

# **Overview of Filtration Media Classes, Their Properties, and Applications in Which They Excel**

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Next Generation Filter Media Conference  
American Filtration and Separations Society  
October 15, 2014

## What is a nonwoven?

Sheet or web of fibers interlocked by mechanical (friction/entanglement) or chemical (adhesion) means

Fibers may be natural or man-made but cannot include paper, fibers formed into yarns, or woven, knitted, or tufted fibers.

Fibers may be stapled, continuous, or formed in situ

## Raw Material Groups used in Nonwoven Filter Media

Type	Raw Material
Natural/Bio Fibers	Cellulose, jute, wood pulp, cotton
Synthetic Polymers	Polyesters, polypropylene, polyethylene, polyamides, polyimides, acrylics
Inorganic Fibers	Glass, metals

# Classification of Nonwovens

- By forming process...
  - Dry formed
    - Airlaid
    - Drylaid
    - Melt spun
      - Spunbond
      - Meltblown
      - Nanofiber web spinning
  - Wetlaid
  - Composite structures
  - Membranes

# Nonwovens Overview

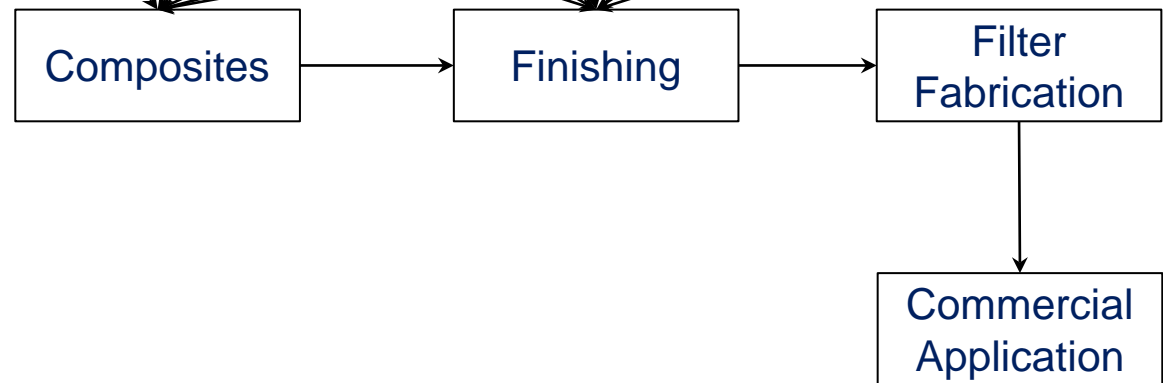
**Fiber  
Materials**



**Forming**



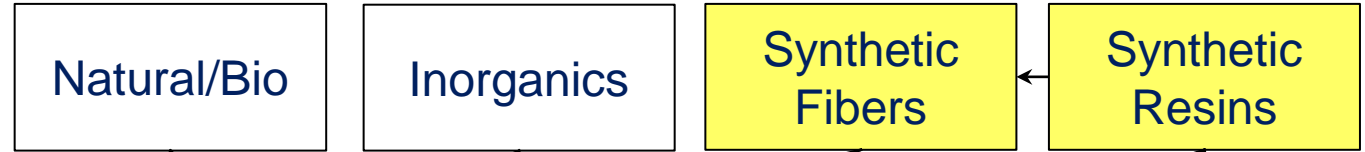
**Product  
Formation**



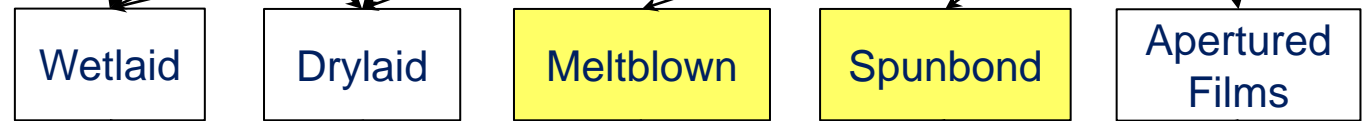
# Synthetics

# Nonwovens Overview

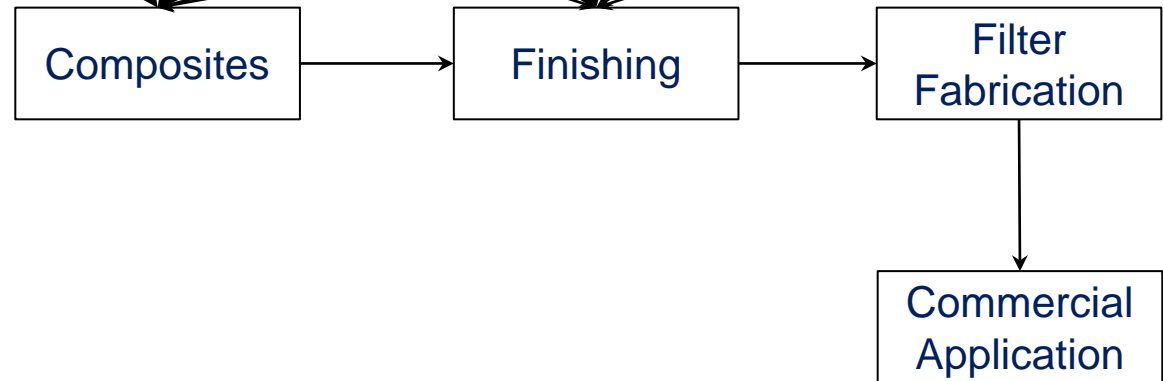
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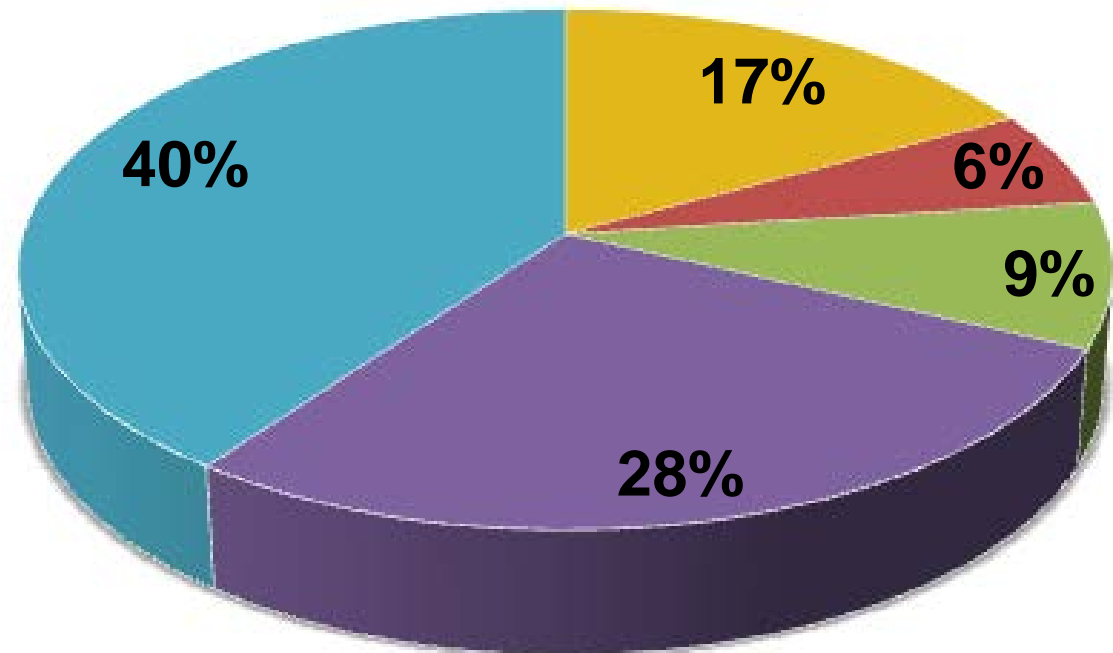


Media comprised of polymeric fibers and/or strands

## Forming Techniques

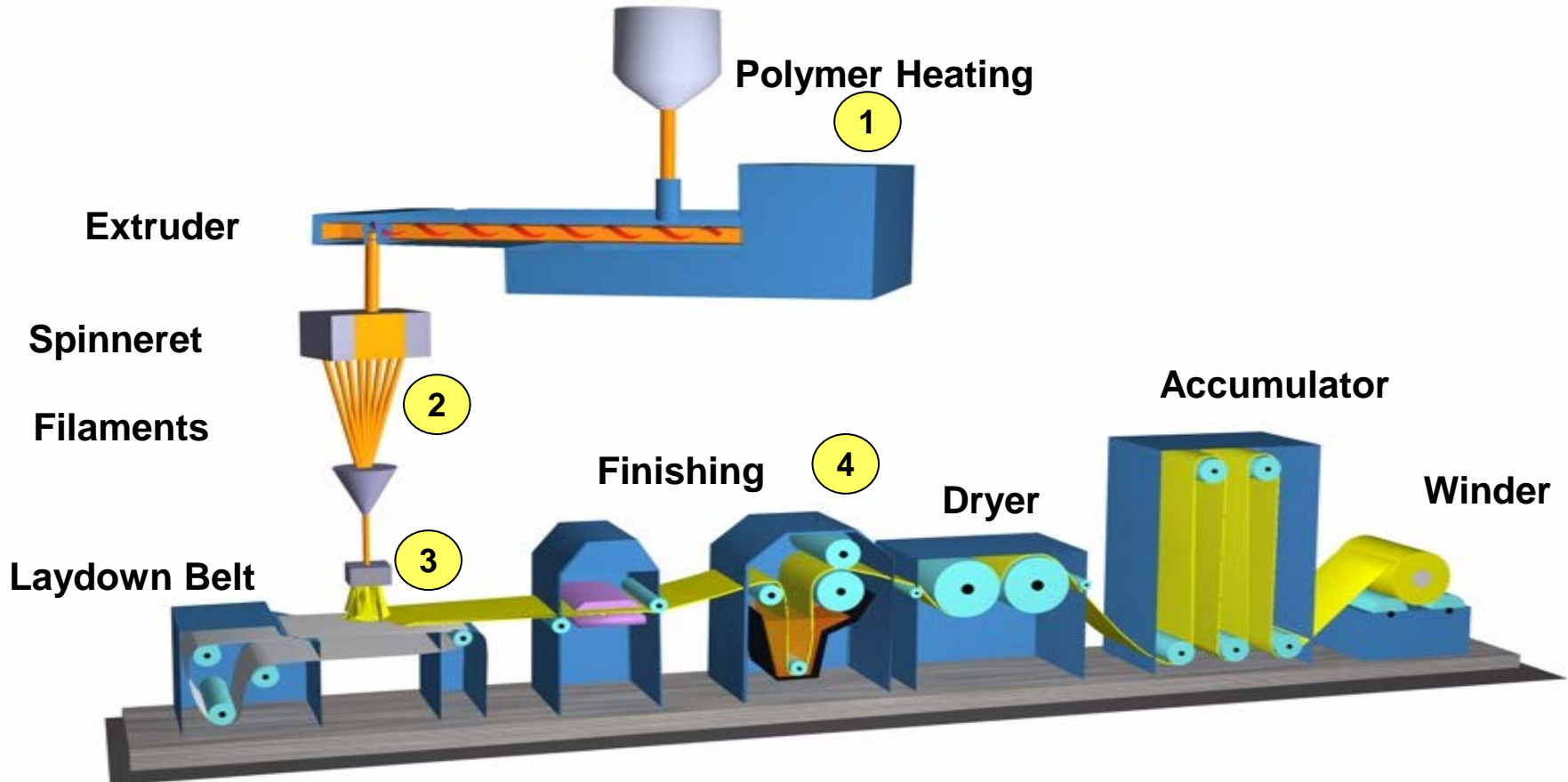
- Spunbond
- Meltblown
- Apertured films
- Airlaid
- Wetlaid

## Global Nonwoven Filter Market



# Meltblown, Spunbond – Process

- 1) Hot polymer resin extruded through die
- 2) Fibers are attenuated with forced air
- 3) Cooled fibers collected on laydown belt
- 4) Optional bonding and finishing steps





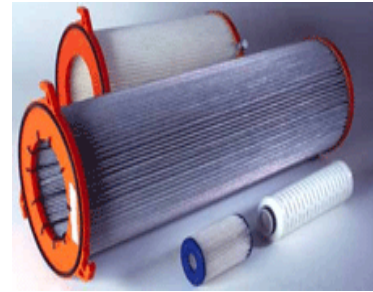
# Meltblown vs. Spunbond

	Meltblown	Spunbond
<b>Developed</b>	1950s	
<b>Opacity</b>	Opaque	
<b>Color</b>	Typically white, can be colored	
<b>Finishing</b>	Calendar, laminating, point bonding	
<b>Pleatable (Y/N)</b>	Yes, when heavy enough	
<b>Basis weight avg.</b>	20 - 200 gsm	10 - 200 gsm
<b>Basis weight range</b>	8 - 350 gsm	5 - 800 gsm
<b>Fiber diameter avg.</b>	2 - 6 $\mu\text{m}$	15 - 35 $\mu\text{m}$
<b>Fiber diameter range</b>	0.5 - 15 $\mu\text{m}$	1 - 50 $\mu\text{m}$
<b>Fiber length</b>	Discontinuous	Continuous
<b>Fiber orientation</b>	Random	Random - somewhat aligned
<b>Fiber attenuation</b>	Strong air, at die exit	Less air, away from die
<b>Typical polymers</b>	PP, PE, PBT, etc.	PP, PET, PBT
<b>Economics</b>	Less capital	Faster, cheaper production
<b>Binders</b>	Self-bonding, binders optional	Chemical binders, needling
<b>Media properties</b>	Soft	High strength : weight

# Applications Suited for Synthetics

## Filtration

- Depth filtration and surface exclusion
- Suitable for air or liquid filtration
- Better suited to liquid filtration than glass
- Support layers for other filters



## Textiles/Medical Uses

- Hygiene/sanitary products
- Diapers, masks



## Other Uses

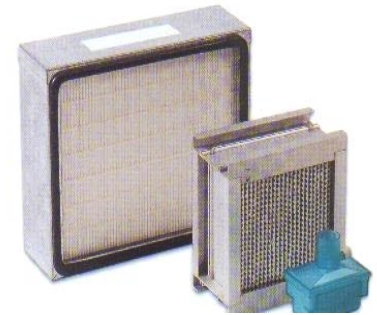
- Geotextiles (erosion control, reinforcement)
- Absorbents
- Packaging



# When to Choose Synthetics?

- **Economics**

- + Bulk polymers are relatively inexpensive
- + Less energy to melt and process than glass
- Fine diameter fibers are costly



- **Application performance (properties)**

- + Variety of polymers and properties
- + Multi-component fibers
- High temperature limitations
- Polymer degradation (oxidation, UV, chemical)



- **Manufacturing/handling**

- + Easier startup and changeover
- + Varied filter dimensions and orientations
- Fine fibers: low throughput and poor distribution
- Media can carry residual charge – particularly meltblown



# Synthetics - Market

- Total nonwoven filtration market: \$3.5B in 2012
- Growth rates<sup>1</sup> [5 yr CAGR (%) 2013-2018]
  - Nonwoven filter media demand: 9.8%
  - Filter demand: 7.1%
- Nonwoven filters growing at 7-10% depending on platform through 2018<sup>2</sup>

## Nonwoven Filter Market Shares

Market Application	Market Share (%)
Transportation	22
Water filtration	20
HVAC	14
Food & beverage	12
Healthcare	11
Manufacturing	10
Advanced technology	6
Hydrocarbon processing	5

## Nonwoven Filter Global Market

	2005	2010	2012	2013	2018	5 yr CAGR (%) 2013-2018
Sales, \$ Million	2118	2739	3499	3745	5319	7.3

<sup>1</sup>Freedonia – Industry Study: Filters 2011-2015 – Nov. 2011

<sup>2</sup>BCC Research – Nonwoven Filter Media: Technologies and Global Markets – May 2013

# Synthetics - Improvements

- Composite media – benefits of multiple media types
- New and expanded polymer chemistries
  - Unique filtration and chemical properties
  - Sustainable fiber sourcing
  - Biodegradable and disposable media
- New and expanded additives
- Narrow fiber diameter distribution
- New post-process treatment and finishing
- Improved nanofiber production – faster, cheaper, more consistent on larger scale
- Improvements in pressure drop, capacity, durability, longevity

# Synthetics - Areas of Growth

- Expand/new products in food/beverage and bio/pharma
- Replace cellulose in numerous filters
- Bridge to membranes (efficiency of membranes for less cost)
- New technology - nanofibers
- Clean air/water (regulatory requirements, public awareness)

## Filtration Classes and Suitable Media

<b>Filtration Technology</b>	<b>Particle Size Removed</b>	<b>Best-suited Media</b>
Coarse Screening	> 2000	Mechanical Sieves
Coarse Filtration	70 - 2000	Nonwovens
Fine Filtration	.1 - 70	Nonwovens
Microfiltration	0.1 - 1	Nonwovens, Membranes
Ultrafiltration	0.005 - 0.1	Membranes
Nanofiltration	0.001 - 0.005	Membranes
Reverse Osmosis	~0.001	Membranes

**Glass**

# Nonwovens Overview

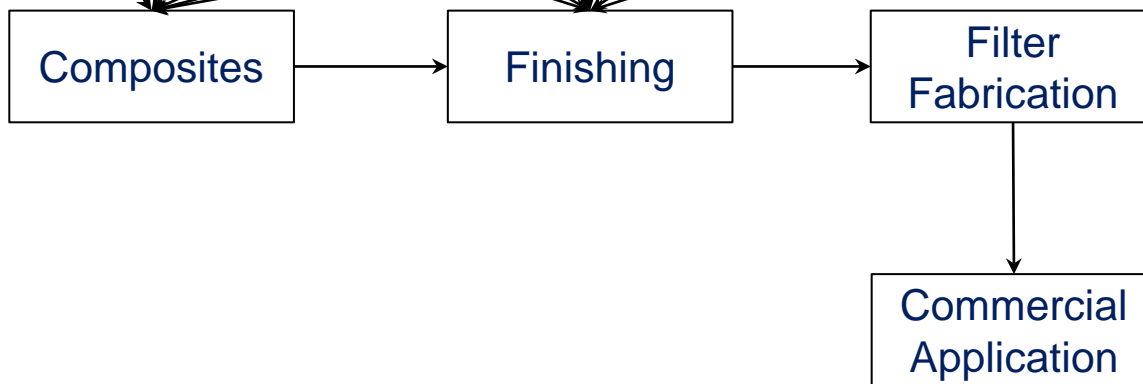
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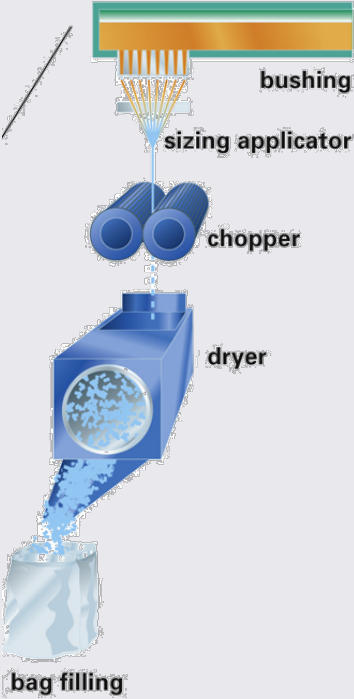
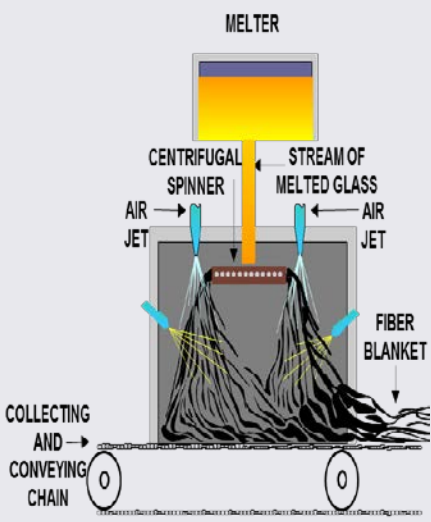
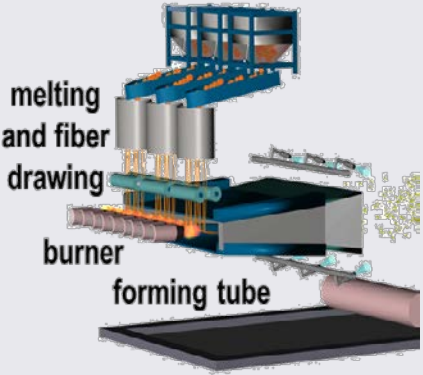
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# Glass Fibers in Nonwovens

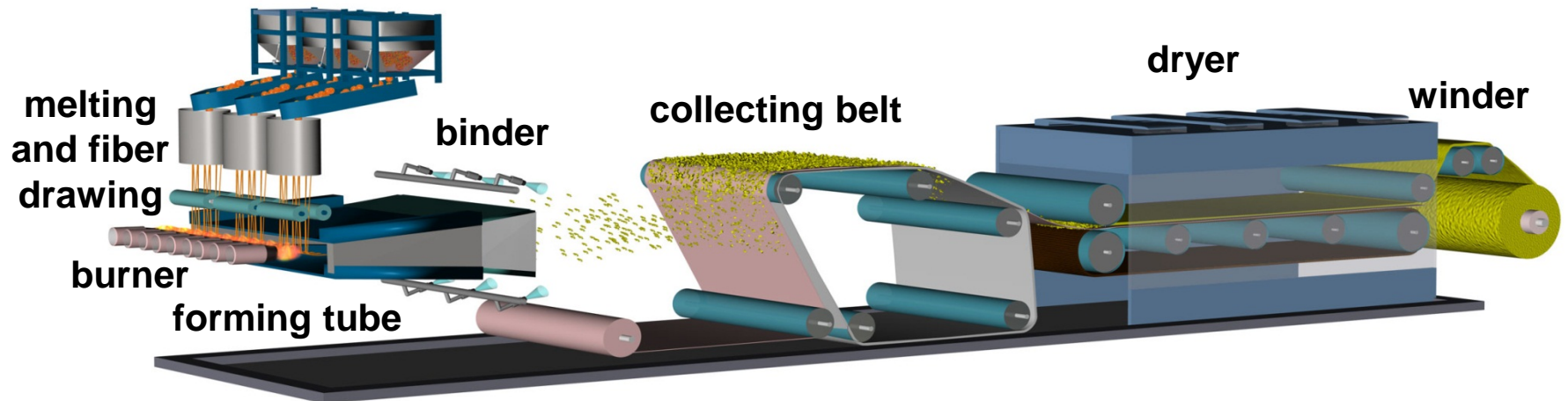
- Method of manufacture
  - Continuous draw fiberization
    - Melt pulled through a myriad of holes in a noble metal (non-reactive) bushing and stretched to the desired diameter, cut/chopped to length
  - Centrifugal (rotary) spinning
    - Two-step attenuation
      - Initial formation of a primary melt stream from holes in the sidewalls of a spinning disc
      - Fragmentation of melt stream in an air or hot gas jet
  - Flame attenuation
    - Two-step attenuation
      - Secondary fragmentation of a primary melt stream through use of high velocity/high temp gas jets

# Glass Fibers in Nonwovens

	Continuous Draw	Rotary Spinning	Flame Attenuation
<b>Mean Fiber Diameter</b>	3 $\mu\text{m}$ to 25 $\mu\text{m}$ (8 to 16 $\mu\text{m}$ most common)	2 $\mu\text{m}$ to 8 $\mu\text{m}$	0.1 $\mu\text{m}$ to 5 $\mu\text{m}$
<b>Fiber Diameter Distribution</b>	Narrower, normal distribution	Broader, positive skew	Broader, positive skew
<b>Fiber length</b>	Continuous, cut to length	Discontinuous	Discontinuous
<b>Process Diagram</b>	 <p>The diagram illustrates the continuous draw process. It starts with a <b>bushing</b> where glass is drawn into fibers. These fibers pass through a <b>sizing applicator</b>, then a <b>chopper</b> (two rollers), a <b>dryer</b> (a box with a circular opening), and finally to <b>bag filling</b>.</p>	 <p>The diagram shows the rotary spinning process. A <b>MELTER</b> provides a <b>STREAM OF MELTED GLASS</b> to a <b>CENTRIFUGAL SPINNER</b>. <b>AIR JET</b>s are applied to the spinner. The resulting fibers form a <b>FIBER BLANKET</b> which is collected by a <b>COLLECTING AND CONVEYING CHAIN</b>.</p>	 <p>The diagram depicts the flame attenuation process. It involves <b>melting and fiber drawing</b>, a <b>burner</b>, and a <b>forming tube</b> to produce a nonwoven mat.</p>

# Air Laid Glass Nonwoven (Rolled Goods)

- Flame attenuated, bonded/unbonded blanket (rolled goods)
- Filtration applications
  - Air filtration (HVAC – ASHRAE grades)
  - Liquid filtration (coalescence/mist elimination)



## Bulk Glass Fibers for Wetlaid Nonwovens

- Continuous draw, rotary spinning, and flame attenuation techniques employed for manufacture of bulk glass fibers
- Manufactured into a nonwoven through a wet laid process
- Filtration applications
  - Air filtration (HVAC: ASHRAE, HEPA/ULPA)
  - Liquid filtration (automotive; hydraulic; laboratory)



# When to Choose Glass?

- **Economics**
  - + Very small fiber diameters achievable at lower cost and higher throughput, relative to polymers
  - Energy intensive production (melt glass)
- **Application performance (properties)**
  - + High temp/chemical resistance
  - Fibers are not self-contained – restraint (binder/backing) may be needed to prevent fiber shedding
- **Manufacturing/handling**
  - + Raw material and finished product storage not as sensitive (UV, oxidation, etc)
  - Labelling/REACH registration of respirable fibers

## Opportunities/Future for Glass Fibers

- Glass chemistry development (biosolubility)
- Fiber surface properties
- More controlled/tighter fiber dimension distribution
- Optimized aspect ratios (diameter/length) for strength and filtration performance

# Review/Conclusion

- Both glass and synthetic polymers are proven materials for a range of filtration applications
- Many factors to consider when selecting a filter material
  - Basis weight, permeability
  - Structural/surface (thickness, density, porosity)
  - Strength (tensile, tear, burst, stiffness)
  - Moisture-related properties (repellency, resistance)
  - Filtration performance
  - Processability