Marine Textiles

By: A.R. Nagaraj &
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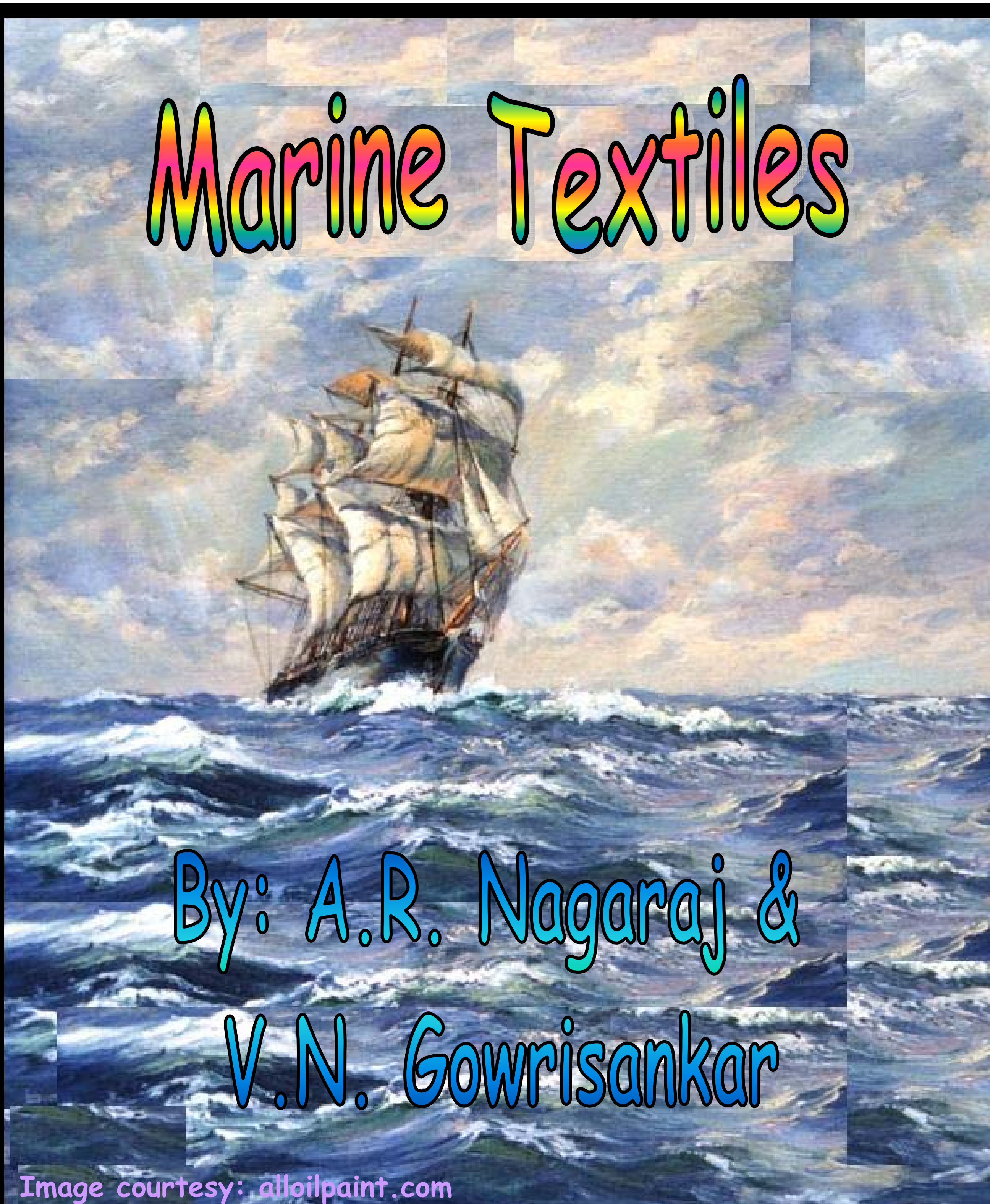

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Abstract

Textile industry began with the need of protecting human being from the changing climatic conditions. Before fabrics were discovered, man first covered his body with leaves, plant fibres. Textiles are now an essential part of every body's life. Rather than just to cover the skin, it is used to provide for fashion requirement and comforts. Textiles are mainly applied in three fields such as

- ✓ Apparel uses
- ✓ Home textiles
- ✓ Technical textiles

Among which technical textiles are an expanding area of textile industries. One of the driving forces of the modern technical textile industry is new yarn and fibre development. With liberalization and globalization as the changes happen all over the world, the 1980s was a particular period which saw the commercial introduction of a wide range of new materials. The various technical fields such as Agrotech, Geotech, Indutech, Medtech, Mobiltech (automobiles, shipping, railways and aerospace), Oekotech, Packtech, Protech, sporttech. Technical textiles are gaining fast recognition to be one of the most dynamic and promising areas for the future of the textile industry in India for high-performance applications. In this topic we are mainly focused on fibres used in marine application and requirements of the marine textiles. The very important things like various textile applications in marine environment, some of the commercial available products, manufacturers and testing methods of appropriate textiles are also discussed in the paper.

Introduction

Transport applications (cars, lorries, buses, trains, ships and aerospace) represent the largest single end-use area for technical textiles, accounting for some 20% of the total textiles. The range of products is vast. They range from carpeting and seating, safety belts and air bags, belt and hose reinforcement, to composite reinforcements for automotive bodies, military and civil aircraft bodies, engine and wings components, and many other uses. In all transportation applications certain important factors recur.

In public transportation situations safety means reduced flammability as far as textiles are concerned. Environmental factors have also become important and these have influenced the transportation textile industry in a number of ways including choice of materials, manufacturing methods and design. Conservation of world resources by using less fuel is now a concern for world governments.

The whole area of transportation is growing with increasing trade between all the nations of the world generating higher volumes both in freight and also commercial passenger travel. With larger disposable incomes, increased interest in foreign cultures and leisure time, leisure travel is also increasing dramatically. The largest growths are expected in air travel as well as marine travels. Normally the marine applications fall in the following material like Boat covers, Cabin topping and canopies Decorative trim components, Exterior upholstery, decking, flooring, Headliners Interior accents Interior upholstery and etc. The luxurious, comfort, softer handle and touch have been achieved many advanced finishing techniques such as antistatic finishes, antimicrobial finishes, encapsulated chemicals, specialist yarns and techniques for improved thermal comfort.

Fibre requirements

- UV degradation and resistance to sunlight
- Abrasion resistance
- Reduced flammability
- Easy clean ability and soil resistance
- Resistant to bacteria and microbes
- Hard, strong with high tear as well tensile strength
- Softer handle and touch
- Very high bursting strength(sails)

Properties of fibres used in transportation

	Density ($g\,cm^{-3}$)	Melting point[b] (°C)	Tenacity ($g\,den^{-1}$)	Stiffness (flexural rigidity) ($g\,den^{-1}$)	LO1 (% oxygen)	Abrasion resistance	Resistance to sunlight
Acrylic	1.12–1.19	150d[b]	2.0–5.0	5.0–8.0	18	Moderate	Excellent
Modacrylic	1.37	150d[b]	(HT)	3.8	27	Moderate	Excellent
Nylon 6	1.13	215	2.0–3.5 4.3–8.8	17–48	20	Very good	Poor–good (stabilised)
Nylon 6.6	1.14	260	(HT)	5.0–57	20	Very good	Poor–good (stabilised)
Polyester	1.40	260	4.3–8.8 (HT)	10–30	21	Very good	Good–excellent (stabilised)
Polypropylene	0.90	165	4.2–7.5 (HT) 4.0–8.5 (HT)	20–30	18	Good	Poor–good (stabilised)
Wool	1.15–1.30	132d[b]	1.0–1.7	4.5	25–30 (Zirpro)	Moderate	Moderate
Cotton	1.51	150d[b]	3.2	60–70	18	Moderate	Moderate
UHM							
Polyethylene	0.97	144	30	1400–2000	19		
Aramid	1.38–1.45	427–482d[b]	5.3–22	500–1000	29–33		
Carbon	1.79–1.86	3500d[b]	9.8–19.1+	350–1500	64+		
Glass	2.5–2.7	700	6.3–11.7	310–380	–		
PBI	1.30	450d[b]	–	9–12	41		
Inidex	1.50	–	1.2	–	40		
Panox	1.40	200–900d[b]	–	–	55		
Steel	7.90	1500	2.5–3.2	167–213	–	–	–
Aluminium	2.70	660	–	–	–	–	–

LOI, limiting oxygen index; HT, high tenacity; UHM, ultra high modulus; PBI, polybenzimidazole.
[a] Data compiled from several sources and intended only as a guide.
[b] d, does not melt but starts to degrade.

Fabric structure

The main fabric types with typical weight ranges are: flat woven fabric (200– 400gm-2), flat woven velvet (360–450gm-2), warp knit tricot (generally pile surface, 160–340 gm-2), raschel double needle bar knitted (pile surface, 280–370gm-2) and circular knits (generally pile surface, 160–230 gm-2). Fabrics in nylon tend to be towards the lower weight range. Using mechanical Jacquard systems woven fabrics have been produced for many years and they once offered the greatest design potential. With them with the introduction of computer controlled knitting machines, knits have now caught up with them.

The growth of automotive fabrics, especially knitted, has been the subject of several papers. Woven fabrics have limited stretch. This restricts their use in deep drawer moulding applications for door casings sometimes. Some polybutylterephthalate (PBT) yarns, which have increased stretch, are being used in certain instances, but they are significantly more expensive than regular polyester even though they are more easily dye able. However, woven fabrics, even with PBT yarns, cannot compare with the stretch capabilities of knitted fabrics.

Flat woven velvet fabrics are the most expensive to produce but are considered top of the range in quality. Knitted fabrics with raised surfaces are softer to Textiles in transportation the touch than flat wovens. Modern weft knitting machines equipped with advanced electronics that allow intricate design patterns offer considerable potential. These utilise yarn packages, compared with warp beams where yarn preparation is necessary in both weaving and warp knitting. Thus machine setup is much quicker and production volumes are much more flexible. Both of these factors are ideally suited to the shorter lead times and sometimes unpredictable production programmes required by car companies.

Composites

Cloth woven from strong Kevlar, stiff carbon (graphite) fibre, or inexpensive fibreglass can be reinforced with resin and laminated on or in a hard-surfaced mould to produce a tough and light boat hull. For the manufacturer who is replicating many identical copies of a boat and needs to produce a slick outer finish with minimal labour per unit, hard moulds are convenient and efficient.

Fortunately, such moulds are not necessary for building a single boat or experimenting with a variety of designs. The fabric form method is a less costly, faster and easier approach to building\ small and one-of-a-kind composite hulls in the home workshop. Something fabricated with or composed of more than one material is known as a *composite*. So wood covered with fibreglass and resin is technically a composite. However, structures made with fibreglass or human fibres and a plastic resin is most commonly described as composite. These structures have also been called fibre-reinforced plastic or FRP. The resin is typically epoxy, vinyl ester or polyester, in small boat construction. The choice normally depends on the type of process, fabric and considerations of stability, strength, ease of use, service life, cost and hazards.

Various Application of Textile in Marine Environment

a) Furnishing fabrics

Cruise ships can be regarded as 'floating hotels' and, therefore, textile properties requirements must be of 'contract standard'. Because of escape restrictions at sea and also because narrow corridors and low ceilings in many vessels make panic more likely in the event of a fire, flame retardancy standards need to be high. Fires in hotels and cruise ships are frequently caused by carelessness on the part of smokers. Carpets are especially important on passenger vessels because of their noise and absorbing properties. Furnishing fabrics must have durable high standards of flame retardancy and more use is therefore being made of inherently FR textiles.

They are more pleasant to walk upon than a hard surface and help to reduce physical stress and to provide a calmer and quieter atmosphere. Durability is important because some areas of vessels are in use 24 hours a day and cleaning is done to rigorous schedules. Dyes used must be fast to light, rubbing and salt water. Some ferries in Scandinavia have a million passengers a year; the heavy duty carpet is expected to last over 7 years. Flame retardancy is important and wool carpets are generally Zirpro (IWS) treated. Sometimes by use of conductive fibres durable antistatic properties are imparted as they are generally required. Conductive fires are more durable than chemical finishes.

b) Sails

The first sails were made from panels of hides or woven natural fibre fabric sewn together. Synthetic fabrics were used because of their advantages of greater strength and resistance to micro-organisms and mildew, minimal water absorption and less distortion. Sails required for competitive racing are different from simple cruise sailing, and sail making is a highly skilled occupation. Sail design is a crucial factor for optimum performance and efficiency. The sail has to be tailored to the vessel and to the purpose required.

The crucial requirements for sail cloth are:

- light weight, dimensional stability (low creep and minimum distortion),
- Puncture resistance, high tear strength, high seam strength,
- Low porosity to wind (i.e. good cover) and low water absorbency
- Good resistance to microbes and UV degradation and smoothness; all these factors contribute to a long service life.

Sails should be easily stowed away and easy to handle. The seam is a point of weakness as under high stress the sewing holes can become larger and thus influence sail porosity, as with protective clothing. Some modern racing sails are produced from polyester film laminated to rip-stop woven nylon or polyester fabric. Because the polyester film has a high modulus of elasticity in all directions, laminated sails generally have excellent shape holding properties with very little distortion or stretch. The film is significantly lighter in weight than a fabric and offers advantages in weight saving. It is only thousandths of an inch (100 micrometres) thick.

The sail laminate must be bonded with an adhesive which can withstand UV degradation and sea water. Sail laminates can comprise two layers of film laminated to each side of the rip-stop fabric or the other way round, that is two layers of rip-stop fabric laminated to each side of a layer of film. Kevlar and even carbon fibres are also sometimes used for high strength with low weight – but at high cost. More recent laminates are believed to consist of a single layer of film and fabric laminated together. However, Kevlar has poor UV stability which leads to losing strength twice as fast as polyester. When performance at low weight is important (in racing), Kevlar is the preferred material as it is having upto nine times the modulus in grams per denier than high tenacity polyester. Kevlar can lose upto 50% of its strength and still be stronger than polyester.

c) Functional applications

Fibre composites of glass reinforced plastic are used extensively in small vessels, patrol boats and pleasure craft. Polyester fibre is being used to replace some of the heavier and more costly glass fibre in the composite. Easy handling, corrosion resistance and low maintenance are the advantages. Sometimes Kevlar (DuPont) is also used in combination with glass fibre. Minesweepers, sonar domes and in corrosive-cargo carriers are examples of specific cases where metal cannot be used. Composites are being increasingly used for navigational aids such as buoys so that no damage results to the craft in the event of an accidental collision. Coated fabrics are used for life rafts buoyancy tubes and canopies. The base fabric for life rafts is generally woven polyamide with butyl or natural rubber, thermoplastic polyurethane or polychloroprene coatings.

The total weight of the material varies from 230 gm-2 up to 685 gm-2. Quality tests include air porosity, coating adhesion and breaking and tear strength both in the warp and weft direction, flexing and water-proofness measured by hydrostatic head test methods. The canopies used on life rafts are made from much lighter coated fabrics. Natural rubber, polyurethane or SBR (styrene butadiene rubber) coated on to woven polyamide fabric give a total weight of between 145–175 gm-2. Life jackets are generally made from woven polyamide coated with butyl or polychloroprene rubber to give total weights of about 230–290gm-2. Performance specifications include polymer adhesion, tensile strength; flex cracking and elongation-at-break, including testing after immersion in water for 24 hours. Performance standards for life jackets and life rafts are usually subject to government departmental controls and specifications.

d) Hovercraft skirts

The skirt material is a nylon fabric coated with a polychloroprene / natural rubber blend or natural rubber/polybutadiene and compounded for oil resistance. PVC blended with nitrile rubber was evaluated but was not as satisfactory.

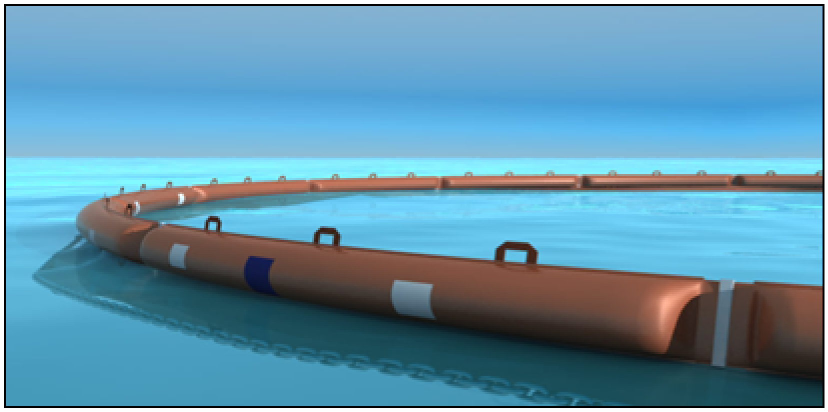
The nylon cords, e.g. 940dtex/2 and 940 dtex/3/3, from which the fabrics are woven, are highly twisted to impart fatigue resistance in order to withstand the rapid and continual flexing in use. Nylon is the best overall fibre for this application. Fibre to rubber adhesion must be of the highest standard, and a suitable RFL priming coat must be compounded. Polyester yarns are less affected by water, but in actual use coated polyester fabrics did not last as long as nylon materials. This is believed to be due to a poorer polyester/rubber bond compared with nylon/rubber. Cotton and rayon absorb too much water and are not generally strong enough for this application. Aramid, which are stronger than both nylon and polyester, have been tested, but they broke down quite rapidly because of low fatigue resistance.

e) Inflatable craft

Inflatable craft have become widely used since around 1960 and have many advantages over rigid boats. They are used as pleasure craft, as freight carrying vessels, rescue crafts and life boats. They have military applications as well. When they need to be transported to a different site or when they are not being used, they can be deflated and folded and packed into relatively small space. They consist of individual buoyancy tubes or several different compartments. If a particular section is damaged, the craft will still float and be capable of supporting weight. There are national standards and minimum performance specifications for the coated fabric and the craft itself. Which materials should be used is not specified in these standards. Hypalon polyurethane, polychloroprene and PVC are the number of different coatings used. Good tear strength is important to prevent propagation of any damage. Nylon fabric about 145g/m2, woven from typically 470dtex yarn, is used in the lighter craft; heavier yarns, typically 940 d/tex, are used for larger boats; and even heavier yarns of 1880dtex woven in a 2 X 2 twill may be used in even larger boats.

Polyester's higher yarn modulus gives it more disadvantages than advantages over nylon. It is usually more difficult to bond rubber coatings to polyester. Certain compounding ingredients can degrade polyester. Polyester is heavier than nylon. Aramid fibres may be used if cost allows as significant amount of weight can be saved. An aramid fabric weighing 85g/m2 can be used in place of a nylon fabric weighing 170g/m2. Life rafts are designed to be self inflating and carbon dioxide is used for the same. Baffles are used to disperse the gas as it emerges from the cylinder. Inflated pressure is about 15kPa. The chilling effect could embrittle the fabric coating if it is not formulated well out of a material with a low glass transition temperature such as natural rubber. Production of durable and air tight seams is the one problem with the making up of inflatable craft. This is a time consuming process and it can be made simpler if a thermoplastic material such as PVC or polyurethane is used. However, PVC has its limitations but it is used in more economical craft.

f) Oil booms



These articles are designed to contain accidental oil spillages in rivers and estuaries. They are usually produced from woven nylon base fabric of about 175g/m2 coated with Hypalon, polychloroprene, PVC or PVC/nitrile rubber are inflated to a fairly low pressure, but they do have to be oil resistant. A two-compartment structure is generally used so that the boom is still serviceable if one compartment is damaged.

g) Twines, nets and ropes

Advances in fibre ropes were made in the mid-twentieth century with the introduction of nylon ropes, followed by polyester. These ropes were about half the weight of steel ropes for about twice the diameter and the same strength. Ropes made from the second generation of synthetic fibres-aramid, Vectran, high-modulus polyethylene, and polyphenylene benzobisoxazole (PBO)-give diameters similar to steel but in one-tenth its weight. Whereas natural fibres have to be highly twisted together to prevent the fibres sliding over one another. New low-twist constructions have been developed, with just enough structure to give coherence to the ropes. Where ropes need to stretch and to absorb high-impact energies, nylon and polyester are the design choices; where resistance to extension is needed, the newer high-modulus fibres are preferred. In familiar uses of ropes, the change in recent years has been in designing for purpose. Until fifty years ago, mountaineers used common hemp ropes; now there is a range of ropes optimized for the different uses in climbing. There is a similar pattern in yachting ropes: one choice for the Olympic racer, and another for the weekend sailor.

In the most demanding applications, fibre ropes are now competing with steel. Since 1997, Petrobras has used polyester ropes to more about twenty oil rigs in deep water off the coast of Brazil. The first installation in North America was in March 2004 for BP's Mad Dog floating production system in 4,500 feet of water in the Gulf of Mexico. The great advantage for BP and its Mad Dog partners was the low weight of polyester compared to steel. Among textile fibres, polyester has the right balance of properties: rugged durability and enough extensibility to prevent large tensions developing as the rigs rise and fall. For Mad Dog, Marlow Super line polyester rope, with a diameter of ten inches and break load of two thousand tons, was used -the strongest fibre rope ever made. The eleven mooring lines taking over ten miles of rope needed more than one thousand tonnes of polyester yarns, which, for the fibre alone, would cost over three million dollars.

In marine applications fibre ropes are well established. The challenge for the twenty-first century is to replace steel in terrestrial application such as bridge cables, elevator hoists, cranes, and so on. The technical advantages are clear; the limitation is the conservatism of design engineers who do not want to replace a material that has been used for 150 years with a new material untested in use. The low weight and high strength of HPPE fibres make it possible to produce heavy-duty ropes with very special characteristics. HPPE ropes float on water, are flexible and have a low elongation. Thus, they are very easy to handle. Abrasion resistance and fatigue are good to any standard, which is why HPPE ropes last much longer than other ropes

Manufacturers of Marine Textile and Other Products:

1. Herculite®
2. Ferrari Stamoid®
3. Tri Vantage®
4. Nolan UDA
5. Aqua Design
6. Omnova Solutions Inc.
7. Jennis Fabrics
8. AB Iflatables
9. Sunbrella® Marine Fabric

The following tests are required for marine textiles

- Peel bond adhesion (face fabric-to-foam and scrim-to-foam) including testing wet, after heat ageing tests and treatment with solvents and cleaning fluids
- Clean ability after soiling with items such as chocolate, hair lacquer, lipstick, coffee, and ball point pen ink and engine oil. Some vehicle manufacturers also

include tests for ‘minking’ (loose hair deposits on the seat from fur coats) and ‘linting’ (white fibrous deposits)
- Dye fastness to perspiration
- Dye fastness to crocking (both dry and wet)
- Dimensional stability
- Flammability
- Tear/tensile strength
- Sewing seam strength
- Bursting strength
- Stretch and set test

Conclusion

Probably the most important challenge facing the transportation industry is its effect on the environment. At the same time, more welcoming and pleasing transportation interiors, enhanced comfort and safety can be expected as competition intensifies between individual car companies, airlines, train companies and passenger shipping lines and the different modes of transport.

All these improvements and advances are likely to be assisted by the invention of novel processes and more specialist materials, both as new fibres and in the form of composites. Significant discoveries bringing tremendous benefits have been made with the introduction of carbon, aramid and other specialist fibres within the last 35 years upto 2000. The most recent discovery was of the ultra high modulus polyolefin fibres. In future years, more ‘breakthroughs’ can be expected.

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