

Primer on Nonwoven Fabric Filtration Media

by

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Description:

There are various definitions for nonwoven fabrics. However, in filtration, nonwoven fabrics can be generally described as a random fibrous web, formed by either mechanical, wet or air laid means and having interconnecting open area throughout the cross-section and able to remove a percentage of particulate from liquid or gaseous fluids streams flowing through it.

Typically, nonwoven fabric manufacturers supply filtration media having from 1 to 500 micron mean flow pore (MFP) ratings. Below 10-15 micron, the fabrics must be calendered in order to achieve the finer micron ratings. The exception being certain wet laid glass fabrics. Micron ratings depend significantly on the test procedure by which the manufacturer rates the media and whether the rating is liquid or air. Because ratings vary widely from one manufacturer to another, users must be extra careful when comparing media from one supplier to that of another. Huge variations can and usually do exist. Therefore, it is particularly important to ask the nonwoven manufacturer for a copy of the test procedure used to rate their media. In addition to the micron pore rating, there are a number of other considerations including dirt holding capacity, flow rates and differential pressure data to name a few.

The market for nonwoven fabrics for filtration media on a worldwide basis is approximately \$2 billion. The distribution is roughly in thirds across the major territories of North America, Europe and Asia. Of the largest volume uses, needlefelt fabrics for baghouse filtration represent the heaviest weight and most costly, whereas spunbonded fabrics, especially from polypropylene polymer for use in coolant filtration used in automotive and aircraft machining are the lowest weight and least expensive.

History:

Nonwoven filtration media has existed for hundreds of years in one form or another, including wool felt and cellulose formed by various means into a web. However, the modern advent of synthetic nonwoven filter media began with, of all things, disposable diaper cover stock in the 1950's and 60's. Manufacturers sold cover stock as an outlet for their over-runs, as an alternative to paper for such applications as coolant and water filtration. Other processes such as wet laid and needlefelt soon created a number of opportunities for the use of nonwovens...opportunities, often at the expense of paper, woven fabrics and sometimes even wire cloth filtration media.

Material(s) of Construction:

Nonwoven fabrics have been manufactured, in multiple forms, from many grades of cellulose and most natural and synthetic fibers at one time or another. The most popular fibers used being polyester, polypropylene and glass. Following are acrylics, rayon, nylon, cotton, fluoropolymers and a host of others that fill niche applications because of their special material compatibility for particular applications. Most people associate glass fibers with air and synthetics with liquid filtration, but there are plenty of exceptions, especially with synthetics in the form of melt blown nonwoven fabrics that are increasing popular in air filtration. Nonwoven fabrics are usually constructed from one of two basic methods. One procedure is to use discrete fibers from ¼ to 3 inches long. After certain preparatory steps, the fibers can be air-laid, wet laid, entangled or bonded by mechanical, chemical or heat fusing into a web. The second most common method is the uses of a direct polymer melt process, where fibers are created in a spinning operation and immediately cast on a moving belt forming a continuous web. Fiber diameter, regardless of the nonwoven process, are controllable and measured in microns or by the traditional textile term; denier. Denier is expressed as the weight in grams of single fiber having a length of 9,000 meters. For staple synthetic fibers, 1-2 denier is “generally” the finest synthetic fiber available, although new technology now coming to market will permit sub-micron diameter fibers. Direct melt processes allow for fibers are now as fine as 0.1 denier or approximately 1 micron in diameter. Glass fibers have been available for many years below 1 micron in diameter and are commonly utilized in HEPA and ULPA gas filtration. Most synthetic fibers sell in a price range from \$0.60 to \$1.50 per pound with micro fiberglass over \$3.00 a pound. High performance staple fibers requiring strength, high-temperature or extreme chemical resistance typically ranges from \$8 and sometimes to \$70 a pound, but these are rare exceptions.

Media Forms:

It is always a debate, whether wet laid synthetic fibers for filtration are considered to be a paper or nonwoven fabric. There is no doubt that wet-laid synthetics are very popular, especially when a thinner web and consistent pore size is important. Other popular nonwoven fabric forms include spunbonded which is relatively strong with modest dirt holding capacity, but lacks the consistent pore size distribution of wet-laid and meltblown webs. Spunbond fabrics serve in applications, which include coolant filtration media and pleat support and drain layers in membrane and melt blown fabric cartridges. Needlefelt fabrics are common when strength and durability are necessary such as in baghouse applications. Air-laid and air bonding are popular because of its high-loft, bulk and large dirt holding capability in air filtration, including prefilters capable of capturing larger particles. These fabrics typically have high void volumes. Melt blown nonwoven fabric continues to be the rising star with rapid penetration into many liquid and air filtration applications. Melt blown technology allows for fibers in the 1-10 micron diameter size range and bulkiness for excellent dirt holding capacity. For low micron rated media, melt blown fabrics are calendered to a rating as low as 1 micron mean flow pore. Melt blown nonwovens are relatively low cost and have had an enormous impact in our industry in the last 10 years. Melt blown fabrics are used in prefiltration and as final filters in applications where high-performance in fine filtration is required. Resin bonded nonwovens are popular in air filtration and point-bonded fabrics provide an alternative to overall bonded fabrics which commonly are used to fibers consisting dissimilar melt or softening points. Typically, the vast majority of nonwoven fabrics

sell anywhere from under \$0.10 per square yard for 0.5 ounce spunbonded polypropylene to \$1.50 per square yard for 16 ounce polyester needlefelted fabric. Melt blown fabrics for filtration range widely due to the many constructions materials of construction and post-calendering processes. Special polymers and fibers create nonwoven fabrics which sell from \$5 to over \$100 per square yard. Surprisingly, the market for these performance nonwovens is larger than most people realize, but requires manufacturers willing and capable of making relatively short runs.

Special Characteristics:

Nonwoven fabrics filtration characteristics and capabilities vary widely depending upon the form and construction of the nonwoven filter media itself. Wide pore size distribution of nonwoven fabrics can be both an asset and limit use to prefiltration or non-precision filtration. However, special manufacturing or post-processing such as calendering can sometimes overcome this. One interesting fact, that few in the filtration industry realize, is that these specialty processed nonwovens do not have a much wider pore size distribution than microporous membranes which are rated above 1 micron. In the 1 to 20 micron mean flow pore range, the cost of nonwovens are much less than membranes and the dirt holding capacity is generally far superior. However, their flow rate suffers due to lower void volume than membranes. All of which reinforces the fact that filter design engineers make their media selections based on performance trade-offs. Nonwoven fabrics have thicker cross-sections and bulk compared to membranes, wire cloth and monofilament fabrics. Thus, nonwovens fabrics are the material of choice when large quantities of particulate loading, long-life or where general clarification of a liquid or gas stream is required. Nonwoven fabrics are relatively inexpensive compared to most other media. Only filter aids have lower cost per pound, but generally do not compete in the same applications as nonwoven fabrics.

Manufacturing Methods:

Nonwoven fabrics are formed, using one of several inexpensive manufacturing methods, sustained by low raw material costs, high-speed processing and few manufacturing steps. There are two basic process methods to manufacture nonwoven fabrics. The first is direct melt, where polymer chip is loaded into process equipment; fiber is extruded while simultaneously forming a porous web. This is usually the least expensive method, because webs are formed in single-step from polymer to roll stock. Typical constructions are spunbond and melt blown fabrics. There are other desirable constructions, with special characteristics, which cannot be made in a single step. Such nonwoven forms include air laid, wet-laid needlefelt, spunlaced and resin bonded. These fabrics require a pre-formed fiber, often referred to as either staple or staple carded fiber. Staple fiber is typically carded and formed into a web. Subsequent in-line processes then needle, spunlace, chemically or thermally bond or post-dry the fabric, as is the case for wet-laid. Although these multiple-steps add cost, they yield special product characteristics and attributes not currently achievable in the direct melt nonwoven fabrics.

Filter Configurations and Function:

Filters, made from nonwoven fabrics, are extremely wide in their configuration and applications. Perhaps, the simplest application of nonwoven media is found in coolant filtration. One popular method is to unroll and index nonwoven media over a tank and flow coolant containing metal chip and grindings through the media. Other common filtration configurations for nonwovens include cut & sewn bags which are attached to pipe outlets used as strainers for milk, paint and chemical products. Needlefelted sewn bags are fitted with metal or plastic rings at the open end, which seal into housings for liquid filtration and long bags that hang in baghouses, which are flexed, or backpulsed to remove large volumes of particulate in air filtration. Other times pleated filter cartridge manufacturing processes use nonwoven fabrics involving spun or point bonded and wet-laid fabrics that serve as drain layers and media separators in cartridges or as a membrane supports. Melt blown and wet-laid media are frequently used in these cartridges as the main filter media. Overall spun bonded fabrics are common as the main medium in pool and spa filters providing a septum for diatomaceous earth. High-loft media has bulk and traditional for air filtration. These structures rely on and are effective, largely because they're thickness and an open structure. Thicker media allows for longer residence time for the capture of particulate across a wide size range within the random size voids. Special fabric post-treatments, such as corona-discharge and the co-mingling of select fibers can yield constructions having electret properties or triboelectric potential which will improve air filtration efficiencies and/or permit greater air flow at lower differential pressure depending upon the construction.

Market/Applications:

Filtration markets for nonwoven fabrics are especially broad. The largest single market for nonwovens, in both pounds and dollars, is baghouse filtration with needlefelted fabrics being the media of choice. Needlefelted fabrics also serve as a base substrate for a microporous membrane or porous coating in this application. Similar needlefelted fabric constructions are found in liquid filter bags in paint, chemical and general industrial applications. Melt blown fabrics are increasingly popular in air filtration for use in vacuum cleaner bags to HVAC and other applications requiring high-efficiency. Meltblowns are also widely used in pleated liquid cartridges as prefilters or as final filters in many high-performance applications from pharmaceutical to the semiconductor industries. Membrane cartridge suppliers were the first to exploit the use of melt blown fabrics in the 1970's and early 1980's and the market continues to expand. Spunbonded fabrics are perhaps the most versatile, with filtration applications including coolant, cartridge pleat and membrane support, downstream layers to retard media migration for both air and liquid, tie-on bags, pool and spa filters and much more. These fabrics supply strength, reasonable dirt holding capacity and in certain cases stiffness and lateral flux. Overall bonded fabrics consist of two or more dissimilar or contracting fibers which bond forming a "bi-component" fabric and an especially stable web and minimal downstream fiber release; an important benefit when foreign contaminate in the filtrate is unacceptable. Many forms of nonwoven of both glass fabric and batting are used in air and liquid filtration including cartridges. Binder materials are often used to maintain fabric structure integrity and prevent fibers release downstream.

Advantages:

There is no question that there are many advantages of nonwoven fabrics, including their versatility, low cost and diverse functionality. The price-performance ratio is outstanding. Nonwoven fabrics are made from standard and many specialty inorganic and organic fibers including common wood pulp, cotton or rayon. Surprisingly, the growing use of soft, highly flexible, fine diameter and non-kinking stainless steel, nickel and titanium metal fibers now permits the use of needlefelted, air and wet-laid nonwoven fabrics which have extraordinary temperature, chemical and wide pH properties. The choices are almost endless. Fine glass fibers are traditional in air filtration from HVAC to HEPA filters. Resin bonded glass fiber liquid filter cartridges also provide many excellent properties. Another advantage of nonwovens is the wide number of diverse processes fibers can be incorporated including needlefelt, air and wet laid, resin bonded et.al. In addition to media from discrete fibers, it is possible to simultaneously melt-spin a polymer fiber while forming a web construction without an intermediate fiber-forming step. One-step processes typically include melt blown, spunbond and certain high-loft webs as discussed earlier. The direct web manufacturing method offers a cost advantage and very popular. These direct web processes produce fine and sometimes continuous filaments and in case of spun bond, a strong and non-shedding web which can not be achieved by any other means for a comparable cost.

Disadvantages:

Nonwoven fabrics like most filtration media, have disadvantages compared to other media choices, such as polymeric membranes, woven fabrics, metal media etc. No single media can or will ever satisfy every filtration requirement. In the case of nonwoven fabrics, the disadvantages are not so much the shortcomings of nonwovens, but the advantages other media. For example, membranes provide narrow pore size distribution, particularly below 1 micron mean flow pore. Monofilament fabrics and wire cloth offer strength and straight through holes for use in sifting and excellent sieving capabilities. All three of these are surface filters, a feature not easily achieved for nonwoven fabrics, because of the nature of the manufacturing processes and resultant constructions; at least, not yet. Many filtration and separation applications require stiffness, minimal flex, and rigidity or even low stretch as is the case of dewatering belts, which by their nature are less favorable to the use of nonwovens. All, which proves, that even with the tremendous growth of nonwoven fabrics in filtration, there are many unmet market opportunities for nonwoven fabric manufacturers to further expand their business.

Market Penetration and Trends:

Nonwoven fabrics continue to grow and in some cases, take market share from other media. However, filtration industry mega-trends provide many challenges for nonwoven fabrics. These mega-trends include (1) environmental consciousness (2) finer filtration and (3) specialized media (4) one-world business. Environmental consciousness suggests that nonwoven media should be reusable, have extended-life, chemical or vapor capture capabilities, compostability and/or be recyclable. Nonwoven fabrics will keep pace with the need for finer filtration...and in some cases may even challenge microporous membranes in some applications as some companies are now beginning to claim efficiencies below one micron mean flow pore. Specialized filtration media is the key to nonwoven growth. As a result, the best years are ahead for nonwoven fabrics as both

suppliers and filter manufacturers continue to exploit untapped opportunities for specialized and performance nonwoven filtration media. Finally, filtration is a business where media, particularly specialized filtration media, often patented or from an unique process type is shipped worldwide.

There are probably more opportunities for filtration media improvements or modifications in nonwoven fabrics than any other media. Unfortunately, sales have been easy in the past and both marketing and R&D efforts specific to filtration have not been under-funded in favor of sales, which continue to grow, but at a slower pace and at lower price levels in recent years. For the innovative supplier or third parties with enabling technology, there are plenty of un-met needs, which could enhance value and re-invigorate profitability.

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