Change is under way in the hard- and soft-shell categories as innovative waterproof-breathable membranes come to market.

The new shape of shells

One could argue that since WL Gore developed the first waterproof-breathable laminate in the 1970s the recipe for weatherproof clothing hasn't changed much: take a fine, rain-blocking and moisture-expelling film, encase it between two protective layers, a textile or a coating. Cut and sew into a garment. Tape the seams. Incremental improvements and variations have been introduced in the past 35 years. In addition to the original expanded PTFE (ePTFE) membrane developed by Gore, melt-blown polyester and polyurethane (PU) films have become available. Starting in the late 1990s, special coatings have been developed to protect the film and create lighter, more packable textiles known as 2.5 layer shells. Roughly at the same time, softer, stretchier fabrics and membranes were bonded together, creating the soft-shell sub-category.

With the development of knitted, nano, hybrid or inverted laminates, new options are now emerging. And the standard recipe for both hard- and soft-shells may - finally - be on the verge of change.



Swedish eco-brand Houdini uses Atmos, a polyester membrane made in Japan by Teijin that can be recycled, for its weatherproof shells. The face fabric, membrane and back contain nearly 75% recycled content with some virgin material added for durability, the company states.

Tomas Arlemo

Rethinking lamination

In what is possibly the most counter-intuitive of the new waterproof-breathable shells, Voormi's Core Construction textile joins a fabric and a "core material" during knitting. The membrane "core", which can be polyurethane or other, is fed into the knitting machine along with the yarn, which passes through the membrane. This creates the need "to re-establish the integrity of the membrane," says marketing director Timm Smith by way of a curing process that "binds the membrane to each individual yarn." Voormi is a good example of a 21st century sportswear brand. Based in Pagosa Springs, Colorado, the company makes active sportswear using merino wool farmed in the Rocky Mountains and its clothing is manufactured in the US. Research on a wool-based shell fabric began in 2010, the year the company was founded. The details of the technology are not fully disclosed: we are told that a special yarn is used and that

the fabric construction is a "hybrid knit". Voormi uses wool, but other yarns could be used. "The properties of Core Construction can be fine-tuned to need by modulating the process that seals the holes," says Mr Smith. Theoretically, air permeability can go from 0 to 200 cfm, and waterproofness from 1 to 3 psi (roughly 700 to 2100 mm water column), in lab conditions. The company has engineered its composite material to offer 10 to 15 cfm air permeability along with protection from snow and light rain. The result is closer to a soft-shell than a hard-shell. The first Core Construction fabric, which will be available in US stores this autumn, weighs around 350 grammes per square-metre. "It feels like a mid-layer, it has a sweater look face and a fleeced back. Our goal was not to create another waterproof breathable textile, but over time we could go there," says Mr Smith. The brand has developed a more classic three-layer laminate with a woven wool fabric face that is also patent-pending.

Columbia Sportswear's new Outdry Extreme technology is another innovative waterproof-breathable shell that seeks to supercharge standard thriple layers. The Portland-based group has turned the laminate system inside out, literally, by placing the membrane on the outside. The starting point for the company's R&D teams was to solve one of the main drawbacks of laminates which is their tendency to wet out. "This immediately reduces a garment's breathability," says Matteo Morlacchi. With his brother Luca, he co-developed a lamination process for shoes and gloves, known as Outdry, which was acquired by Columbia Sportswear in 2010. Outdry Extreme does not actually use the original process developed by their original company, Nextec, but it does share its philosophy, says Mr Morlacchi, "because it moves the membrane from the inside to the outside".

Outdry Extreme is a multi-layered material: a transparent polyurethane membrane is bonded to a backing knit and coated with a dotted, abrasion-resistant finish. The membrane itself is micro-perforated to enhance breathability. "The backing fabric is chosen for its ability to diffuse moisture and the outer surface will not absorb water," says Mr Morlacchi. With the result that "the user will perceive a higher level of comfort." The shiny laminated face resists stain penetration and dries fast. It also presents a novel aesthetic, reinforced by the outside taping, that Columbia chose to emphasise in its first range of products. "Not only does Outdry Extreme introduce a new level of performance but also a new aesthetic, which is a plus," he adds. It also has the advantage of making the technology visible, something that Columbia Sportswear has often put forward as a sales feature, seen in the metallic matrix of Omni Heat Reflective or in the blue circles of Omni Freeze Zero.



Swiss skiwear brand Mountain Force seals every single seam of its skiwear, and only the critical seams of its après-ski clothing.

Mountain Force

New nano membranes

In development for a number of years, and first introduced by Polartec in its NeoShell range, non-woven electrospun fabrics now seem to be poised for growth in outerwear. This technology was featured in *WSA November-December 2013 (Next-generation membranes)*. Czech company Nanomembrane commercialises laminates on a nanofibrous polyamide 6 film whose fibres measure less than 150 nanometres. The company says it has 20 million more pores per square-centimetre than a microporous membrane. Nanomembrane can thereby offer high vapour permeability, 100% wind resistance and its hydrostatic resistance can exceed 30,000 millimetres. Nylon 6 was chosen for its thermal stability and because it requires few or no dangerous solvents during manufacturing, the company claims. The Nanomembrane range is a joint collaboration between textile manufacturer Svitap and the Faculty of Textile Engineering of the Technical University of Liberec.

The electrospinning process used by Nanomembrane is based on its Nanospider, needle-free technology using machines designed by Elmarco in 2004. Also based in Liberec, Elmarco claims to be one of the few companies to offer reliable industrial level electrospinning machines. Turkish textile group Abalioglu Teknoloji has recently acquired a production line from the Czech company.

Korean company Bristex produces an eletrospun PU membrane said to contain 25 billion pores per square-centimetre! "These pores are 10,000 times smaller than a water droplet, but 500 times larger than a water vapour molecule. This makes the nanomembrane fully waterproof from the outside, while allowing perspiration to escape from the inside," says company manager KeunHun Chang. These characteristics also make the Bristex non-woven membrane ideal for active outerwear and soft shells. However, it has a low heat-resistance and can easily be damaged. "It needs to be treated with care," he says.

More nonwoven options are becoming available as FibeRio ramps up production of its nano membrane. The McAllen, Texas-based company uses a different technology, that it calls Forcespinning, in which the film is produced using a centrifugal force instead of an electrostatic charge (used in electrospinning). It says its Forcespinning technology provides a more sustainable method of production because it does not require solvents. This technology was developed by the Nanomaterials lab of the University of Texas-Pan American. A VF brand will probably be the first to market a finished garment with this type of membrane, as FibeRio and VF announced this April. "Our partnership with FibeRio is a great step toward the co-development of proprietary, high-performance nanofibre materials that will help push the boundaries of performance and explore the creation of new apparel and footwear market categories," Dan Cherian, who heads VF's three innovation centres, stated when the agreement was made public.

Durable breathability

Nanomembrane has an oleophobic plasma-applied finish that prevents the build-up in the micropores of soil, which would impede breathability. This nano-finish technology is applied to the knitted or woven face and back fabrics. This is also the case for the ePTFE membranes made by US-based Trinity Technology Group (TTG). A new product, called N-Air, a reference to its high air permeability, is said to have a very high level of oil-repellency. This is especially critical for PTFE membranes that degrade in the presence of body oils.

These protective, nano-fine layers help laminates maintain vapour and air permeability. As nano-membranes are nonwoven, they tend to let more air through. Yet this can reduce waterproofness, making them better suited to soft-shells. But the notion of air permeability is becoming more important in hard-shells as well. It is increasingly considered a key property to offer enhanced wearer comfort in active outdoor pursuits.



Voormi's Core Construction knitted membrane is the result of the brand's philosophy to simplify layering by "collapsing multiple garments into a single layer," says marketing manager Timm Smith.

Voormi

Porelle Air Sport, the newest reference to be introduced by UK-based laminator Pil Membranes, is specifically engineered to address the need for added breathability. Air permeability for Porelle Air Sport is 0.2 to 0.8 cfm (membrane alone), says Porelle product manager, Steve Dorling. He sees air permeability as a key trend in active sportswear, which he says tends to favour polyurethane over ePTFE. Hydrophilic PU membranes also have more stretch, thus responding to another major demand that is freedom of movement, he adds.

With over 40 years of experience in polyurethanes, supplying membranes to the military and medical sectors, Pil Membranes makes many types of waterproof-breathable membranes in PU or ePTFE. These are produced to the specifications of each client in terms of thickness, weight, breathability and waterproofness. "We have something to suit any outdoor activity," says Mr Dorling. Eco-friendly brands might find it interesting to learn that the polyurethane membranes are made using wind and solar-powered machinery.

Pil Membranes is currently working with textile agency Concept III to develop "bespoke" laminates for its sportswear clients. Concept III works with a brand's product managers to find the best combination of film, face and back fabrics. These are then laminated by Pil, where "the whole package is put together for the client," adds Mr Dorling.

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Hybrid concepts

While three-layer shells seem to have taken over the 2.5-layer category, once touted for their enhanced breathability, new developments in "paclite" laminates may make them more popular in the future.

Japanese company Toray has developed what it calls a hybrid concept that is technically a 2.5-layer but looks and feels like a three-layer laminate. The back of the membrane is embedded with three-dimensional ceramic particles. "This layer replaces the usual nylon knit backing fabric," says Toray Europe marketing manager, Steffen Meiler. "This leads to fewer points of contact between the laminate and the skin. The textile will remain lighter as there will be less moisture uptake compared to nylon mesh linings. The particles also protect the membrane, leading to added durability," he says.

Here again, Toray offers something for the eco-conscious since this hybrid laminate is made with the Ecodear Dermizax membrane, containing up to 30% plant-derived raw materials, and 60% of the nylon face fabric is plant-based (castor oil). "Toray is working on a sustainable clothing concept without sacrificing any functionality. We are making progress step by step. We started with the fibre, then the fabric, and now, the membrane," says Mr Meiler.

Sympatex's Phaseable membrane is also a hybrid 2.5-layer in which the back of the polyester film is coated with three-dimensional foam dots that act as spacers to the skin, the company explains. The membrane expands or retracts depending on humidity levels to step up moisture wicking during high activity and boost thermal insulation during low activity, thereby adapting to need.

Taping issues

Whatever the number of materials bonded together to make a waterproof-breathable shell, the seams, all the seams, are more often than not fully taped. With the trend towards lighterweight face and backing fabrics and more elaborate styles, including multiple pockets, flaps, ventilations, and so on, it has become a challenge for brands to manufacture performance outerwear without the taping marks showing on the outside; unless they are deliberately placed there, as Columbia Sportswear has done with its new Outdry Extreme shells.

A fully taped jacket can require anywhere between 12 and 25 metres of taping. Roman Stepek, head of Swiss upmarket skiwear brand Mountain Force, says manufacturing each jacket can take from eight to 12 hours. The quality of taped seams depends on multiple parameters, including the amount of adhesive, pressure and speed of the machine, and the mechanical properties of the backing and outer fabrics. Mountain Force tests each fabric in-house to find the best taping solution. Similarly, at Swedish brand Norrøna, "all prototypes are tested in-house so that we can control and experience different methods and solutions before sending it to our factory," says Anna Madella, the brand's lab and field test manager.



German sportswear brand Kossmann is introducing Sympatex Phaseable into its ranges, taking advantage of the lighter weight of hybrid 2.5-layer laminates. The outer fabric is made in polyamide and the total laminate weighs 87 grammes per square-metre.

Kossmann



Looking to find a way to avoid the wetting out of face fabrics, Columbia Sportswear placed its polyurethane membrane on the outside of this "inverted" 2.5-layer laminate in which the film is backed with a moisture-wicking knit fabric and the face is coated with an abrasion-resistant dotted finish.

Columbia Sportswear

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Italian cycling brand Northwave is introducing a range designed with the newest eVent ePTFE membrane technology, DVstretch. The three-layer laminate is said to stretch 35% and fully recover.

Northwave

Other brands limit the number of fabrics to avoid unseemly tape lines. Swedish eco-friendly brand Houdini doesn't change fabrics every season, using the same backing for several different face fabrics to reduce the risk of taping marks on the outside. All are lab- and field-tested, says Houdini production manager, Katarina Grönhaug.

Mountain Force has been using the same four-way stretch face fabric and lining fabric for its shells since 2010. The brand uses a hydrophilic PU membrane to which ceramic particles are added. It was developed specifically for Mountain Force by Japanese company Komatsu. "It functions as a shield, keeping the cold out and offering high breathability," says Mr Stepek, adding that it allows the brand to use lighterweight (40 or 60 grammes per square-metre) insulation. The stretch lining is preshrunk before manufacturing so that puckers or wrinkles won't appear between the outer fabric and the lining after home washing.

The company is currently testing a new outerwear fabric, which may be introduced in its F/W 2017 collection, if it makes the cut. "I believe in reducing the number of fabrics, to keep it simple. The look, cut and comfort are essential. Our goal is to make a garment you can wash and wear for many years," says Mr Stepek, who believes the industry puts a lot of money into marketing and less into their products.

Multiple materials, with new fabrics introduced every season, are one of the reasons why taping markings seem to be more visible lately, says Michel Coudrez, sales manager for Scottish company Ardmel Technology, a maker of seam-sealing machines. "Each fabric should ideally be tested to determine the best settings," he adds. The company is currently preparing to launch a tape with a cotton face designed specifically for laminates with 100% cotton face fabrics.

With the trend for softer and lighterweight fabrics, new seam-tapes have followed suit, says KeunHun Chang, Sealon manager (sister company to Bristex). There was a time, he says, when seam-sealing tapes typically measured 22 millimetres. Now the company offers multiple widths, down to 13 millimetres. He adds that if the fabric is laminated on a low heat-resistant membrane such as an electrospun nano-membrane, the seam-sealing tape should likewise be applied at a lower temperature.

In addition to aesthetics, taped seams are a source of fragility and lower performance, says Matteo Morlacchi. While standard membranes resist 20,000 to 30,000 millimetre water columns, taped seam requirements are usually in the range of 3,000 to 5,000 millimetres. This inspires some brands to streamline their designs. "Since the seams are less waterproof, it's a good idea to reduce their number and taping width. We are careful at Houdini to develop the best design for performance," says Ms Grönhaug at Houdini. A tune also heard at Norrøna: "Norrøna's design philosophy is loaded minimalism. All decisions are made according to the product's needs and functionality. This to say that so far we haven't focused as much on the aesthetic of seam tapes as on their performances," says Ms Madella.

Though consumers may not be aware that taped seams are not as waterproof as the main fabric, the multiple markings that seem to have become a new industry standard can be found unappealing, particularly on high priced three-layer shells. To accompany the arrival of the radically new membrane concepts, it may be time to review the recipe for seam-taping too.

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