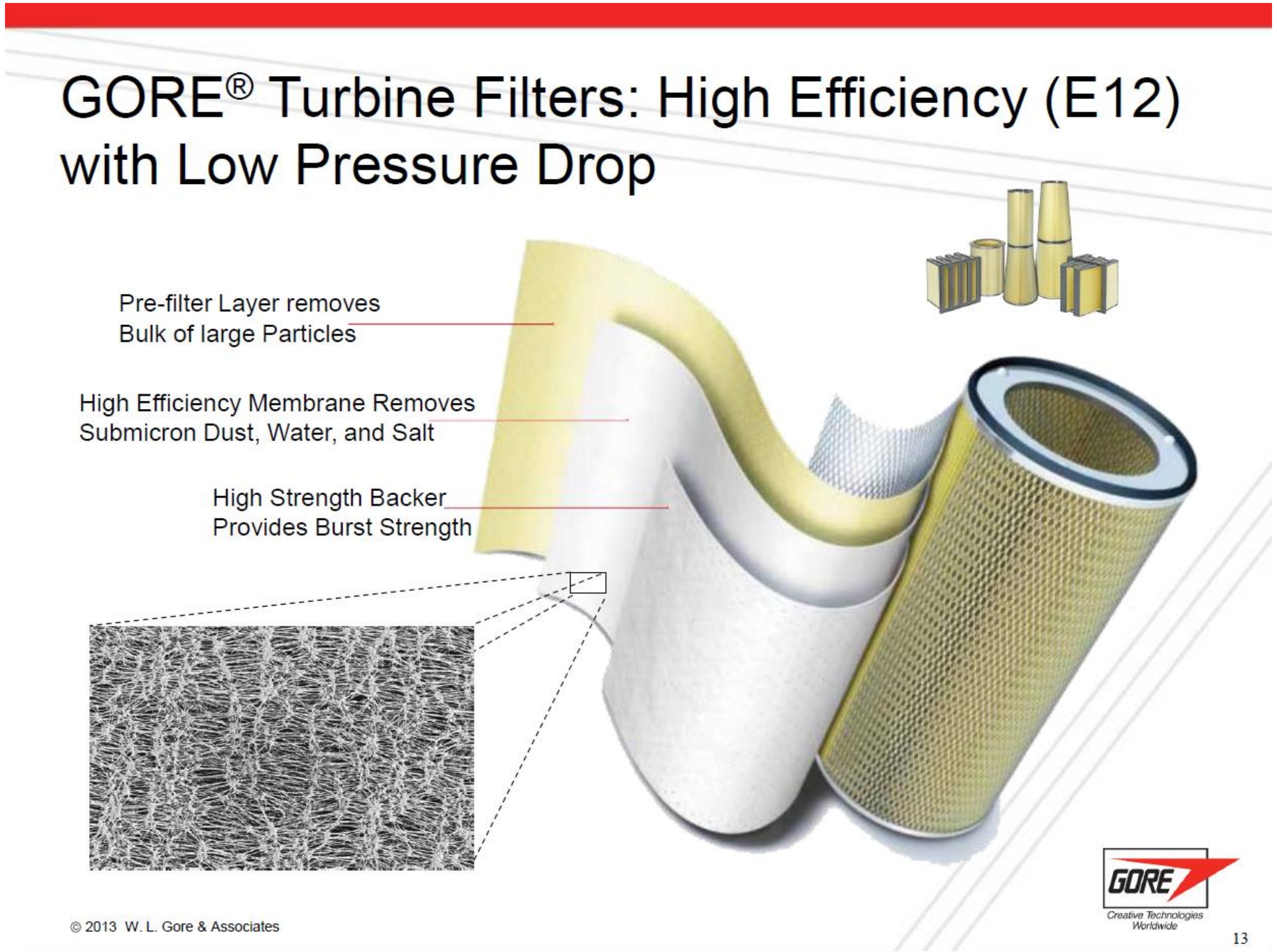
Bag filters are also commonly used for pre-filters. These offer higher surface area that reduces the pressure loss across the filter.

Pre-filter options – Which, where? (AAF)

Panel - Ar

Bag-V Bank

Cartridges with Integral Pre-filters (Gore)



Gore membranes reduce salt corrosion

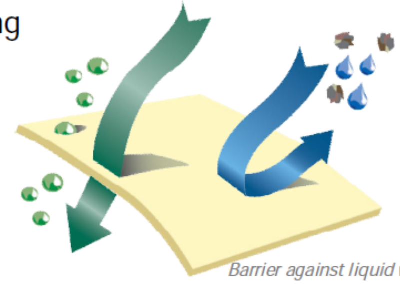
BENEFITS OF GORE® TURBINE FILTERS

OPTIMIZE POWER OUTPUT

- Eliminate power loss from compressor fouling
- Eliminate fouling-induced heat rate increases
- Prevent captured contaminants from rinsing through filters during periods of heavy rain or fog

INCREASE TURBINE AVAILABILITY

- Eliminate need for off-line compressor washing
- Avoid risk of startup and shutdown failures
- Operate continuously with clean compressor performance



REDUCE SALT CORROSION

- Prevent liquid water ingress through filters
- Stop penetration of airborne and waterborne salts
- Reduce corrosion in compressor and hot section

W. L. Gore & Associates

Gore hydrophobic HEPA static and cartridge designs

BENEFITS OF GORE® TURBINE FILTERS

HYDROPHOBIC HEPA TECHNOLOGY

- E12 efficiency with pressure drop (ΔP) comparable to lower efficiency filters
- Direct replacement for current filters
- Proven lifetime in challenging environments

W. L. Gore & Associates

II. Filter Choices #4 - Decision Diagrams

Subject	Slide Contributor	Relevant decision
Filter Options	Ahlstrom	What filter options are available?
Selection Based on Operating Conditions	GE	What filter should be selected based on dust loading, remoteness of operation and other conditions?
Selection Based on Environment	GE	What filter systems are recommended for each type of environment?
Selection Based on Environment	GEA	What filter systems are recommended for each type of environment?

Trends in Gas Turbine Air Intake Filtration

Gas Turbine Air Intake Filtration

Trends

- Growing awareness of impact of filtration on turbine compressor health & energy output
- Different cost/performance needs for inland/offshore, static/pulse-jet, peak operation/base-load
- Maximum reliability in tough environments and longer service life
- Need for real-life performance demonstration

Ahlstrom's Response

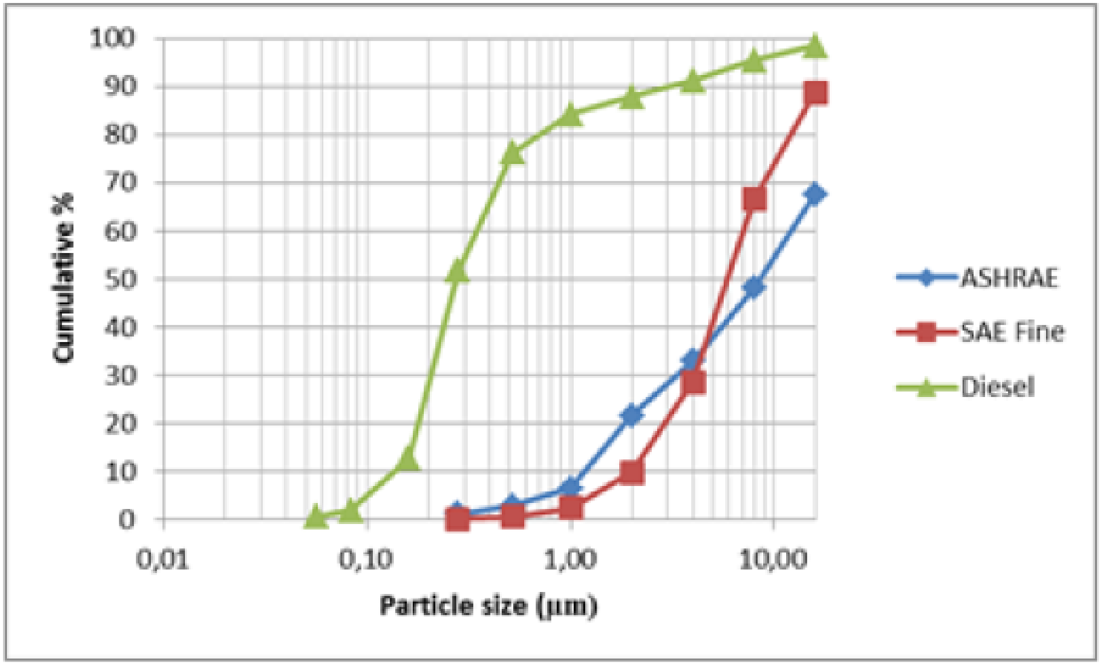
- ✓ Complete GT portfolio to address wide efficiency range with various value-add treatments (high WR, FR), for both static & pulse-jet
- ✓ Global coverage of equivalent solutions
- ✓ Focus on new products with
  - a) High efficiency
  - b) Lower pressure drop
  - c) Synthetic composition for improved WR
- ✓ Expansion of testing capabilities beyond flat sheet media testing → "Flying Dutchman" to simulate real-life GT filter performance, expanding to high soot/ humidity/salt test conditions (Finland, China) pulsing test rig for flat sheets

AHLSTROM

Why take the performance testing from lab to "real world" conditions?

GT filter media design challenges:
- Particle concentrations varying in the < 20 to +300 ug/m³ range globally including hydrocarbons, suspended dust, ash, smog, salt, etc.
- > 99% of all particles under 1 micron (based on number of particles)
- Humidity variations in the 20-100% RH range and temperature roughly ± 50 C

Implications between ambient air and standardizied test dust particle counts



AHLSTROM

Remote performance testing capability – *"The Flying Dutchman"*

Purpose:
To test filtration performance at any given location using the ambient outside air as the test contaminant instead of artificially developed test contaminants in laboratory scale. Only an electrical plug is needed in order to start the testing.

Targeted applications:
Gas Turbine Air Intake, High Efficiency Air (HVAC)

Capabilities:
- Five flat sheet filter holders for simultaneous benchmark testing
- In-line monitoring of pressure drop development
- In-line monitoring of relative humidity and temperature
- In-line monitoring of total particle count (mg/m^3) below 2.5 micron
- Off-line efficiency testing at start and finish of the chosen test cycle using DEHS aerosols
- Dust Holding Capacity measured in mg at the end of the test cycle
- Pulse-jet cleaning can be done manually at any point of the test cycle
- For static applications possible to add pre-filters

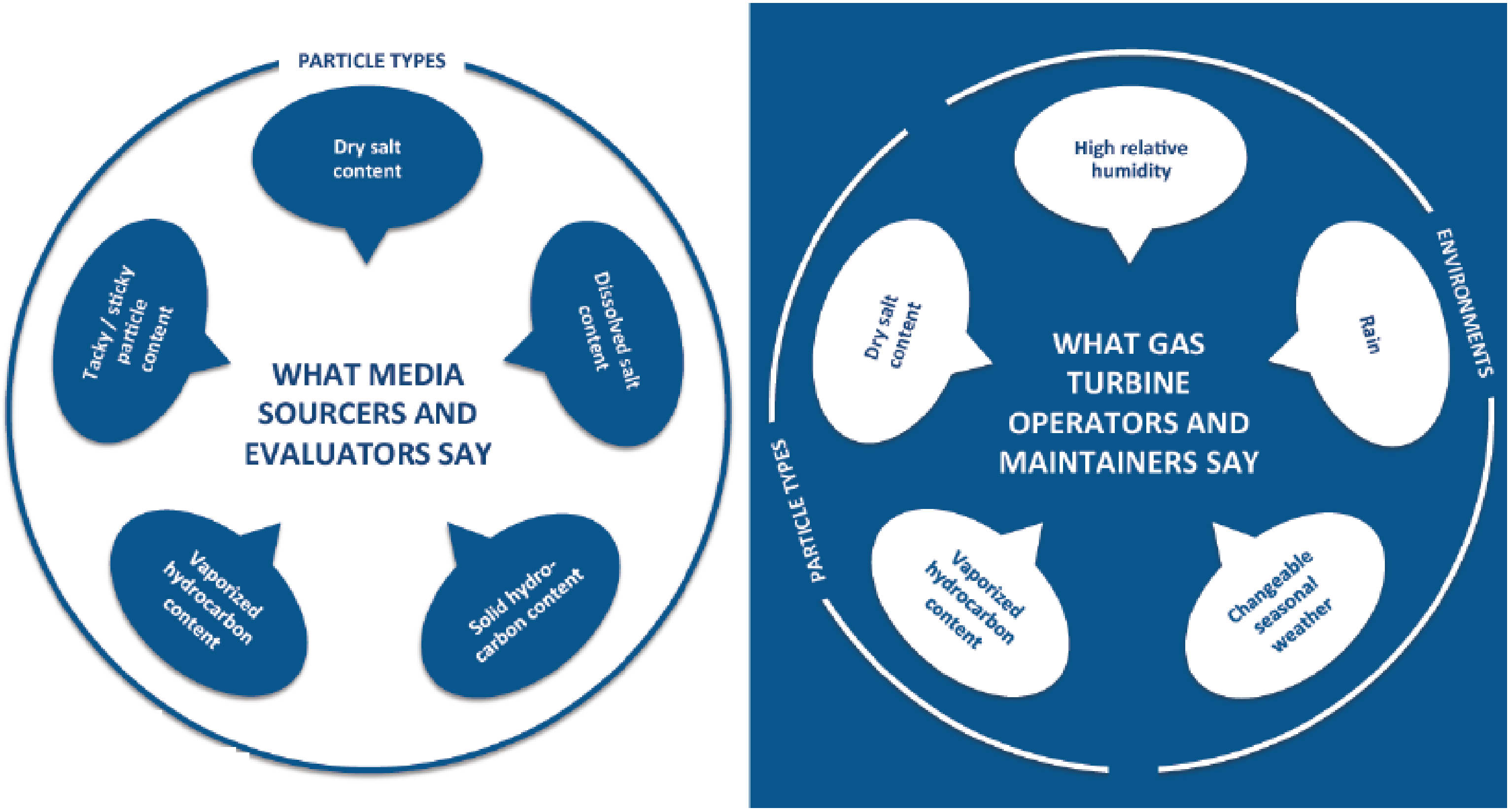
Benefits
- To better predict overall performance at selected power plant sites
- To lower the risks when introducing new filter solutions
- To better understand environmental effects vs. performance over time

AHLSTROM

“Outcome Driven Innovation” (ODI) project as input for Product Development efforts

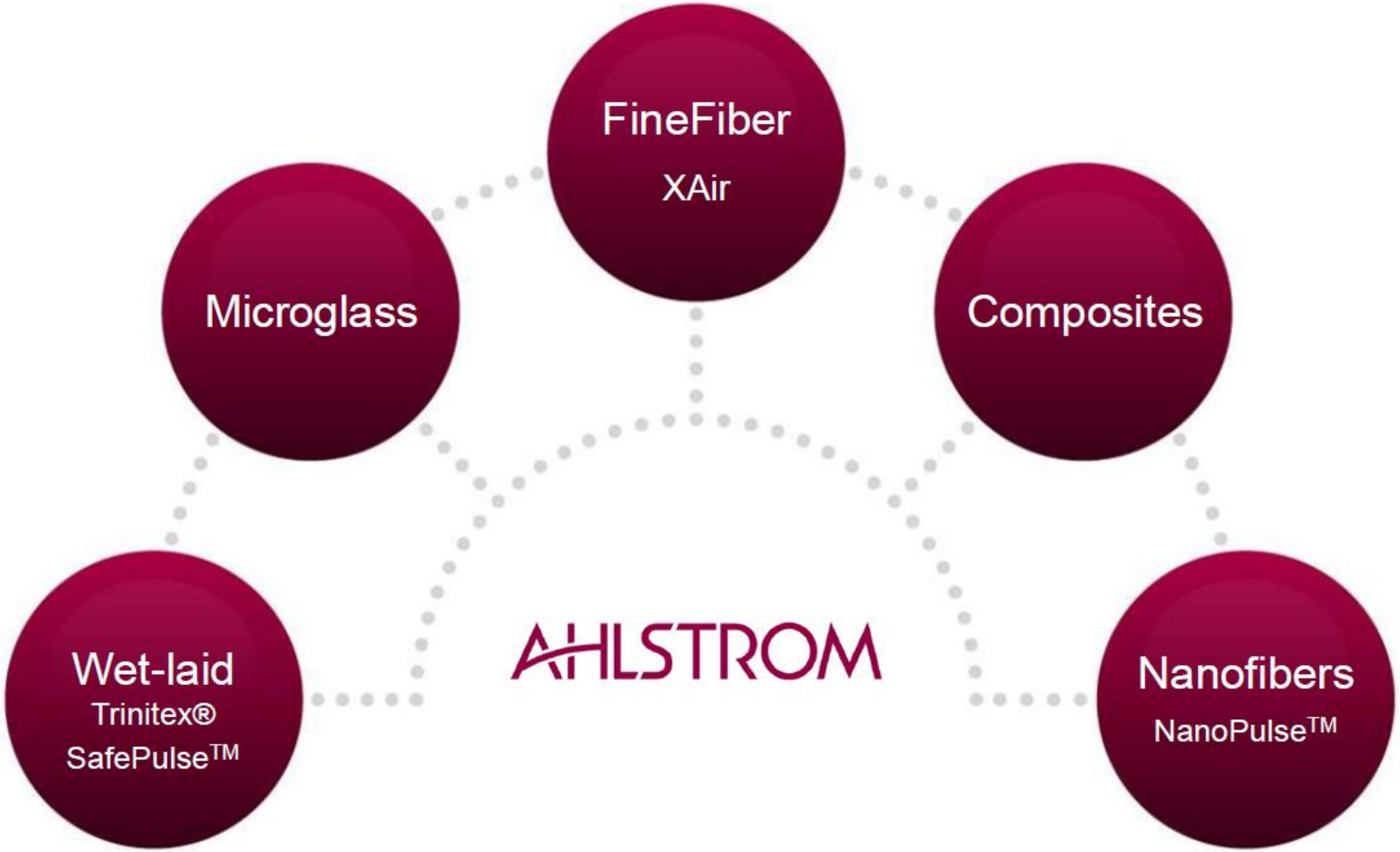
THE MOST CHALLENGING FILTRATION CONTEXTS

IN WHICH CONTEXTS ARE GT AIR INTAKE FILTRATION NEEDS MOST UNMET?
WHEN THERE IS....



AHLSTROM

Filtration technology portfolio



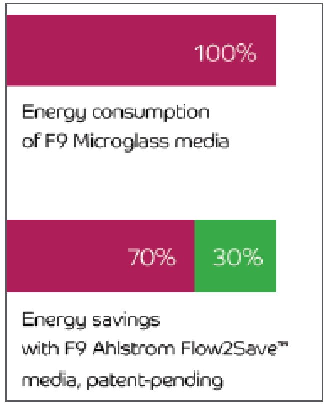
Ahlstrom Global Gas Turbine Filter Media Portfolio

	Material	Pre-Filter Static	Pre-Filter Pulsed	Fine-Filter Static	Fine-Filter Pulsed	HEPA Static	HEPA Pulsed
Trinitex®	Synthetic	X	X	X	X		
	→ 3 layers can be tailored to obtain high strength & superior performance in challenging environments – diesel soot, high humidity, salt						
Microglass GT	Microglass (& PET)			X		X	
	→ Options for additives & blends with synthetic fibers to enhance strength and pleat-ability						
Ahlstrom SafePulse™	80/20 Cellulose/Synthetic, up to 100% Synthetic	(X)	X	(X)	X		
	→ Excellent pleat-ability, high corrugation, superior performance in dusty environments, currently up to F8, EN779-2012						
Ahlstrom NanoPulse™	Electrospun nanofiber on Ahlstrom SafePulse™ carrier		X		X		
	→ Excellent pleatability, high corrugation, good nano-adhesion, excellent dust release, low pressure drop, currently up to F9, EN779-2012						
XAir GT	Synthetic Fine-Fiber Meltblown on SafePulse™ carrier	(X)	X	(X)	X		
	→ Good pleatability, high corrugation for good pulsing behavior, high dust holding capacity						
Ahlstrom Flow2Save™	Synthetic			X	(X)	X	(X)
	→ Proprietary synthetic media with low pressure drop currently up to H13, evaluation for Pulse applications ongoing						

Enhanced Energy Efficiency – Ahlstrom Flow2Save™

Key benefits:

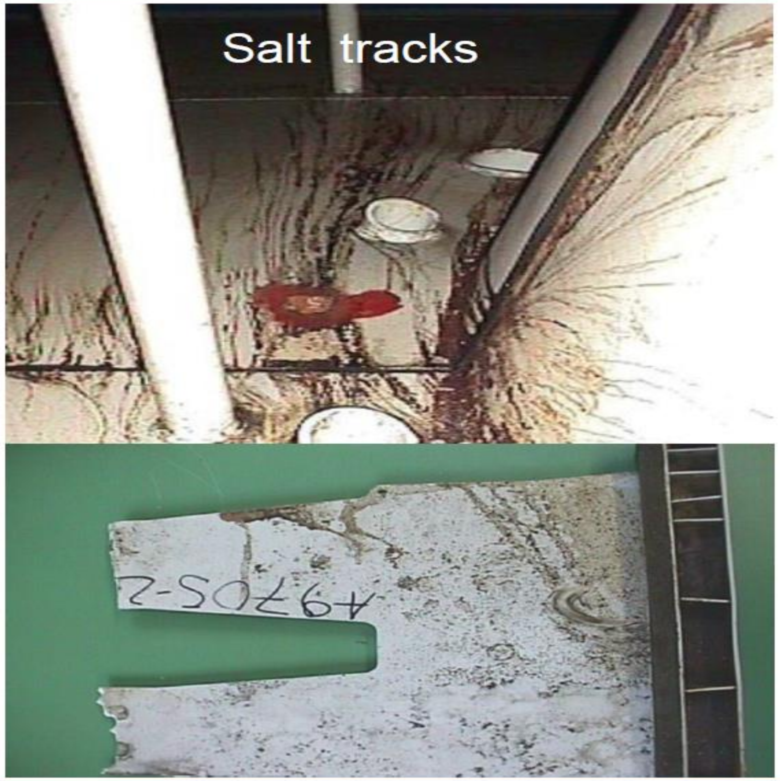
- **Approximately 30% energy savings** for end users and more sustainable footprint than conventional High Efficiency Air media throughout its life cycle
- **Low energy consumption** at every efficiency level
- Unique gradient structure for **superior** dust loading characteristics



Filtrair solution for water at second stage

Problem: Water at second filter stage

Filtration Group
Process Technologies Division



Problem: "Brown water" in final filter (= Ammonia salt)

Reason: Hydrophilic dust (salt) transferred with water droplets from pre to final filter

Effects: Significant pressure drop increases of final filter (at > 80% r.h.)
Water penetration through final filter stage (after evaporation = salt particles)

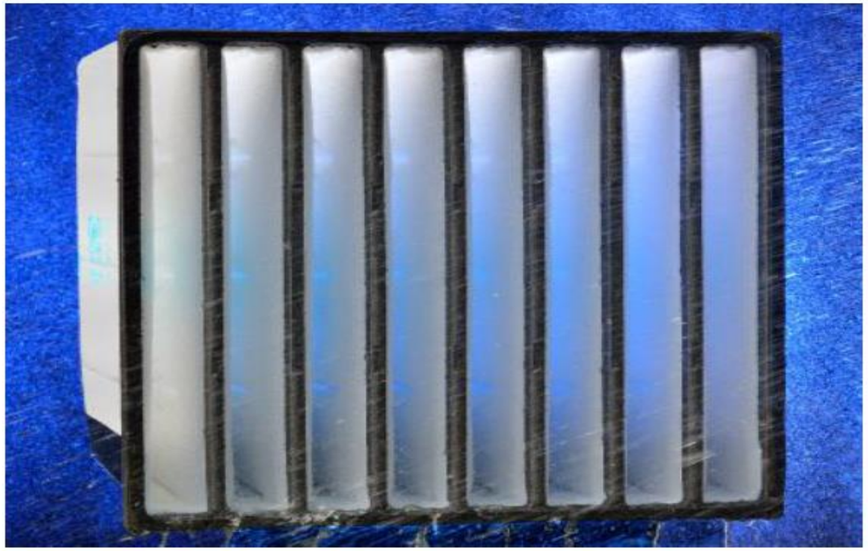
Measures: Solve water coalescing and drainage in separate pre-filter stage (→ Filtrair DS filters) and use fully potted final filters

Pockets remain open in completely wet state-Filtrair

Filtrair Drop Safe® filters – The solution

Filtration Group
Process Technologies Division

- A filter specifically designed for applications with free water and 100% rel. humidity:
- Filter media in-house hydrophobically treated for increased coalescence properties
- Rigid pockets, remain perfectly open also in completely wet state
- Conical plastic boots at bottom of pockets prevent droplet carry-over and drain water upstream
- Integrally molded PU header connects pockets and frame 100% water tight
- Patented product



In DK, NO, SE, FI and Iceland, Wide has exclusive sales rights for DS filters.

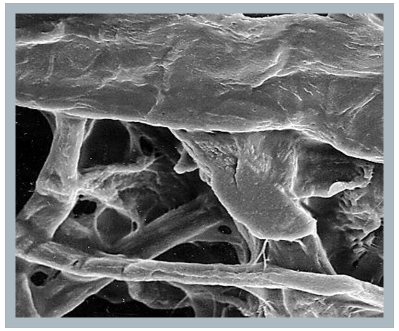
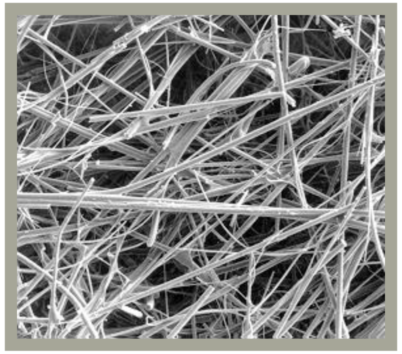
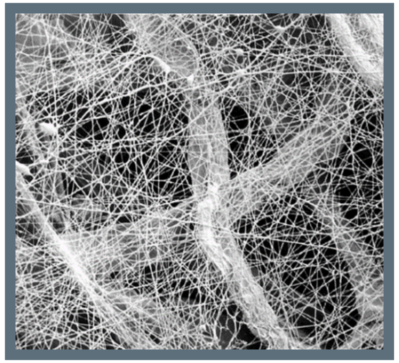
CLEAR|EDGE Filtration   Filtrair®   GLOBAL FILTER   JONELL

DRB's Product Offerings:

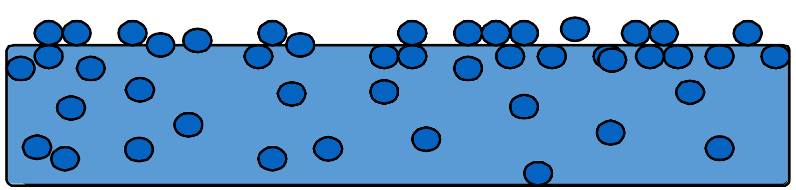
- V-Bank Static Barrier Filters
- HEPA Filters
- Conical / Cylindrical Cartridge Filters
- Pocket (Bag) Filters
- Q Cell Final Filters
- Pre-filters
- Pre-filter Frames – Plastic & Metal
- Mist Eliminators
- Polyester Pads & Rolls
- Evaporative Cooling Media
- Drift Eliminator
- Cooling Tower Parts
- Spare Parts – Pressure Switches & Gauges, Timer Boards, Repair Kits, Solenoid, Pulse Jet, & Diaphragm Valves, & Filter Clips

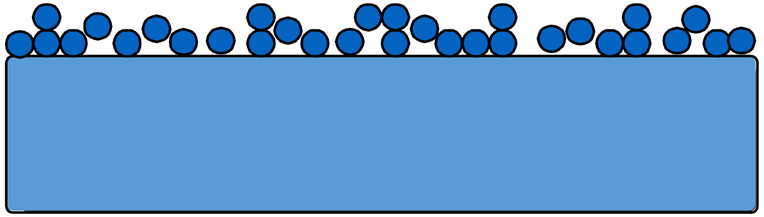
Common Materials-Donaldson

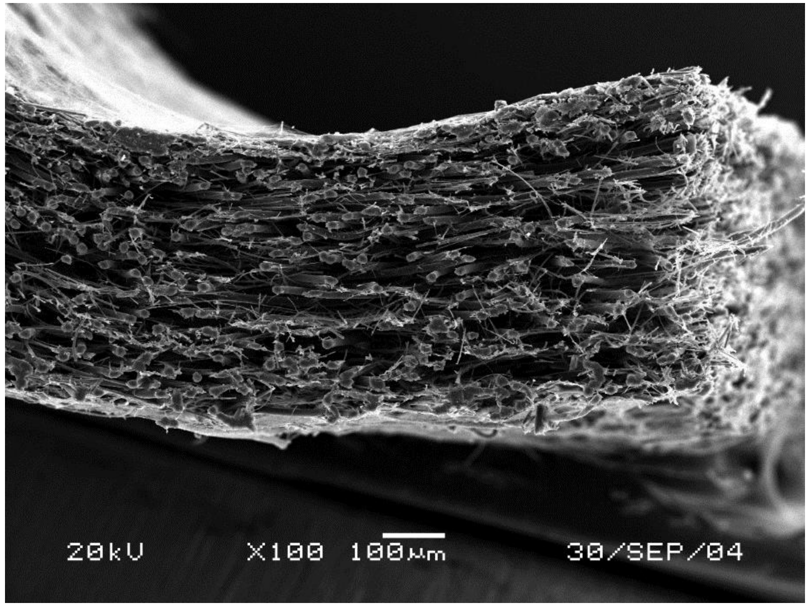
- Filter Media Type
  - Cellulose (paper)
  - Cellulose & synthetic blend
  - Fully synthetic
  - Spunbond
  - Nano-Fibers (Donaldson's Spider-Web®)
  - Membrane (ePTFE)
  - Fiberglass
  - Meltblown
  - Composites

Two Primary Approaches to Filtration



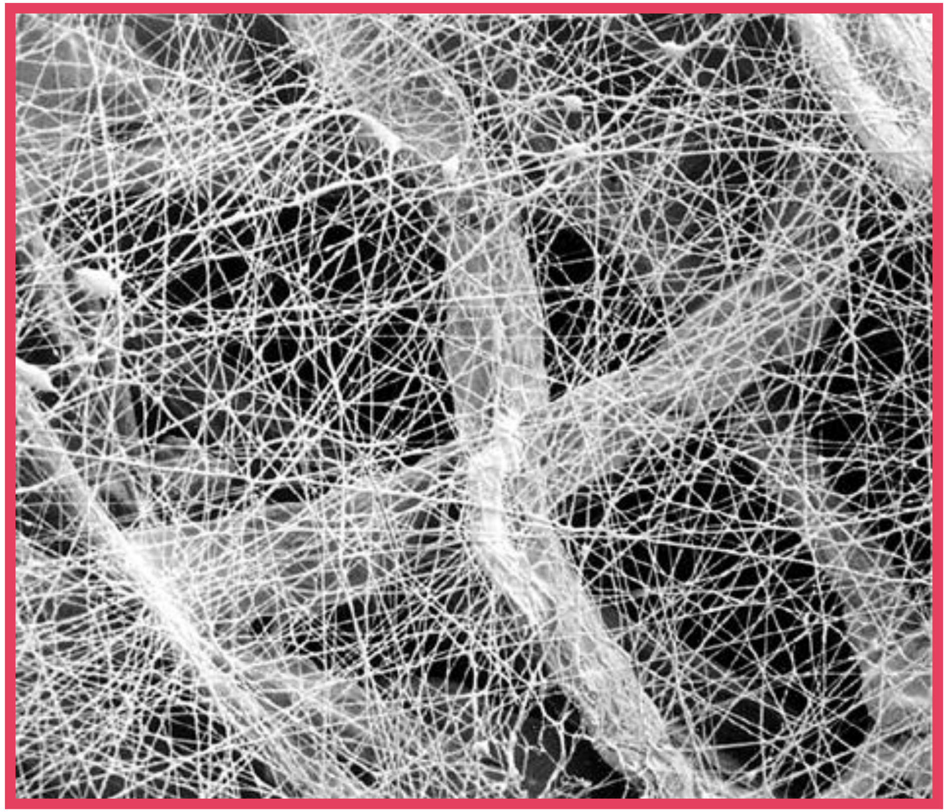




Static: Depth Load

Pulse: Surface Load

Spider-Web®

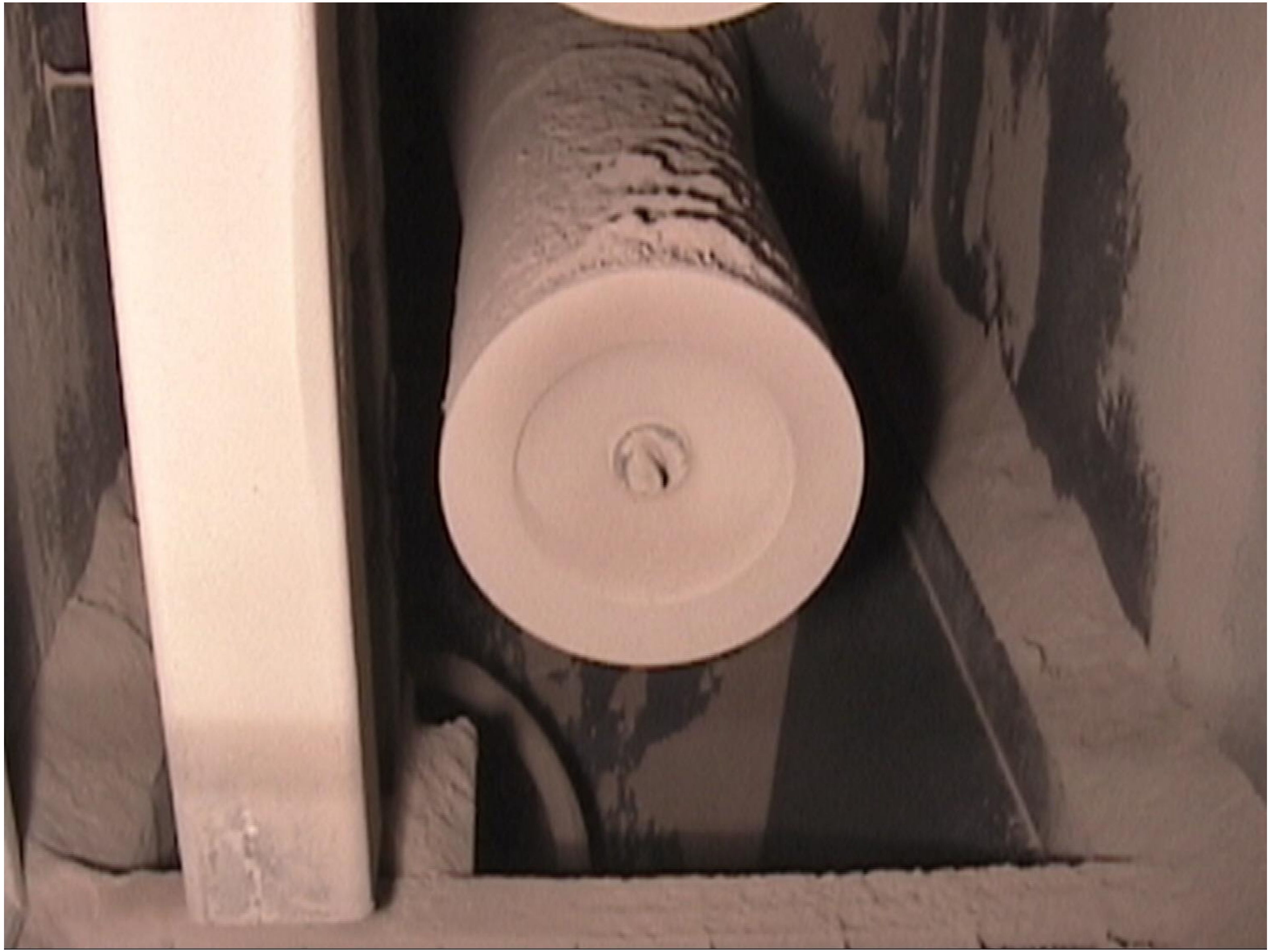


- Layer of nano-fibers
- Bonded over substrate media
- Catches dust that’s SMALLER than a micron!
- Patent protected Donaldson exclusive

Horizontal cartridges-Donaldson

Benefit of a Pulse System

GDX Pulse System



GDX Pulse System

Static Panels

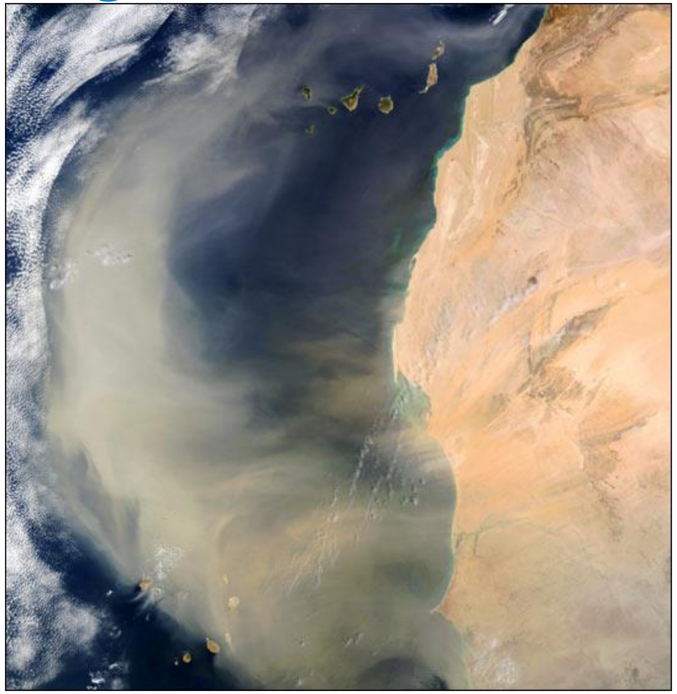
- Donaldson Northern NorrVee product line
- 12” and 17” mini-pleat, multi-V elements
- Marine and standard versions
- F6-E12 efficiency range

Environmental Factors…

- Relative Humidity (RH) & Liquid Water (Fog & Rain)
- Snow & Frost
- Hydrocarbons
- Salt

Environmental Factors…

- Dust Concentration
- Environmental Changes



New Generation of Donaldson GTS Media

TURBO-TEK™ ECO

TURBO-TEK™ H_2O

TURBO-TEK™ H_2O+

Donaldson Gas Turbine Systems (GTS)

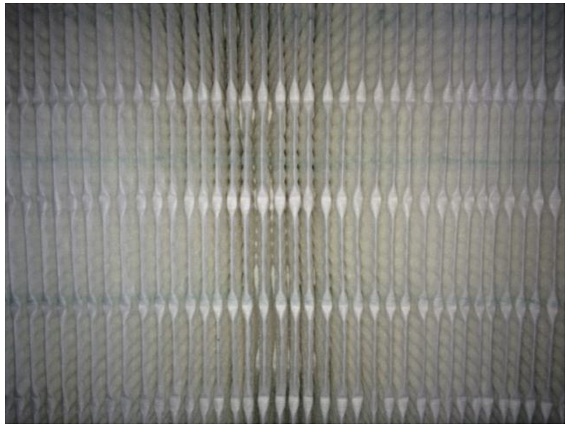
TURBO-TEK™ H_2O+

High Efficiency Filter

Product Overview

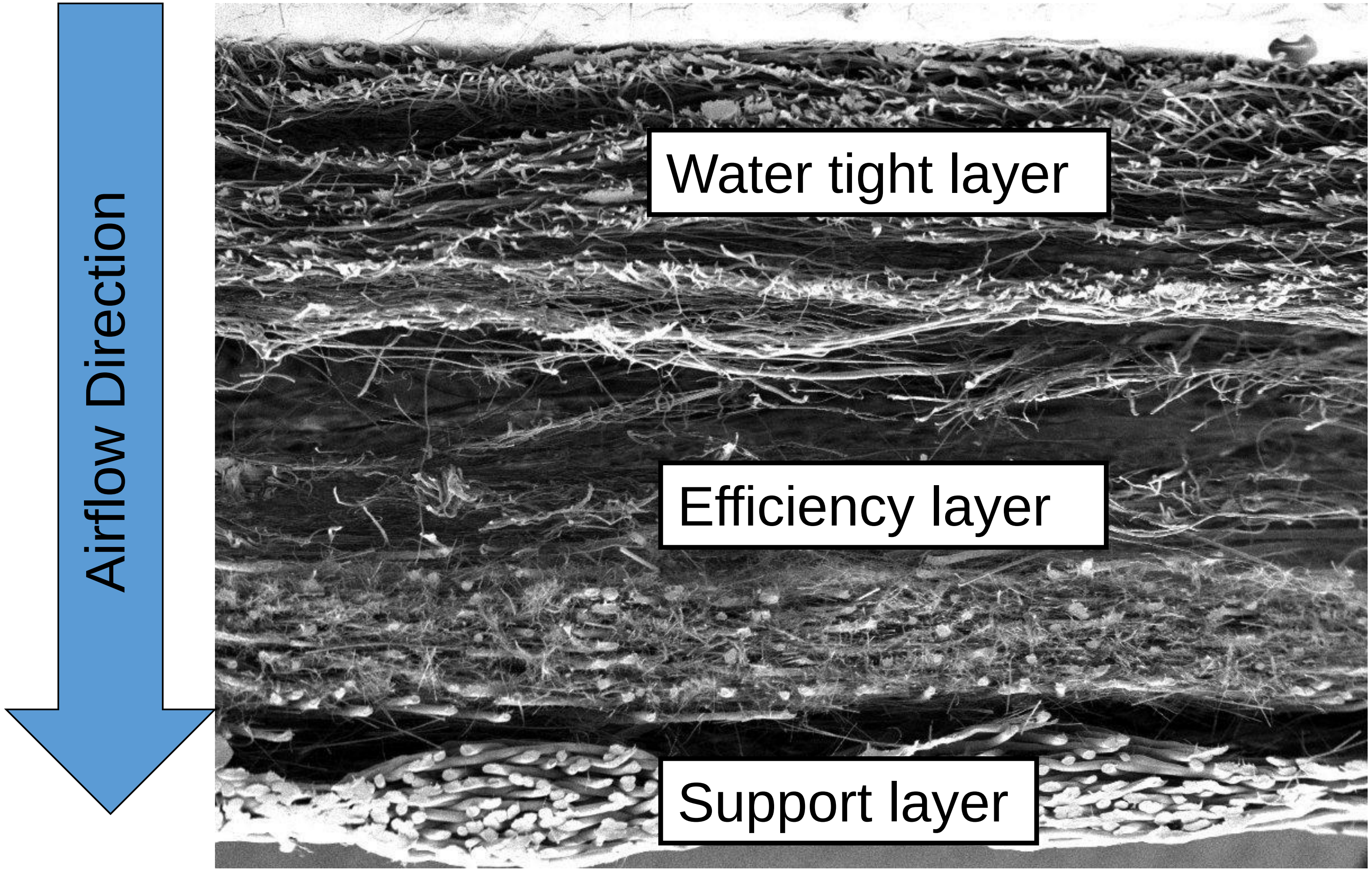
Donaldson proprietary product design

- Multifunctional multi-layer composite
- Very high efficiency
  - E12 per EN1822
- Water-tight media
- High dust holding capacity
- Fully synthetic
- Very durable
  - Pulsable (e.g. icing conditions)
- Not sensitive to humidity/moisture, shore environments.

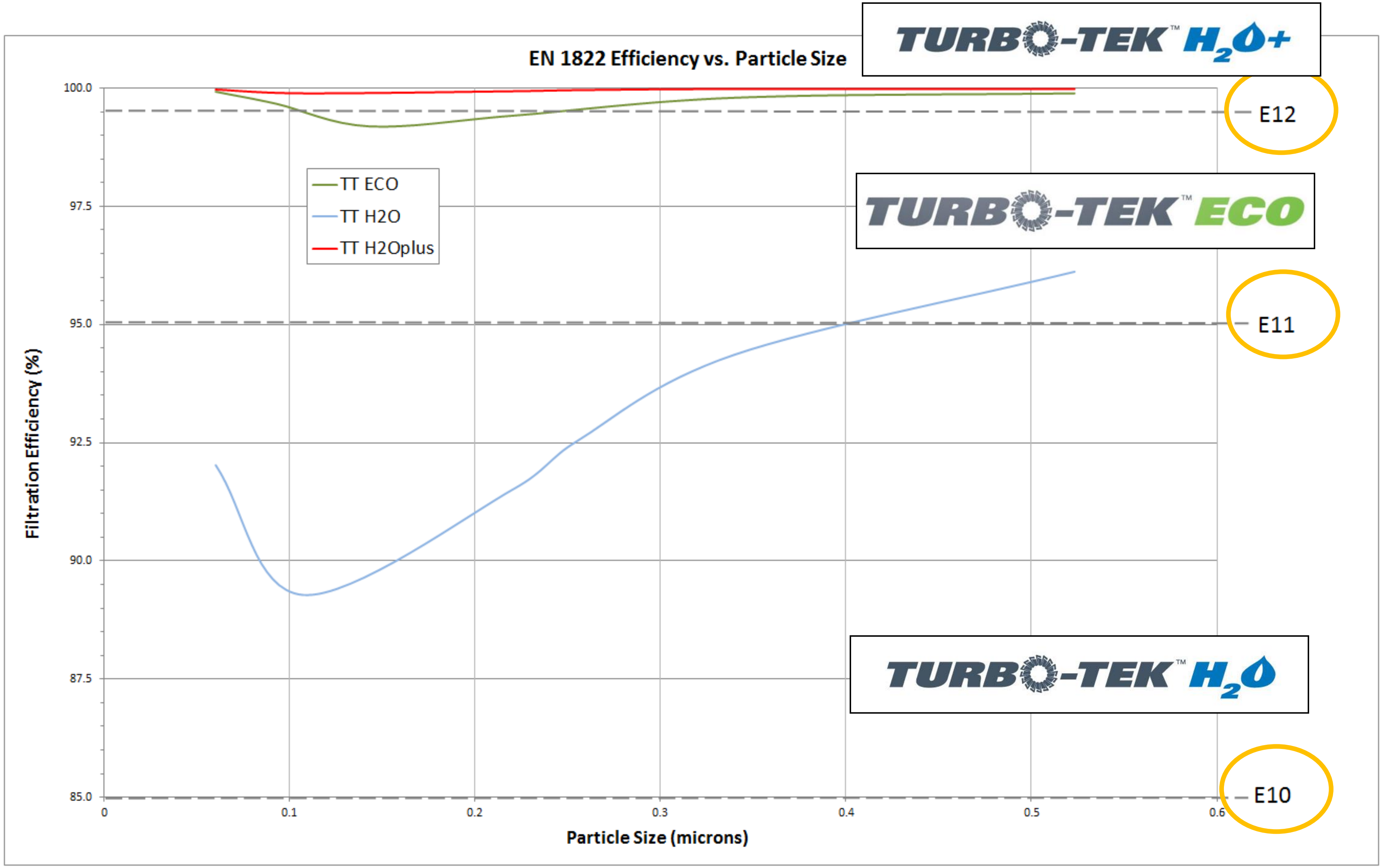


TURBO-TEK™ H_2O+

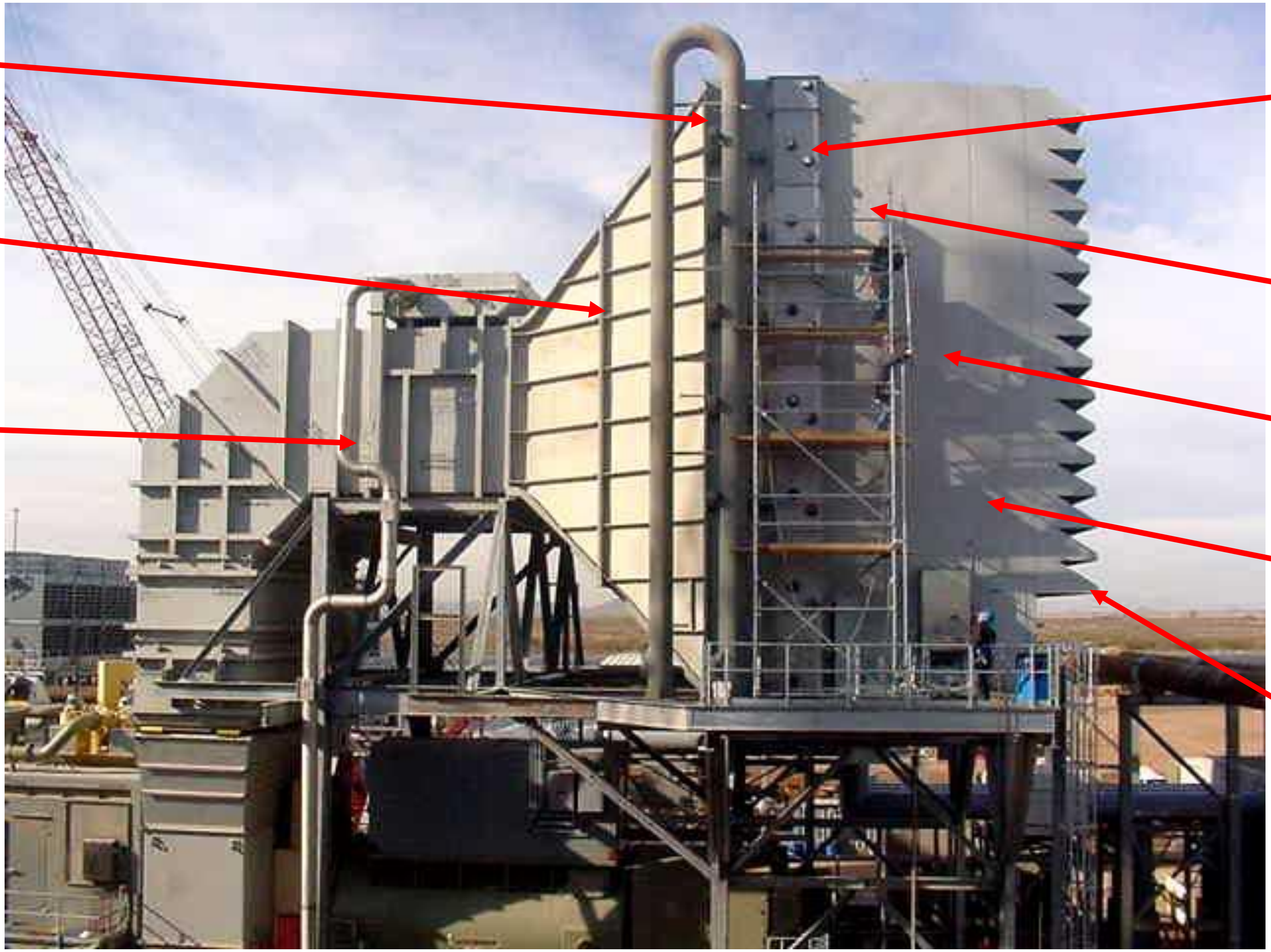
Media Configuration



TURBO-TEK™ Summary



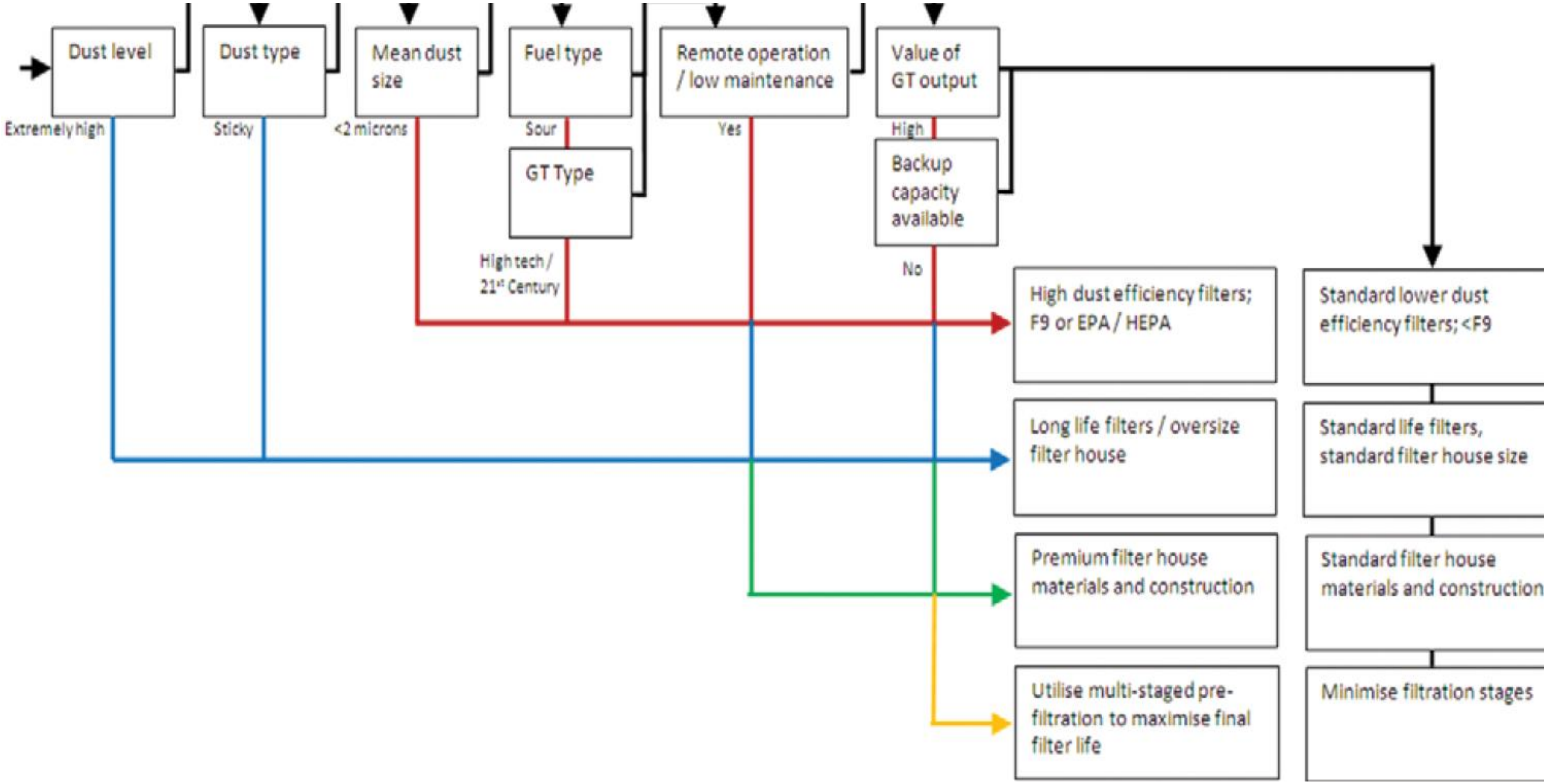
Inlet Air Cooling



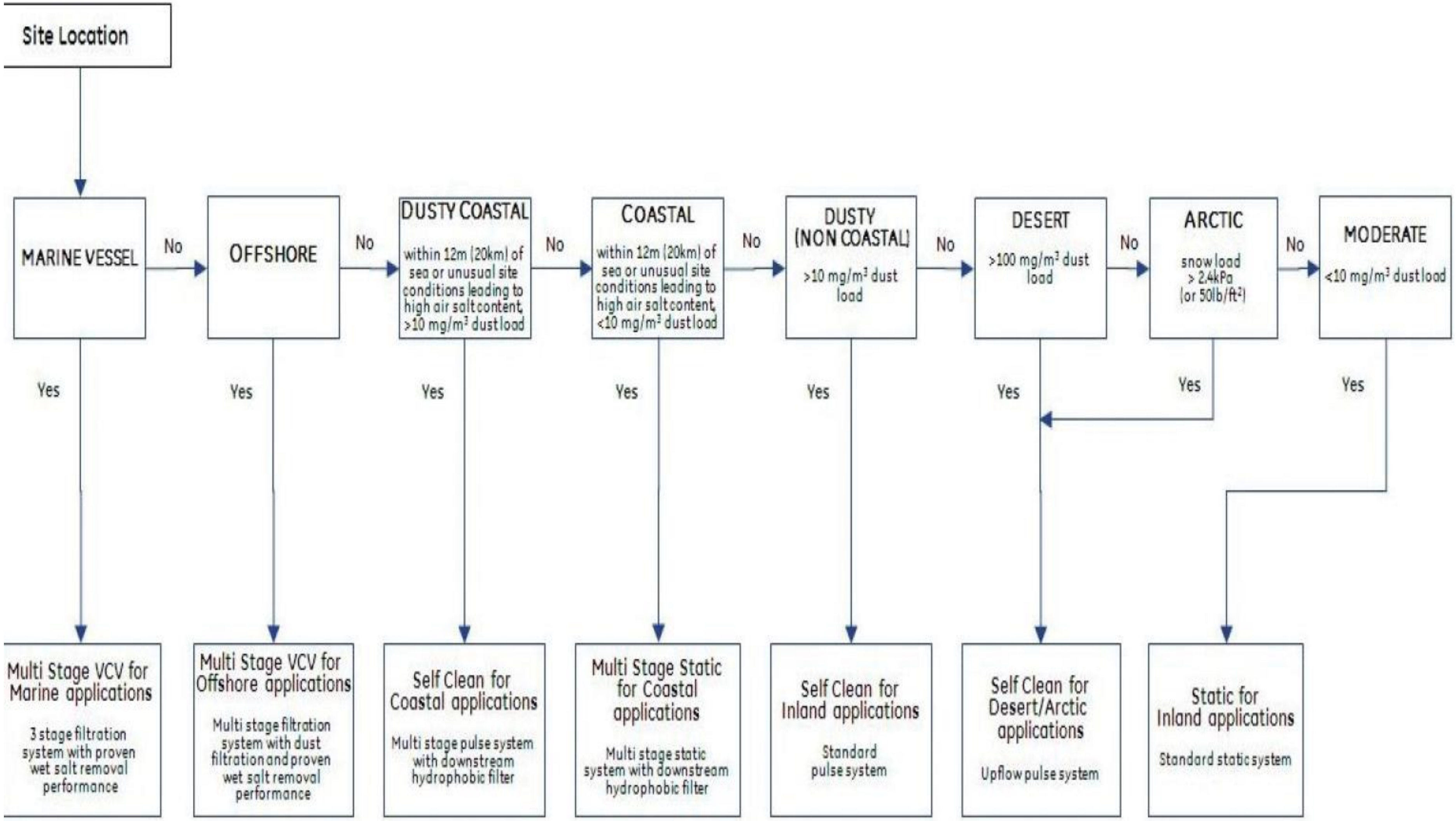
Inlet Treatment

- Remove moisture (fog, mist, rain, snow)
- Exclude birds and insects
- Attenuate noise

Filter Recommendations
Based on Operating Conditions (GE)



Filter Recommendations Depending on Environment (GE)



Selection Criteria
for Intake Systems (GEA)

Dust concentration
Low
< 0.2 mg/m³

- **Climate**: **Dry** < 80% rel. humidity
- **Climate**: **Wet** > 80% rel. humidity

Dust concentration
High
> 0.2 mg/m³

- **Climate**: **Dry** < 80% rel. humidity — Sandstorms are possible
- **Climate**: **Wet** > 80% rel. humidity

Customised systems

Configuration 1
Weather protection
Pre-filter
Fine filter
Anti-icing if required
Or, as alternative
Pre-filter
Depth filter cartridge

Configuration 2
Droplet separator
Pre-filter
Fine filter
Anti-icing if required
Or, as alternative
Pre-filter
Depth filter cartridge

Configuration 3
Pulse filter
Fine filter if required

Configuration 4
Pulse filter
Or, as alternative
Configuration 1

Configuration 5
Inertial separator
Coalescer, if required
Pre-filter
Fine filter
Or, as alternative
Configuration 2

Standard systems

System A
Duct air filter
MultiMaster Vario
Weather protection
Pre-filter
Fine filter
Anti-icing if required

System B
Air-duct filter
MultiMaster Vario
Droplet separator
Pre-filter
Fine filter
Anti-icing if required

System C
Pulse filter
PowerTower
Or, as alternative
System D

System D
Rotary oil bath filter
RotaClean
Fine filter, if required
Or, as alternative (equipped with sand filters)
System A

System E
Rotary oil bath filter
RotaClean
Droplet separator
Fine filter, if required
Or, as alternative
System B

Decision Route – Filter Choices

Webinars

Date	Recording Title
February 5, 2015	**Gas Turbine Regulatory Drivers** 120 minutes
May 15, 2014	**Gas Intake Filters: HEPA or Medium Efficiency** 101 minutes

InterWebViews™ (Free)

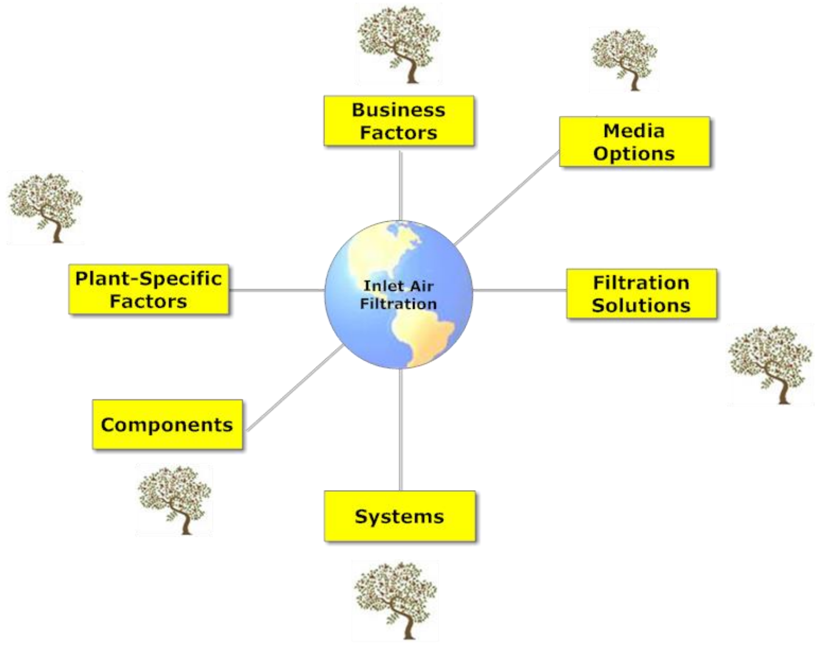
Date	Topic

Search Category	Key Words
By Product	Air Filter Air Inlet House
By Company	AAF, Ahlstrom, Clarcor, Donaldson, Freudenberg, Hollingsworth & Vose, GE, GEA, Gore, Midwesco, Nederman
By Topic	Efficiency Humidity Moisture

Components

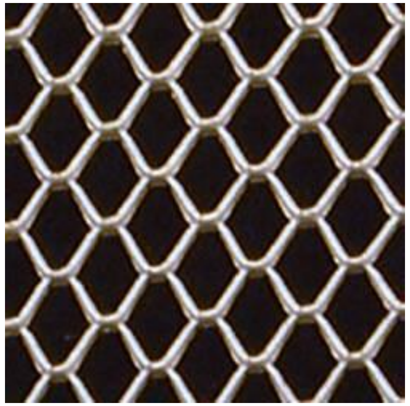
- Support mesh
- adhesives

Inlet Air Filtration
Decision Guide
(Orchard route map)
Click on Cells for Information



Variety of materials and mesh sizes can be use to support the media

- Dexmet polygrid and microgrid products can be used in several gas turbine filter applications including
- Internal Core Material: Media Support & Backing
- Primary Filtration
- Pre-Filters
- There is a range of metals and high temperature as well as low temperature plastics available. Pore size can be varied from 25 microns upward. Dexmet is an exhibitor at AFS and wants to explore the expanded use of their materials in the tough offshore, artic an desert environments for the filters. Also they want to match their pore capabilities to the industry needs as it switches to the EPA from the medium efficiency filters



Adhesives

- Site testing has shown that ensuring efficiency under humid conditions was more challenging than under dry conditions, highlighting the importance of water tightness in a filter to prevent any by-pass. Factors influencing water tightness includes the design around the sealing of the media pack within the filter, and, on static filters, how many sides are glued.
- MULTIPLE APPLICATIONS OF GLUE
- The latest generation of filters has been moving towards double sealing design where there are multiple applications of glue. Drainage is also critical for water tightness, and features such as vertical pleating and water drains in the frame help by avoiding any water accumulation. If drainage is not achieved quickly enough, the accumulated water will build pressure drop to a point where water will be forced through the media no matter what its efficiency is. It is also important when looking at vertical pleats to ensure that the glue beads are open enough not to reduce the drainage effectiveness.
-

- Henkel- Dan Oberle will be giving a speech Wednesday on adhesives
- Franklin Adhesives will be an exhibitor