PROPERTY

COMMENTARY PAPER

Absorbing the facts: nonwoven materials and production plant risks

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Nonwoven products have become integral in a wide array of everyday applications — from hygiene and medical to industrial and consumer products. The global market for nonwovens is estimated to be more than $50 billion and continues to grow steadily, replacing traditional textiles in many areas. The growth in nonwovens stems from their unique properties and cost-effectiveness. Nonwovens are broadly defined as sheet or web structures made by bonding and/or interlocking fibers by mechanical, thermal, chemical or solvent means. Unlike traditional woven or knitted fabrics, nonwovens do not require conversion of fibers to yarn and are produced directly from the raw material.

Major nonwoven product categories include disposable hygiene products, wipes, medical products, filters, geotextiles and many other specialty applications.

Nonwoven geotextiles are modern wonder materials used behind the scenes in a wide array of construction applications ranging from small residential uses to heavy civil construction projects. These fabrics may not look "high-tech", but they provide critical functions. Geotextiles are usually made by weaving or pressing together synthetic fibers like polyester or polypropylene to form permeable, durable sheets. While we may not see them, geotextiles are hidden heroes in foundation drainage systems as well as large-scale projects like highways, landfills, dams and even coastal revetments. What do these fabrics do? They can separate, reinforce, filter, drain and control erosion — feats of engineering made possible through advanced material design. So next time you drive on a highway, see a dam, or hear your sump pump running, know that humble fabrics are hard at work keeping things in place and water where it should be. Geotextiles are the unsung fabric forces supporting impressive infrastructure.

Disposable diapers are the largest segment of the nonwoven market followed by feminine hygiene products, adult incontinence products and wipes. Nonwovens also have significant use in medical products such as surgical gowns, drapes, sterilization wraps, wound dressings and face masks. Industrial and specialty nonwovens are used for filters, insulation, battery separators, oil absorbents and packaging applications. The multitude of end uses for nonwovens is made possible by the diversity of materials, manufacturing processes and product characteristics that can be achieved.

To produce these wide-ranging nonwoven products, specialized manufacturing equipment and processes are used to form, bond and finish the webs. Major processes for web formation include spunbonding, meltblowing, spunlacing and airlaid. Bonding the fibers can be done through thermal, chemical or mechanical means. Finally, finishing steps enhance the properties and performance of the nonwovens for the end application. The most common finishing operations include printing, slitting, perforating, stretching, coating and packaging. While the basic manufacturing process sounds straightforward, producing quality nonwovens at high speeds and large volumes requires sophisticated engineering and equipment.

An overview of common nonwoven manufacturing methods and equipment will provide context on the scale and complexity of these production facilities. This commentary will examine the three main steps in detail: web formation, web bonding and finishing. The electrical and mechanical systems involved in each stage will also be discussed. In addition, the risk factors and potential vulnerabilities of nonwoven manufacturing facilities will be explored. Fires, equipment breakdowns, utility disruptions, weather events and human errors can all result in costly downtime and damages. Proper coverage is essential for nonwoven producers, so insurance considerations after a major loss will be addressed. With an understanding of the manufacturing processes, equipment and risks, insurers can be prepared to respond quickly and effectively if a claim arises.

Nonwovens production line that can manufacture feminine hygiene products, diapers, wet wipes, food pads and tabletop items among other products. Credit: Oerlikon Neumag Airlaid Technology

Nonwovens medical applications - disposable masks, gowns, and head covering. Credit: Nonwoven Industry

Nonwoven products and applications

Nonwovens have grown from a cottage industry in the 1950s to a key component of the global textiles market today. The largest segment is disposable hygiene products. For example, more than 20 billion disposable diapers are sold globally each year. These products all rely on nonwovens for their absorbent and fit properties. Polypropylene and polyester are common materials due to their wet strength, softness and processability. Spunbond and spunlace fabrics are frequently used in disposable diapers along with superabsorbent polymers for moisture management. Feminine hygiene pads and adult incontinence products have similar constructions but smaller sizes.

Wipes for personal care, household cleaning, industrial use and baby care are another major nonwovens segment. Spunlace, airlaid and wetlaid products are ideal wiping fabrics. Viscose and polyester are common wipe materials that provide strength when wet. Disinfecting wipes became ubiquitous during the COVID-19 pandemic, increasing demand significantly.

Healthcare and medical nonwovens include sterilization wrap, surgical drapes and gowns, wound dressings, face masks, and liners. Hydrophilic spunlace and composite nonwovens are manufactured with specialty fibers and treatments to achieve antimicrobial, absorbent and barrier properties. Orthopedic casts have also converted from plaster to synthetic nonwoven padding.

With this diverse variety of products, the global market for nonwovens in 2020 exceeded 50 billion square meters (19,305 square miles) of fabric produced, with a value over $40 billion (PK 3982 MarketsandMarkets 2020). The largest regional markets are China, North America, Western Europe and East Asia. Continued growth is expected across most categories as nonwovens displace wovens and knits. Their performance, cost-effectiveness, scalability and customizability will drive further adoption in hygiene, medical, construction, filtration and automotive applications.

Major manufacturing processes

While many different processes exist for manufacturing nonwovens, the most common web formation methods used at an industrial scale are spunbonding, meltblowing, spunlacing and airlaying. The desired fiber arrangement, bonding mechanism and final properties are what dictate which process is selected. These technologies have a relatively high capital cost due to the complex equipment, but they can produce high volumes of nonwovens in a continuous process with limited labor.

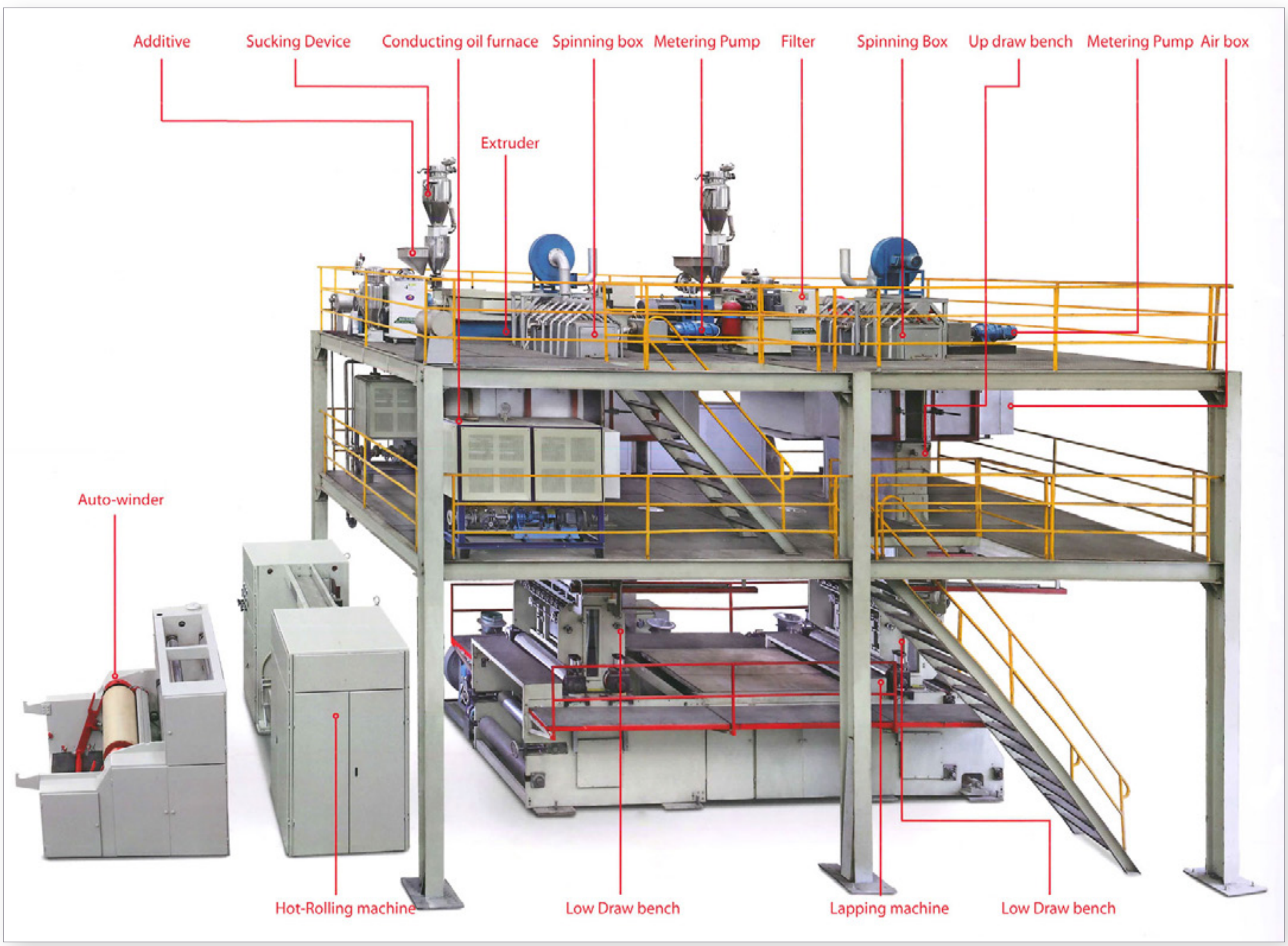
Spunbonding

Spunbond fabrics are made through an impressive manufacturing process, but result in simple, useful materials we use every day. The production starts by melting down plastic polymers into a liquid that is pumped through small holes to create continuous, flexible fibers. These fibers are quickly cooled and randomly laid onto a moving belt, forming a loose web of material. The web is then bonded together by heating it or punching it with needles, which fuses the fibers where they cross over each other. What emerges is a soft, breathable and durable fabric. Although the manufacturing process is complex, spunbond fabrics make up simple products we see in everyday places. They make great materials for baby diapers, surgical gowns, furniture linings and more. The reason is that their production method makes them strong yet gentle, absorbent and cost-effective.

Meltblowing

Meltblowing creates a special kind of fabric using incredibly fine fibers thinner than a strand of silk. The process starts the same as spunbonding. Plastic polymers are melted down and pushed through small holes to form fibers. But here, hot air blows the fibers onto a conveyor before they solidify, making them extremely fine and tangled together. This web of nanofibers is useful for advanced filters, absorbents and insulation. Regular fabrics have holes too large for small particles, but meltblown fibers are so tiny and tightly spaced that even microscopic contaminants get trapped. The result is an ultra-fine mesh that can filter anything from air pollutants to germs in medical masks.

Spunbond nonwovens machinery. Credit: Geotex Taiwan



Spunlace line. Credit: Andritz

Spunlacing

Spunlace fabrics use waterpower to turn loose fibers into top-notch materials. First, short staple fibers are carded into a fluffy web with the fibers going every which way. This web then gets blasted with strong jets of water that tangle up the fibers where they meet, creating bonds throughout the fabric. The high-pressure water jets essentially get the fibers to hold hands. No other bonding or weaving is needed, just the sheer force of water and entanglement of the fibers. This spunlacing method works with many different fibers, even sensitive ones. It gives the final fabric great softness, absorbency and wet strength perfect for items like medical gauze, wipes, tea bags and other filters. Best of all, spunlace lines can whip out hundreds of meters per minute of finished fabric.

Airlaid

Airlaid fabrics sound technical but make everyday items ultra-absorbent. The production process starts by spraying loose, short fibers onto a moving porous belt or drum. The random fibers build up into a thick web with plenty of air pockets. Next, latex or heat-activated binders are added to fuse the fibers together where they meet, turning the fluffy web into fabric. Airlaid's direct fiber distribution creates uniform materials ideal for soaking up liquid. The resulting fabrics are prized for their softness and "dry" feel while being super absorbent. This makes them perfect for anything that needs to lock in moisture. Although airlaid production is slower and pricier than other methods, it results in higher-quality products.

Nonwoven manufacturing

While earlier generations of nonwovens equipment were mechanically driven, today's plants rely on sophisticated electronic controls and software to coordinate all machines and services. Programmable logic controllers (PLCs) act as master controllers, communicating with human-machine interfaces (HMIs), machine operating panels, distributed input/output (I/O) racks, instrumentation, and motors across the facility. PLC systems monitor sensor inputs, stored process parameters and setpoints to regulate variables like temperature, pressure, tension, flow rate and speed. Advanced software algorithms model, predict and optimize production.

Nonwovens production controls. Credit: Guangdong Yizhou Advanced Materials

Supervisory control and data acquisition (SCADA) software gathers data from the PLCs and HMIs to allow operators to control and visualize the entire production from desktop interfaces. Data collected by SCADA software helps identify opportunities for efficiency and quality improvements across all integrated lines. With its birds-eye view, SCADA software is essential for streamlining the complex manufacturing process.

Modern computer numerically controlled (CNC) components like drives, motors, hydraulics and servos allow precision control of critical operating parameters through closed-loop feedback. This automation allows nonwoven material producers to meet exact standards with minimal labor intensity and material waste. Extended data logging, traceability, diagnostics and preventive maintenance are all enhanced through the digital architecture.

Nonwovens winder. Credit: A.Celli Nonwovens

While this computer-controlled hardware offers major advantages, it also introduces cyber risks that must be managed. Network security, access controls, backups, anti-malware programs and timely patching are required. Equally important is training personnel on proper cyber hygiene.

Beyond the electronics, specialized mechanical systems handle the physical materials and provide services. Major components include:

- Polymer handling: dryers, hoppers, extruders, melt pumps, filters, spinneret packs.
- Web forming: beams, spinning machines, lay down belts and drums, calendars.
- Bonding: thermal bonding rolls, hydroentanglers, needling looms.
- Finishing: slitters, perforators, printing stations, coaters, laminators, winders.
- Utility systems: air compressors, vacuum systems, chilled water, boilers, wastewater treatment.
- Environmental systems: heating, ventilation, air conditioning, dust collection.
- Material handling: conveyors, balers, cranes, forklifts, automatic guided vehicles.
- Safety systems: cable and pipe trenches, safety guarding, fire detection and suppression.
- Warehousing: storage racks, pallet jacks, shrink wrap machines.

Proper installation, operation and maintenance of this equipment is challenging. Detailed mechanical, electrical, controls and software documentation must be maintained. Routine inspections, lubrication, adjustments, part replacements and overhauls are required. Personnel must be highly trained to run multiple jobs and material types. With integrated lines, a problem in one section can quickly cascade into downtime across many machines. Backups and redundancies in key systems are thus very beneficial.

While running such a synchronized manufacturing orchestra seems daunting, advanced industrial Internet of Things (IoT) automation makes it more achievable. Still, the complexity and hazards involved make nonwoven material facilities prone to disruptions, as will be discussed next.

Risk factors and vulnerabilities

Given the sheer scale, speeds, hazards and interconnectedness involved, nonwoven manufacturing carries inherent risks. Major categories of threats include fires, equipment failures, utility disruptions, adverse weather, cyber incidents and human errors.

Fires are a significant concern in production plants, as the accumulated fibers and dusts provide fuel while process heat and static electricity can provide an ignition source. Polymer residues and solvent vapors also create flammability hazards. Poor housekeeping or inadequate ventilation and dust collection aggravate these risks. Fires can result in property damage, inventory losses and expensive downtime. Proper design, maintenance and housekeeping are vital, along with extensive fire detection and suppression systems.

Mada Nonwovens plant. Credit: Nonwovens Industry

Equipment breakdowns are another common exposure, as the complex high-speed machinery suffers wear and tear. Failures in extruders, spinnerets, belts, calenders, coaters and slitters can all force unplanned downtime. This machinery often runs 24/7, accelerating wear. Lack of preventive maintenance or improperly scheduled maintenance during brief changeover windows also increases risks. Detailed monitoring, maintenance plans, spare parts inventories and redundancy for critical components reduce losses when the inevitable breakdowns occur.

Nonwoven materials production is heavily reliant on utilities including electricity, water, compressed air, natural gas and wastewater systems. Disruptions to any of these cripple manufacturing. Power outages, voltage fluctuations or setup errors have been known to damage sensitive electronics and motors. Flooding can overwhelm storm drains and sewers. Compressor failures reduce instrument air availability. Boiler issues cut off needed steam and hot water.

Severe weather impacts are another concern, especially for facilities located in tornado, hurricane or earthquake zones. Storms bring high winds and flooding that damage structures, equipment, utilities and inventories. Extreme cold or heat disrupt operations, utilities and worker availability. Blizzards and floods restrict supply chains.

Machinery troubleshooting. Credit: The Nonwovens Institute

Cyber incidents like malware, ransomware, denial-of-service attacks and unauthorized access present insidious risks due to increased connectivity between information technology (IT) systems and industrial control systems (ICS). Worms, viruses, phishing and social engineering threaten data security and integrity as well as availability and safety. Vulnerabilities get introduced during technology upgrades, configurations, maintenance and testing. Strong ICS cybersecurity programs are a must, given safety and business implications.

Lastly, human errors in operations, maintenance or management are unavoidable over time. Improper machine setup, configuration changes, unscheduled downtime, ignored alarms and delayed maintenance all happen periodically. Insufficient training and staff turnover exacerbate these issues. Lean staffing leaves little excess capacity to catch errors. Behavioral safety programs, management of change processes, alarm management, cross-training, documentation, and succession planning help manage human fallibility.

Insurers have seen all these perils cause significant losses in nonwoven material facilities. Prudent risk management is thus essential, though it will not entirely prevent problems from occurring. This leads to a final topic - how insurers should respond once a claim does occur.

Insurance considerations after a major loss

Even with excellent risk control and safety programs, losses are inevitable at a nonwoven manufacturing facility. When they occur, insurance coverages like property damage, business interruption, equipment breakdown and liability become essential to survival and recovery. However, the technical complexity of nonwoven manufacturing means insurance adjusters need expertise to properly investigate, quantify and resolve claims. Several considerations are useful when handling such events.

Firstly, when dealing with fire events, there is a great need to get an origin and cause investigator to the scene as quickly as possible. Many of these facilities will attempt to “clean things up” or work towards getting their equipment back online soon. Many times, this process will remove the evidence required to determine the cause of the failure and greatly affect any subrogation potential. Early response for fire investigators is critical to make sure all personnel are on the same page as to the need to protect the area of origin for potential joint scene examinations, and to secure the items of interest and avoid spoliation claims from interested parties.

Secondly, the services of forensic engineers should be secured to evaluate damaged machinery like polymer extruders, slitters, winders and bagging units. Engineers can collaborate with original manufacturers or third-party service providers, to develop a recovery protocol that will restore the affected equipment to a pre-loss condition. Manufacturers will be able to advise about expected lead times for parts and installation.

Spunmelt production line. Credit: Suntech Textile Machinery

For damaged nonwoven inventory like reels of spunbond for diapers, testing is needed to determine if the materials can still be converted into sellable products or if a total loss has occurred. Smoke contamination, water exposure and other conditions must be evaluated against customer specifications. Industrial hygienists and appraisers with nonwoven expertise can provide these assessments.

Since business interruption will result from the property damage and equipment repairs, the projected timeline for resuming operations must be urgently determined. The equipment manufacturers' repair estimates will drive this but constraints like utility restoration, structural repairs, inventory replacement, and cleanup activities must be considered too. Realistic timeframes and critical paths are essential for the business interruption claim.

Given all the concurrently damaged equipment, utility systems, and structures, comprehensive project management is crucial for coordination between the insured, contractors, and insurance representatives. Permitting, engineering, contracting, purchasing, mobilization, demolition, installation, rehabilitation, commissioning, and monitoring comprise a major undertaking. Communication and coordination prevent delays that worsen downtime and business interruption.

During cleanup, testing by industrial hygienists is prudent to measure air quality regarding particulates, solvent vapors, and other byproducts. Any hazardous waste disposal must comply with regulations as well.

Finally, rigorous documentation throughout the response and restoration process is key. Costs, schedules, impediments, contractor changes, scope alterations and business decisions should all be recorded. Photos, reports, invoices, meeting notes, call logs and correspondence help substantiate claims for property damage and business interruption to reach a fair settlement. With large complex losses, data is king.

In summary, when a major loss hits a nonwoven manufacturing facility, insurance adjusters should engage technical experts in forensic investigation, equipment, materials, project management and industrial hygiene to fully assess the damage, develop repair options, and determine timeframes and expenses. Documentation and communication are also paramount given the intricacies involved. This approach allows the best outcome for all stakeholders and facilitates a successful recovery.

Summary

Modern life relies heavily on nonwoven materials, from the obvious products like diapers and wipes to the less known products like medical fabrics, air filters and insulation. Producing these essential products involves sophisticated equipment, hazardous processes, interconnected utilities and meticulous controls. The combination of high speeds, high volumes, flammable fibers and heat make nonwoven material facilities prone to fires, equipment failures, utility disruptions, weather events and human errors. All can result in expensive downtime and damages.

Risk management and property insurance are thus indispensable to nonwoven manufacturers. Safety programs, risk management, preventive maintenance, mechanical redundancy, cybersecurity and emergency preparedness help reduce the likelihood and severity of losses. But when major losses inevitably strike, insurance coverage and responsive expert claims service ensure continuity and prompt recovery. By understanding the manufacturing methods, equipment, risks, and insurance needs, insurers can be proactive partners to their nonwoven industry policyholders. This technical familiarity creates a collaborative relationship that serves all parties when misfortune occurs.

About EFI Global

EFI Global, part of Sedgwick, is a well-established brand with an excellent reputation in the Americas, Africa, Asia-Pacific and Europe as a market leader in environmental consulting, engineering failure analysis and origin-and-cause investigations. Each year, EFI Global completes more than 45,000 projects worldwide for a wide range of clients, such as commercial, industrial, institutional, insurance, government, risk managers, public and private entities. EFI Global is one of the world's most respected emergency response firms, capable of providing practical solutions to the most complex problems. Our multidisciplinary team of first responders, project managers, engineers, geologists and scientists are selected for their technical proficiency and in-depth industry knowledge to aid clients in resolving technical problems. For more, see **efiglobal.com**.

Get in touch with an expert

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As a licensed professional engineer with a decade of experience, Jake has a background in structural design and analysis, rehabilitation and repair design, forensic investigations, load-rating studies, and construction inspection and management. Jake also has extensive experience performing construction failure investigations, foundation and retaining wall inspections, water intrusion investigations, roof assessments associated with wind and hail damage, and building envelope failure investigations. Having worked with a variety of structures — including commercial and residential buildings, public and private port and harbor marine structures, and industrial/material handling facilities — Jake is equipped to work with insurers, building owners, developers, architects, contractors, commercial divers, federal/state/local authorities, and permitting officials throughout the east coast. For more information, contact **Jake.Carlyle@efiglobal.com**.

Werner Sieburg, Pr Eng. – lead forensic engineer
As a licensed professional engineer with a decade of experience in post-loss electrical investigations, Werner is well versed in the failure mode and comprehensive root cause analysis of complex and integrated engineering systems. Within the electrical utility industry, his experience includes all aspects of power system failures at high, medium, and low voltages, large power station multi-unit failures, electrical protection, transformers, current and voltage transformers, switchgear, power lines, earthing and lightning. His expertise also includes power quality, integration of renewable energy onto the power grid, and he is up for any challenging problem to solve. Werner is well equipped to work at all levels of expertise with insurers, specialists, business owners, manufacturers, authorities, and operators. For more information contact **werner.sieburg@efiglobal.com**.

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