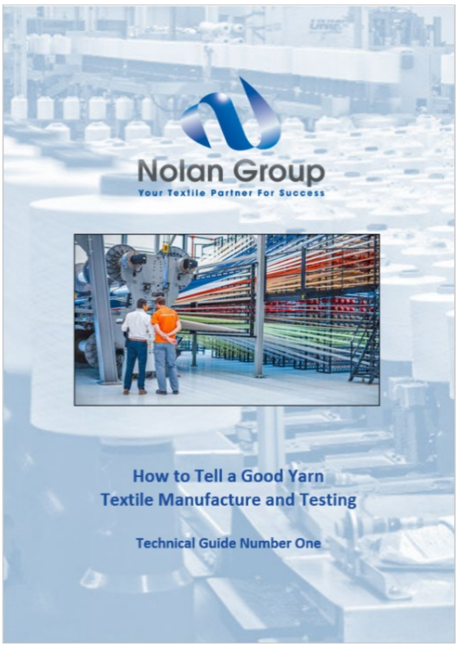
Nolan Group

Your Textile Partner For Success

# How to Tell a Good Yarn
# Textile Manufacture and Testing

## Technical Guide Number One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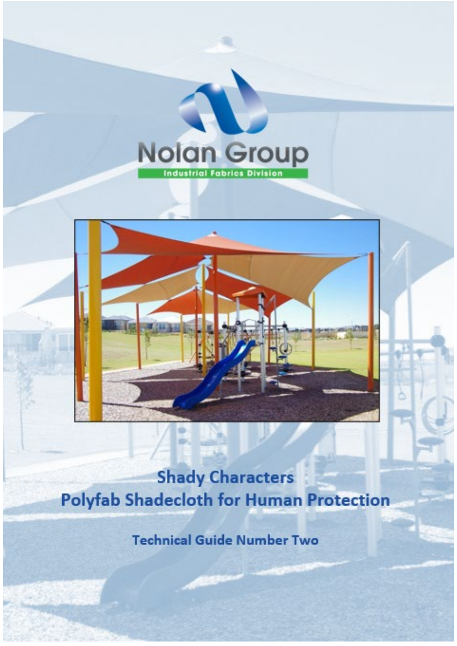
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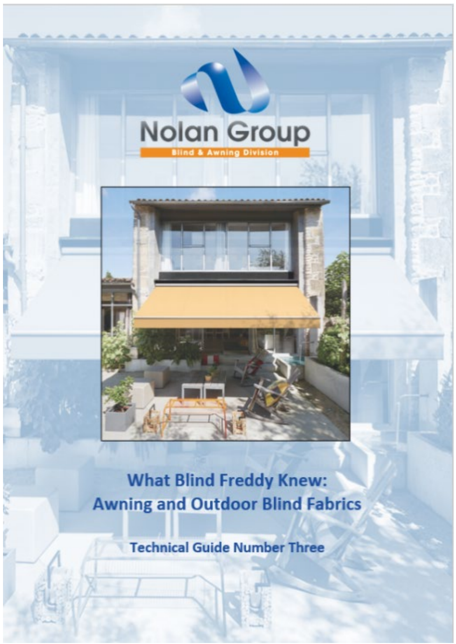
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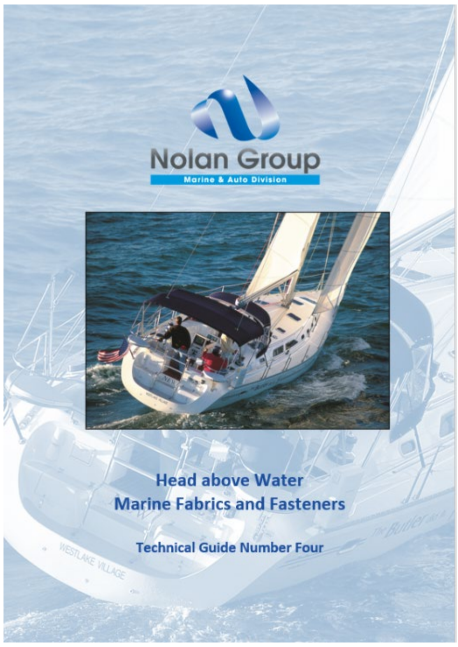
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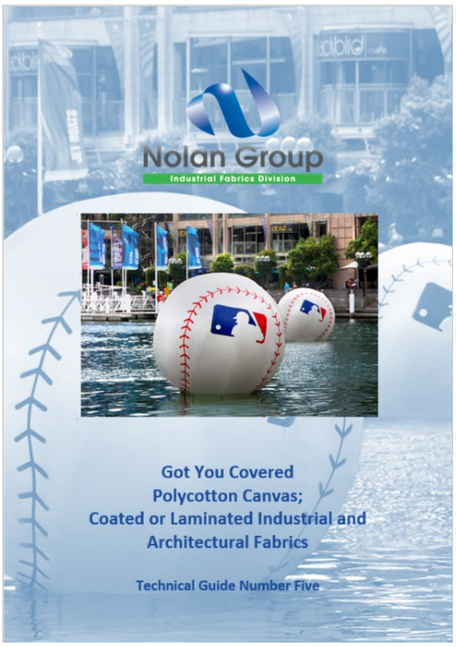
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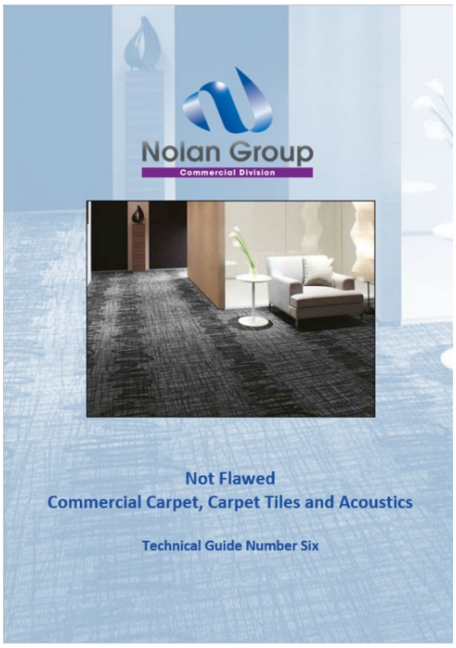
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# How to Tell a Good Yarn

# Textile Manufacture and Testing

## Technical Guide Number One

First Edition, First Printing May 2020

**About the Nolan Group**

Nolan.UDA Pty Ltd, now trading as the Nolan Group, was officially incorporated in 2009. It originally comprised the merger of the trading operations of Nolan O'Rourke and Co. Pty Ltd (trading as Nolan Warehouses) and Upholstering Distributors Australia Pty Ltd as a 50-50 joint venture, and hence the company name.

In 2016, the Business of Radins Australia Pty Ltd was formally integrated into the company. Despite its hybrid nature and relatively short history, the Nolan Group has a proud legacy inherited from its constituent partners.

Nolan O'Rourke was established in 1920 by William Bernard Nolan, and is still third generation family owned. The company had its beginnings importing Motor Body Parts and Accessories, but over the years, it diversified first into wholesaling upholstery and furnishing supplies; and then related products in Marine and Motor Trim, Industrial Textiles and Commercial Flooring markets.


*A delivery vehicle at Circular Quay, Sydney circa 1930*

Upholstering Distributors Australia Pty Ltd (UDA) is itself a subsidiary of a fourth generation family company, Thomas Peacock and Sons, established in 1881. The principal operations of that group are the manufacture of Bedding, expanded foam and lofted polyester.

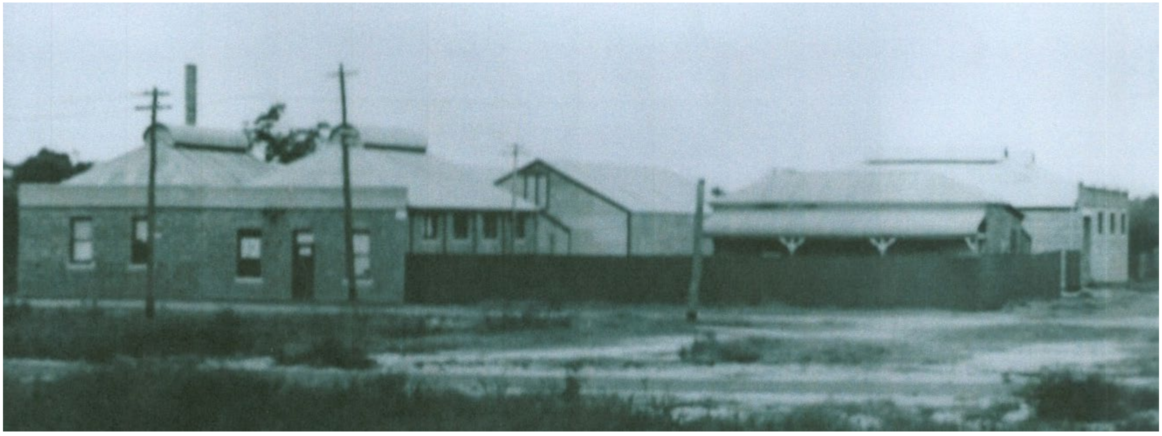
These two businesses were well suited to merger. They were of similar size, operated in a like fashion, sold comparable (some identical) products to the same market segments in overlapping geographic areas. They complemented each other well, especially in terms of relative market penetration by both product type and geographic location.

Importantly, the partnering businesses were well established, had an excellent reputation and a high level of mutual respect, mainly because of similarities in their cultures and business approach.

The success of the original merger led to the Radins' acquisition. Radins had its origins in the nineteenth century as a sailmaker, and the morphing into a wholesale distributor occurred gradually, with the fabrication arm sold off in the early nineties. The company's specialty was fabric supply to the awning and blind sector, complemented by a significant presence in Marine and Industrial Fabrics.

The business of Polyfab Australia was acquired in 2017. Originally founded in 1995, the company had developed a number of innovative knitted shade and horticultural products in conjunction with its Indonesian manufacturing partner P.T. Carillon Sdn  Bhd, which were sold internationally, including in the USA, New Zealand and the Middle East. The Nolan Group had been distributing these products in Australia for many years.


*The Sydney Warehouse in the mid-sixties. Captured in the picture (bottom right) is William Marden Nolan, son of Nolan O'Rourke's founder William Bernard Nolan.*



*Thomas Peacock and Sons factory at Maylands, Perth circa 1946.*

The original merger and subsequent acquisitions have allowed the company to realise its ambition to become a complete wholesaler of outdoor textiles and related products to the automotive, marine, awning and blind, industrial fabrics and commercial market sectors. The business trades from six branches throughout Australia, located concentrically with its customer base and the country's population; and has contract arrangements with Polyfab operations in the USA and the Middle East.

Our Company's philosophy is building and strengthening partnerships with our Customers and Suppliers. Our team of account managers and customer service staff undertake extensive product and sales training to ensure they provide the highest level of support and advice possible.

**How to Tell a Good Yarn**
**Polyfab Shadecloth for Human Protection**

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**Acknowledgement**

Because of its universal applicability, the general information herein on fibres, yarns and weaving has been drawn from "Raw fibre to Finished Fabric" written by Peter Shepherd and Delma McSwan for poly-cotton canvas and originally published by Bradmill Textiles in 1994, and reproduced with kind permission of the authors. Much of the other information has been drawn from suppliers and other information freely available on the internet. Particular thanks is due to Glen Raven, Wax Convertors Textiles, Achilles, Herculite Products Inc, and the Industrial Fabrics Association International.



First Edition, First Printing May 2020

## INTRODUCTION

In the late 1990's, the first of the Nolan Group's Technical Manuals "Coolaroo Shadecloth" was published. It was designed to collate into one document all of the information relevant to the product, including how it was manufactured, fabrication advice, maintenance guidelines, chemical resistance, care instructions, test results, warranties and regulatory requirements. Originally intended for staff and key customers only, it ended up being distributed far more widely, and reprinted twice. Ten other manuals on other products were published over the next decade, with similar outcome.

In late 2018, it was decided that the manuals should be updated. However, because of the ad hoc way in which the project had evolved, some of the content of the original manuals had been duplicated, particularly the descriptions of common manufacturing processes and fabric test methods. In addition, much of the more current technical specifications for the Nolan Group's products was published in the "Fabricator Product Catalogue", which was released in September 2019. For this reason, it was decided to remove unnecessary duplication, and collate the common information into a single new guide, with emphasis on those production processes relevant to the products sold by the Nolan Group. The products had been arbitrarily categorised by "Type" in the catalogue, and the same logic has been followed in this document.

Thus, the "Fabricator Product Catalogue"", and this guide should be considered as essential appendices to the others in the series. Perhaps appropriately, the first to be published is the third edition of the original guide, now titled "Polyfab Shadecloth for Human Protection".

## TYPES OF OUTDOOR FABRICS

There are many brands of Outdoor fabrics available on the market, of varied composition, weather-proofing, weights and widths. But all woven fabrics, or those with a woven base as foundation, can be classified into five basic groups, as illustrated in **Figure One** "Physical Structure of Outdoor Fabrics". The Outdoor fabrics supplied by The Nolan Group are collated into these categories in this guide and the company's "Fabricator Catalogue" . In addition, there are Knitted Synthetic Fabrics, used for shadecloth or netting; and Flexible Clear PVC, which is used for roll-up blinds or marine glazing; and non-woven fabrics, used as hull lining, furniture covers, and patterning material.

## "TYPE A" PLAIN WEAVE CANVAS FABRICS

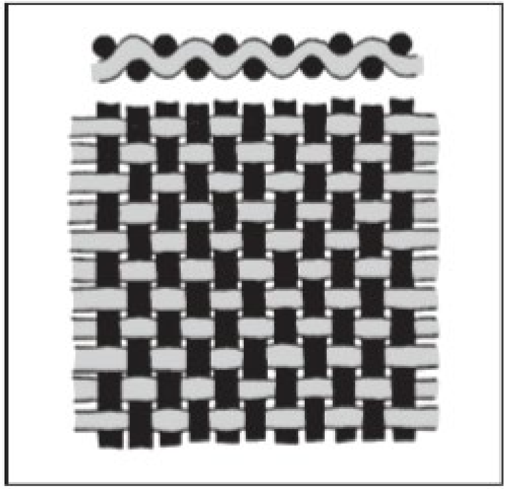
Plain weave fabrics feature so prominently in our everyday lives, that we take woven products like clothing and bed linen for granted. Weaving is the process of interlacing yarn at right angles on a loom, those running in the lengthwise direction termed "warp" and the crosswise direction "weft" or "fill". There are many different types of weave, but the most common in canvas is a "Plain Weave", where the warp yarns are held tightly stretched in the loom and the weft yarns inserted over and under every alternate one. All of the acrylic and polycotton canvases sold by the Nolan Group are of plain weave, and the basic characteristics of these products are shown in **Table One**.

### How Canvas is Manufactured

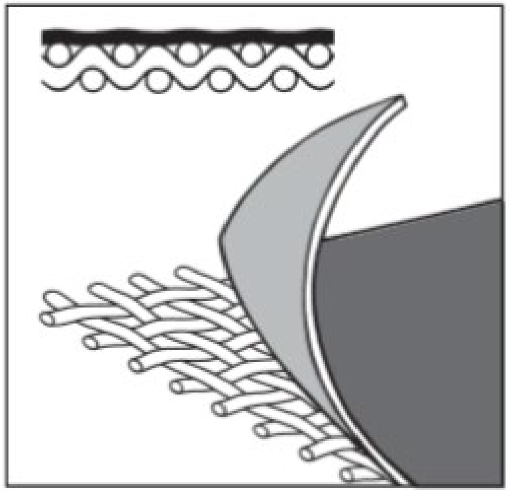
### The Production Process

The basic process for the manufacture of fabrics is shown schematically in **Figure Two**. The actual process is far more complex and sophisticated than this simple model implies, and there can be significant variations within it that affect outcome. For example, the selection of a particular type of fibre, say cotton or polyester (or a blend of both) significantly alters the strength and weathering

**Figure One** "Physical Structure of Outdoor Fabrics"

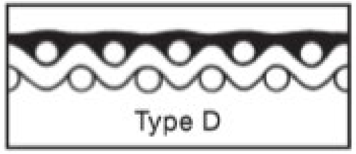


Type A: PLAIN WEAVE FABRICS
Water proofing and mildew treatment absorbed by fibres.

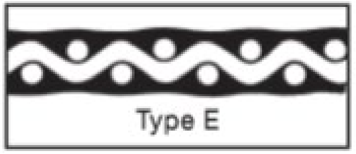


Type B: BI-LAMINATE
PVC sheet bonded to a single side of woven scrim. Exposed fibres are mildew treated.

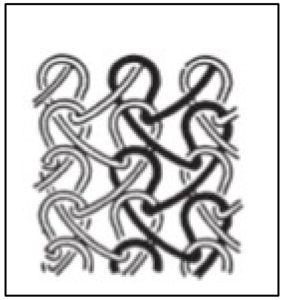
Type C: TRI-LAMINATE
PVC sheet bonded to both sides of woven scrim.




Type D & E: SPREAD COATED FABRIC
Molten PVC or coating material is spread over the fabric surface. Exposed fabric is mildew proofed. Type E fabrics are coated both sides.




**TYPE F: knitted horticultural and shadecloth fabrics**



**Type G: Non- Woven or Needle Punch Fabrics**

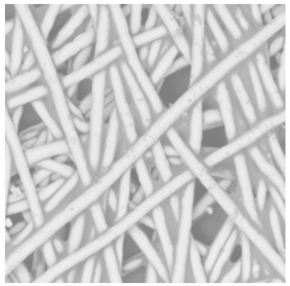


**Table One** - "TYPE A" Plain Weave Canvas Fabrics sold by The Nolan Group

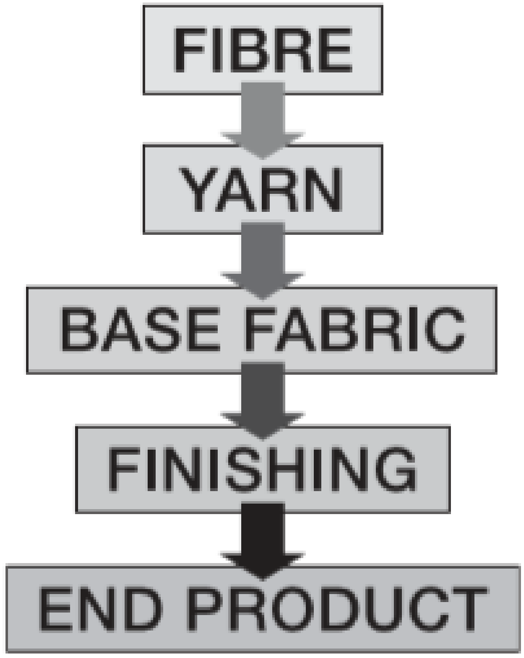
| Brand | Nominal finished weight (gsm) or loomstate weight (ounces) | Nominal Width | Description | Features and recommended applications |
|---|---|---|---|---|
| Wax Convertors Textiles (WCT) "Coolabah" | 275 gsm (6 oz) | 204 cm | Polyester/cotton (65/35) canvas, Warden proofed for mildew, rot and water penetration resistance. | Lightweight canvas suited for tent roofing or walling, or covers for old wooden craft being restored "as original". Requires periodic re-proofing to retain water penetration resistance. |
| WCT "Billabong" | 370 gsm (8.8 oz) | 204 cm | Poly/cotton (65/35) canvas, Warden proofed for mildew, rot and water penetration resistance. | Medium Weight canvas suited for campervans, tenting, covers and canopies |
| Bradmill "300 Superdux | 345 gsm (8.4 oz) | 200 cm | | |
| WCT Basecamp | 505 gsm (11.5 oz) | 200 cm | Poly/cotton (52/48) canvas. Warden proofed for mildew, rot and water penetration resistance. | Heavy weight canvas suited for swags, temporary shelters, trailer covers, tarpaulins, marquees and tents |
| WCT CS12 | 505 gsm (12.1 oz) | 204 cm | | |
| Bradmill 373 Superdux | 515 gsm (12.7 oz) | 200 cm | | |
| WCT Bullduck TT | 535 gsm (12.6 oz) | 204 cm | Poly/cotton (50/50) canvas, reinforced in both directions with a heavier grid of yarns ("Tearstop") weave. | Extra Heavy weight suited for Long haul truck and trailer tarpaulins |
| WCT CS 12 TS | 575 gsm (13.3 oz) | 204 cm | Poly/cotton (52/48) canvas, high tenacity polyester yarn with ("Tearstop") weave. | |
| Bradmill 440 Superstop | 530 gsm (12.7 oz) | 200 cm | Poly/cotton (52/48) canvas, reinforced in both directions with a heavier grid of yarns ("Ripstop") weave. | |
| Bradmill 411 Kordux | 530 gsm (14.4 oz) | 200 cm | Poly/cotton (52/48) canvas, high tenacity polyester yarn with ("Ripstop") weave. | |

**Table One (continued)** – "TYPE A" Plain Weave Canvas Fabrics sold by The Nolan Group

| Brand | Nominal finished weight (gsm) or loomstate weight (ounces) | Nominal Width | Description | Features and recommended applications |
|---|---|---|---|---|
| Bradmill "Brella" | 500 gsm (12 oz loomstate) | 220 cm | Poly/cotton (52/48) canvas. Warden proofed for mildew, rot and water penetration resistance. Painted surface finish. | Suited for traditional drop down or fixed guide awnings. |
| Hunter Douglas | 498 gsm (12 oz loomstate) | 220 cm & 280cm in some colours. | | |
| Dickson Orchestra | 290 gsm to 320 gsm | 120 cm | 100% woven solution dyed acrylic with fluoro - carbon water repellent finish. Suited for awning applications | Available in a broad selection of colours, weave patterns, and stripes. |
| Dickson Infinity | 290 gsm | 120 cm | 100% woven solution dyed acrylic with fluoro - carbon water repellent finish. Especially designed for large awning applications. | Can be successfully fabricated with the weft in the direction of the awning extension. |
| Dickson Spark FR | 290 gsm | 320 cm | 100% woven polyester with fluoro - carbon water repellent finish. Commonly used in awning applications. | Designed to meet likely changes to the Flammability standards in the Australian National Construction Code |
| Glen Raven "Sunbrella" | 310 gsm | 200 cm in standard marine colours. 152 cm available in boutique colour selections | 100% woven solution dyed acrylic with fluoro - carbon water repellent finish. Commonly used in marine applications | Particularly suited where "breathability" is essential – e.g boom and sail covers. Suited also as a water repellent canopy cover. Requires periodic re-proofing to retain water penetration resistance. |
| Glen Raven "Sunbrella plus" | 340 gsm | | 100% woven solution dyed acrylic with fluoro - carbon water repellent finish on top surface, and a polyurethane water proof coating on the underside (Type D fabric). Widths and colour selection as for "Sunbrella" above. | Surface finish identical to "Sunbrella" but has higher degree and longevity of water penetration resistance. Does not "breathe" to the same extent. |

characteristics of a proofed canvas. Even the way a staple fibre is spun into yarn affects the tear strength of the finished product, and there are numerous ways of finishing a substrate. For example, an acrylic "canvas" may be made water-resistant through application of a hydro-phobic chemical, or completely water-proofed by lamination to vinyl, or by coating with polyurethane.

**Figure Two** – Schematic Process of Fabric Manufacture




**Yarns and Fibres**

Fibres are the basic building blocks of woven canvas, and are either natural (cotton) or synthetic (Acrylic and Polyester). Cotton fibres are strands of short length (10mm to 150mm), and range in diameter from ten to fifty microns. These strands, termed "staples", need to be spun together into a continuous length, termed "staple yarn", before weaving can occur.

Man-made yarns can be extruded in any desired length or diameter, and are termed "filament yarns" or simply "filaments". Filament yarns are produced from a viscous chemical solution ("dope") or by melting polymer resin, which is then forced through a number of fine holes of a dye. On emergence, the individual filaments are then spun together into a "multifilament", and allowed to coagulate (**Figure Three (a)**)

In acrylic canvas, these filaments are then cut into staples and recombined into spun yarn the same way as natural fibres. The reason for doing this is reproduce some of the characteristics of natural spun yarn, particularly texture and lustre. Filament yarns can also be crimped, twisted or otherwise processed ("texturised") to achieve a similar outcome.

There are several stages in the process of producing cotton yarn. The first stages ("blowing" and "carding") entail extracting the raw staple fibre from bales, and after cleaning and blending, combining it into a loose rope ("sliver"). Then follows a series of processes (combing, drawing and roving) which align, stretch, twist and intertwine the slivers into a continuous strand of decreasing diameter and increasing density, until it is suitable for spinning, either about itself or a central filament core ("corespun" **Figure Three (b)**) .

**Figure Three (a**) Mod-Acrylic Yarn Extrusion

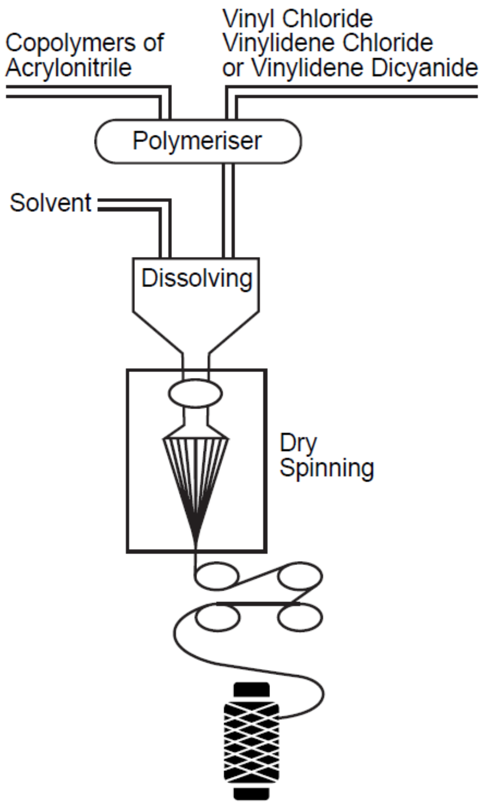
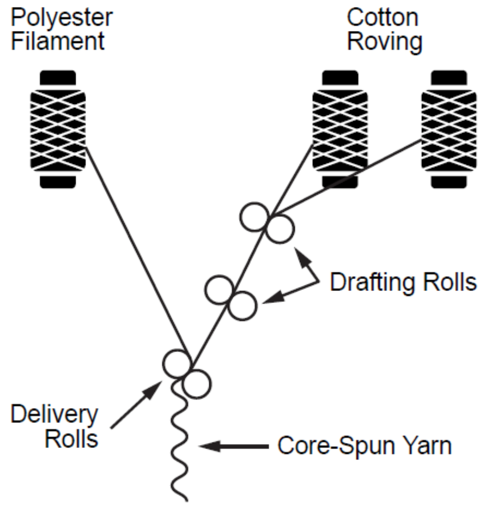



**Figure Three (b)** Core-Spun Yarn




There are also several methods of spinning, differentiated primarily by efficiency (e.g. energy consumption or speed of output) and also importantly by the structure of the finished yarn. The simplest, “ring spinning”, results in a uniform yarn structure, with fibres aligned in a parallel fashion along the length of the yarn. Other methods, such as “Open-end spinning”, result in fibres oriented at random and entangled. As a result, yarns spun using different technologies can have different characteristics in terms of strength, lustre and water absorption, even though constituted from the same fibres.

For strength, staple yarns rely on inter fibre friction imparted by twist and hence tenacity is generally in proportion to the length of the fibre used. On the other hand, because of its continuity, filament yarn fully utilises the inherent tenacity of its constituent material. Consequently, filament yarns tend to have higher strength than staple yarns.

The density of the yarn is usually expressed as a weight per length or its reciprocal. The most commonly used units are “Tex” (grams/ 1000 metres); “D’Tex” (grams/10,000 metres); Denier (grams/9,000 metres); and “Metric” (kilometres/kilogram).

To a large extent, the performance characteristics of the canvas are dependent on the physical properties of the fibres used (**Table Two**). For example, the tear strength of a woven polyester is much higher than a cotton of similar weight, because of the relative difference in the tenacity of the fibres. Similarly, because of their differing structure, each of the polymers react differently to chemical or micro-biological attack. For these reasons, each of the fibres commonly used in canvas has relative advantages and disadvantages.

Acrylic yarn is made from the synthetic polymer acrylonitrile, which is manufactured from coal and oil based compounds. It has properties that make it very suited for outdoor use, namely a low propensity to absorb moisture, good elastic recovery and resistance to chemicals, particularly acids and bleach. It has excellent mildew resistance and suffers minimal strength loss when exposed to ultra-violet radiation. The solution or dope dyed process, which introduces colour into the yarn during its extrusion, also ensures prolonged colour fastness over its effective life.

Cotton is a natural cellulosic, 'staple' fibre, with only a moderate strength to weight ratio, and a high propensity to absorb moisture, which makes it susceptible to mildew and fungal attack, but also makes dying and surface treatment of the woven fabric relatively straightforward.

**Table Two**-Physical properties of textile fibres

| Fibre<br>F: filament<br>S: staple | Tenacity (grams/denier) | | Specific Gravity | Moisture Regain (%) | Limiting Oxygen Index (LOI) |
|---|---|---|---|---|---|
| | (Dry) | (Wet) | | | |
| Cotton | 3.0 - 4.9 | 3.3 – 6.4 | 1.54 | 8.5 | 19 |
| Polyester (F) | 4.3 - 9.0 | 4.5 – 9.0 | 1.38 | 0.4 | 22 |
| Polyester (S) | 4.7 - 6.5 | 4.7- 6.5 | 1.38 | 0.4 | 22 |
| Acrylic (S) | 2.5 - 5.0 | 2.0 – 5.0 | 1.15 | 2.0 | 18 |

*Notes:-*

*Tenacity is a measure of fibre's tensile strength; Specific gravity its density relative to water; and moisture regain the amount of water it absorb when initially dry, then exposed to 65% humidity at 20℃.*

*The "Limiting Oxygen Index" (LOI) is the minimum percentage of oxygen that must be present in the atmosphere surrounding the fibre for it to ignite and burn. The proportion of oxygen in the air is normally 21%, and therefore fibres which have an LOI above this level do not ignite readily.*

*The intrinsic values for synthetic fibres are usually less than 21, but can be altered by the addition of flame retardants. For example, mod-acrylic, which is acrylonitrile with up to 30% by weight of a halogen compound (Vinyl Chloride) added, has an LOI of 31*

Polyester (i.e. Polyethylene Terephalate or PET) is an ester formed from the reaction of an acid and an alcohol (Terephalic acid and Ethylene glycol). This base material can be used to manufacture almost anything, from plastic bottles to boat hulls, as well as yarns. Its moisture absorption properties, elasticity and chemical resistance are at least on a par with acrylic, and it has a much higher initial strength to weight ratio, but unfortunately loses significant strength under the action of ultraviolet radiation. However, the cotton which wraps the polyester yarn as a result of the core-spinning process provides the latter with UV protection. The effect of blending polyester with cotton on yarn strength is demonstrated in **Table Three.**

**Table Three -**Variation of tenacity for yarns of different blend or structure, but equivalent yarn count

| **Blend** | **Tenacity(mN/tex)** |
|---|---|
| 100% Cotton | 170 |
| 50/50 Polyester / Cotton | 210 |
| 65/35 Polyester / Cotton | 245 |
| 50/50 Corespun Polyester / Cotton | 315 |
| 100% Staple polyester | 350 |
| 100% Filament polyester | 700 |

**Weaving**

The weave pattern can be varied by changing the number, colour and texture of warp and weft yarns, and the tension of the weave. For example, Jacquard looms allow individual selection of each yarn within the weave to achieve distinctive colour patterning and texture.

The difference in tension of the warp and weft yarns causes different behaviour of the canvas in each direction. The (approximately) straight warp yarns simply stretch under load, whereas the bent fill yarns flatten. Hence tensile strength and elongation are different in each direction. This effect can be ameliorated (or exacerbated) by using different denier yarns, or a different number of them in each direction.

The higher tension applied to the warp yarn also results in greater shrinkage in this direction, as the yarns tend to contract once residual stresses incurred during manufacture are relieved. Filament yarns can also be subject to considerable tension and temperature during extrusion, and will inherently contract unless their elastic properties are permanently altered by heat treatment ("heat-set"). This entails exposing the elongated yarn for a reasonable period of time to temperatures higher to that which it is likely to be further processed or subsequently exposed. Tensioned woven fabric can also be similarly treated.

Shrinkage is also caused by moisture absorption during weathering. When wet, yarns swell, causing them to contract in length in the woven matrix and therefore the fabric overall to shrink. The action of heat can have a similar effect. Due to its hydrophilic propensity, cotton shrinks more than synthetic yarn when wetted. Paradoxically, because acrylic yarn does not swell significantly when subjected to moisture, and has relatively low recovery when stretched, woven acrylic fabric tends to expand rather than contract when subjected to weathering.

The density of the woven, untreated fabric is dependent on both the yarn count and the tightness of weave, which is a function of the amount of yarn used. This is usually expressed in "picks per inch" or "picks per centimetre" in the weft, and "ends per inch" or "ends per centimetre" in the warp, although the former can be used generally. Literally it means the number of yarns over that specified length.

**Finishing and Proofing**

Canvas taken off the loom requires stabilisation before further processing can proceed. The aim of this is to remove impurities or residual chemicals ("scouring" and "bleaching") that may affect the further colouring process (if any), and to ensure dimensional stability ("Heat- setting").

Colouring can be achieved by the application of dyes, of which there are wide variety of natural and synthetic, water soluble and insoluble. They can be applied to the fibre, yarn or fabric through physical impregnation, chemical or mechanical bonding.

Natural fibres with their high moisture regain characteristics, are amenable to the application of natural or synthetic dyestuffs, which are soluble in water, and easily applied. On the other hand, because their low moisture regain, the synthetic yarns used in outdoor fabrics are usually pigmented, with the notable exception of Acrylic, which is solution dyed. Pigments are small particles that are insoluble in water. When applied to the textile, they do not penetrate the fibre, but are mechanically or chemically bonded to the surface.

**Figure Four (a)**– A typical weaving mill, in this instance with yarn being inputted directly from bobbins, rather than a beam. The cards and shuttle (foreground machine) are located directly behind the drum in the centre of the picture.


**Figure Four (b) –** Weaving from a beam, which is the large, elevated cylinder in the background.

The expression “solution-dyed” or “dope-dyed” describes the process where pigments are thoroughly mixed into the solution or dope prior to extrusion of the filaments, which means they are blended through the whole yarn structure, not just to a limited depth from the surface. Solution dyeing of the acrylic fibre woven into canvas results in a high degree of colour fastness of the finished product, which does not require colouring after weaving.

Polyester filaments are rarely solution dyed, relying instead on surface impregnation of “disperse” dye at elevated temperature and pressure, and chemical reaction to bond it within the fibre.

Polycotton Canvas is coloured after weaving. The “loomstate”, which is the off-white coloured raw weave (sometimes called “greige”) is usually “pad” dyed, that is passed through a bath of dye-stuff then squeezed between two rollers. Proofing compounds, designed to provide water resistance and protection against fungal attack, are applied the same way.

Unlike polyester, cotton is particularly amenable to this treatment, which is the reason it is incorporated in modern canvases, which are polyester / cotton blends, usually in proportions of between 35/65 and 50/50. This is a classic example of a composite material designed to maximise the intrinsic advantages of the fibres - in this case polyester providing the strength and dimensional stability, and cotton enhanced receptivity to proofing.

Dying and proofing adds weight to the substrate, the amount dependent on the finishing process. Because of the variation that can occur, the weights of acrylic and polycotton canvas are usually quoted in their pre-finished state (“loomstate weight”).

**Water Repellence**

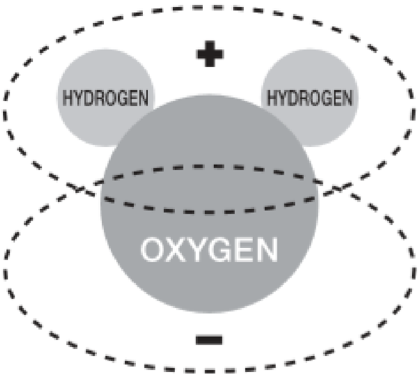
Woven fabrics can be made either “water repellent (resistant)” or “water proof”. A fabric is made water repellent by depositing a hydrophobic material onto the yarns. The interstices between the yarns remain open and allow movement of air and water vapour. “Water-proofing” involves filling these interstices with a physically impermeable substance. The result is a much higher resistance to water pressure, but the loss of vapour permeability.

Vapour permeability of fabric is important in some circumstances. The perceived comfort of clothing, for example, is determined by how well the material facilitates evaporation of moisture from the skin. The more impermeable the material, the less comfortable it will seem to the wearer.

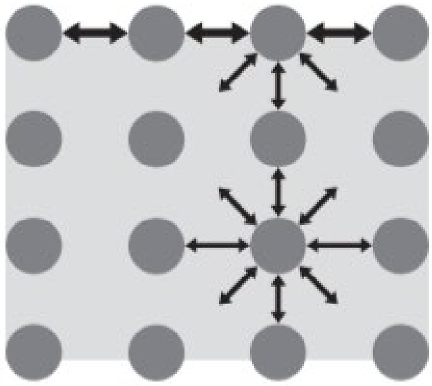
“Water repellency” is dependent on the relative disparity between the surface tension of water droplets and that of the fabric. Wetting, that is seepage into the fabric, occurs when its surface tension is sufficiently high to break that of a water droplet sitting on it.

Surface tension is a force that stems from the polarity of molecules. The water molecule comprises one negatively charged oxygen atom, and two positively charged hydrogen atoms. Even though the total charge of the combination is zero, the positive and negative charges do not totally overlap due to the asymmetry of the molecular structure, as shown in **Figure Five (a)**. This intrinsic characteristic, termed “polarity” or “dipole moment”, results in an electrical attraction between the molecules in the liquid. Those that are submerged are subjected to the same nett force in all directions, but those on the surface are not, and cohere more strongly to their nearest neighbours, as illustrated in **Figure Five (b).**

**Figures Five (a)** – Bipolar Molecular structure of Water **Five (b) –** Cause of Surface Tension




*Surface tension is the result of the asymmetry of the molecular structure of water (and similar dipolar molecules) which causes distortion of its electrical field and...*

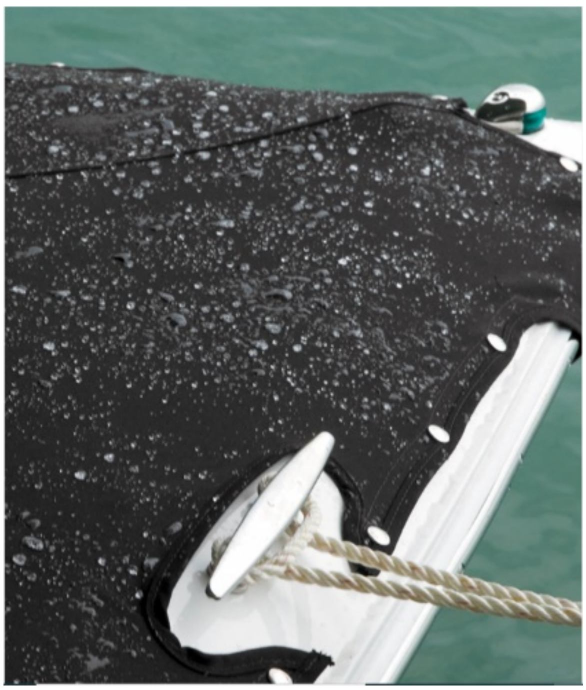


*... leads to the enhancement of intermolecular attractive forces at the surface relative to those in the rest of the liquid.*

This relative enhancement of force at the surface is termed "surface tension", and is the reason water forms droplets, as these cohesive forces pull it into a spherical shape, which is the most energy efficient natural form. This envelope can be distorted or fractured by the action of a counter-acting electrical imbalance, that is, the surface tension of the medium on which they may rest. Thus, the behaviour of water droplets sitting on a particular medium depends on the relative surface tension of each. If that of the droplet is higher than the medium, water will not adhere to or penetrate the surface.

Greater water resistance is achieved by coating the fabric with a substance (e.g. a fluorocarbon or a wax) which has similar polarisation to water, hence increasing the electrical repellence. It is now takes greater force to overcome the increased disparity in surface tension, which incidentally results in much larger droplets being formed on the surface. (**Figure Six**). It becomes more difficult for water to penetrate, but the movement of air and water vapour is unaffected to a large degree.

**Figure Six** – Polarising Effect of Surface Coatings on Water Droplets



This is the basic principle of "water repellency". However, the dipolar forces involved are relatively low compared the pressure of even a very small column (or "hydraulic head") of water, and 500mm is about the maximum that can be expected from proofed canvas and acrylic fabrics in hydraulic tests.

There are a number of water repellent finishes, classified by their chemistry. Most Australian canvas producers proof with a modified emulsion of hydrophobic wax in combination with pigments (for colouring) and rot-proofing agents, the latter based on Zinc or Copper compounds, which impart a greenish hue to the finished cloth. Acrylics (e.g Sunbrella) are proofed with Fluoro-polymers, that is, long chain compounds based on carbon, fluorine and sometimes hydrogen.

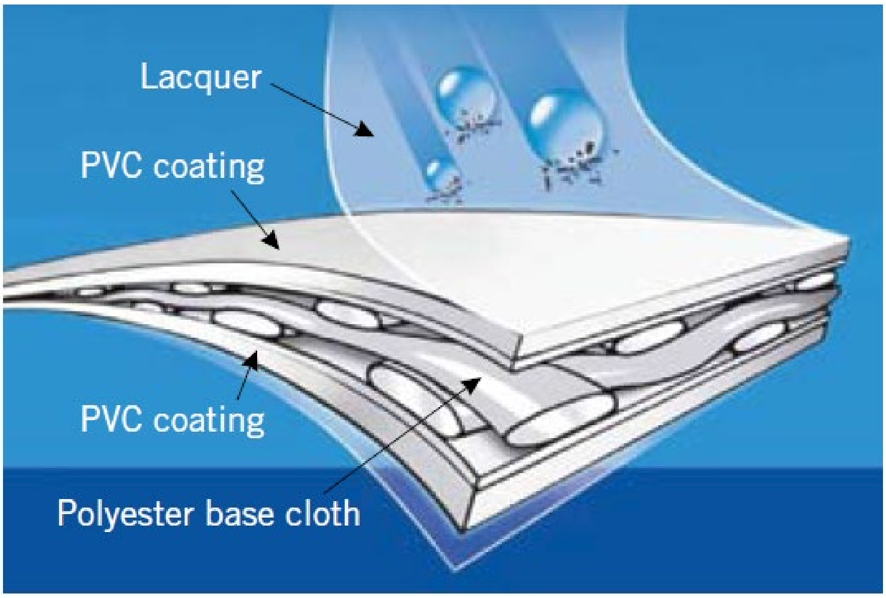
Capillary action is the movement of water upwards against gravity in a thin tube. It is the result of adhesion of the dipolar water molecule to the inside surface of the tube (leading to an upward meniscus at the periphery) coupled with surface tension, which holds the rest of the surface intact as it is drawn upwards. The "wicking" of thread is caused by a similar phenomenon. The combination of "wicking" and the porosity of fabrics is the reason why they "breathe".

The surface tension of water explains the why saturated canvas tents can leak when touched internally. In this case, the surface tension of the water causes a bridge to be formed across the interstices of the finely woven material. Touching the fabric ruptures this bridge, and allows the action of gravity to force the water through.

**LAMINATED OR COATED REINFORCED PVC**

Reinforced PVC is a composite product, comprising a base woven scrim overlain by one or more flexible vinyl films, applied through either lamination (Type C fabric) or coating (Type E Fabric), and in turn lacquered with a protective finish, as shown in the **Figure Seven**.

**Figure Seven** – The structure of Laminated or Coated PVC.




The woven scrim provides tensile and tear strength, and resistance to dimensional change; whereas the vinyl provides waterproofing, abrasion and chemical resistance, which are further enhanced by the protective lacquer. The result is a durable, relatively light-weight fabric, easily maintained and widely used not just in structures, but as awnings, covers, tarpaulins, tent enclosures, marine canopies, banners, billboards and a host of other outdoor applications.

From a life cycle perspective, the main risk to Reinforced PVC Fabrics is degradation due to Ultra-violet light, which attacks plasticisers and undermines the integrity of the polyester scrim. Without protection, the fabric loses strength over time, and becomes brittle, as plasticiser migrates to the surface, which becomes sticky, attracting a residue of dirt that is impossible to clean off. For this reason, surface lacquers play a crucial role in extending the life of the fabric.

The lacquer is a thin coating of less than twenty microns. Acrylic is the most commonly used lacquer for general purpose coated PVC's. It is economic, resistant to chemical attack, and substantively improves the fabrics appearance.

In the context of making a fabric totally impermeable, the outcome of coating and lamination is essentially the same. During the coating process, the water proofing compound (e.g. PVC or polyurethane) is applied in a liquid or molten state, whereas in lamination it is applied as a solid film. Some processes, such as transfer coating, where a molten compound is first spread on release paper and then transferred to the base fabric, are effectively a combination of both processes.

In the case of reinforced PVC, particularly where the PVC is applied to both sides of the fabric, coated products behave a little differently to laminates. Because the PVC is applied in molten or liquid form, it tends to seep into the interstices of the fabric, holding each yarn firmly in place. On the other hand, the solid surface of a laminated film cannot deform to the extent necessary to wrap around every single yarn. This allows the yarns relative freedom of movement to bunch together under the action of an applied tearing force. Thus, a laminate with the same base fabric or scrim as a coated product tends to have a higher tear strength.

Similarly, the thickness of the PVC coating on the high points of the woven substrate is less than on the low points, compared to the more uniform surface of a laminate. This means that for the same weight of impermeable material applied, a laminate tends to have a better abrasion resistance. On the other hand, mechanical adhesion, which is the grip that results from the physical penetration of the interstices of the fabric, is higher in a coated product.

In practice, the base fabrics or scrims of coated and laminated products are very different. Those of coated PVC's tend to be flatter, heavier and more densely woven and therefore have higher break strengths, and at least equivalent tear strengths. On the other hand, the vinyl, as a proportion of total weight, tends to be greater in a laminate.

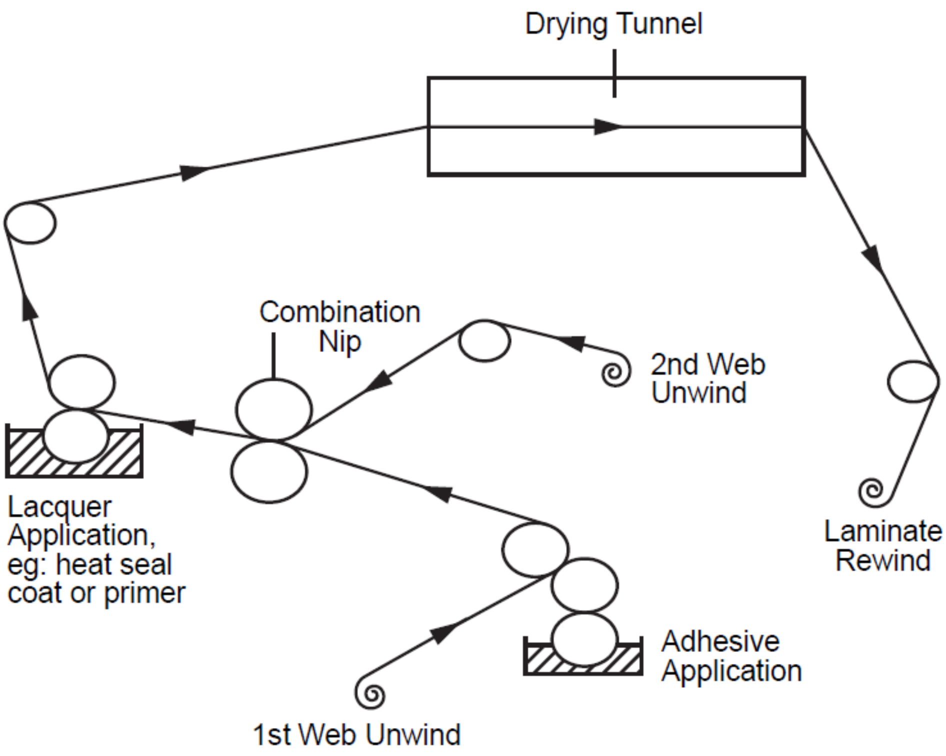
**"TYPE B and C" PVC LAMINATES**

The basic characteristics of the Laminates sold by the Nolan Group are shown in **Tables Four (a) and (b)** .

**The Lamination process**

Lamination is simply the process of joining PVC film to a polyester scrim usually with a pressure sensitive adhesive. This adhesive can applied by 'knife-over-roller' directly to the scrim, or alternatively, for open weave scrims, spread on a release paper and then transfer coated to the PVC film, which is then combined with the polyester scrim by bringing these into contact under heat and pressure (**Figure Eight**). Typical of the adhesives used are natural and synthetic rubber, styrene-butadiene resins (SBRs), polyvinyl alcohol and acrylic polymers.

**Figure Eight –** Schematic view of the lamination process




**The calendaring process**

The PVC film is produced by "calendering", a process whereby PVC resin is heated to a semi-liquid form, and passed over a series of metal rollers to form a thin sheet of film **(figure nine)**. This is subsequently adhered to the reinforcing scrim in a cold state, although it can be heat-set. There can also be several layers of both film and scrim, but most products are either a "single" laminate (Type B) , which comprises one layer of film on the surface of the woven fabric, or a "double" laminate, (Type C) which has film on both sides (**Figure One**). As with coated products, the top and bottom films may be of different thickness.

**Figure Nine –** Schematic view of the PVC calendaring process

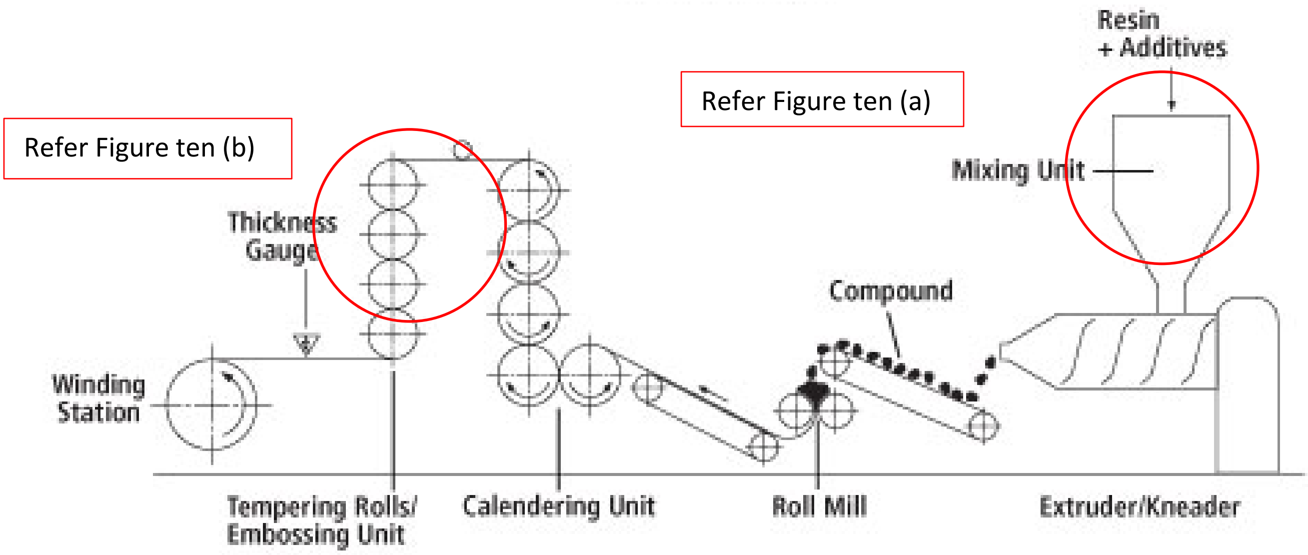


**Figure Ten (a)** – PVC “dough” being mixed prior to being introduced to the Extruder

**Figure Ten (b)** - Calendered PVC being tensioned over rollers

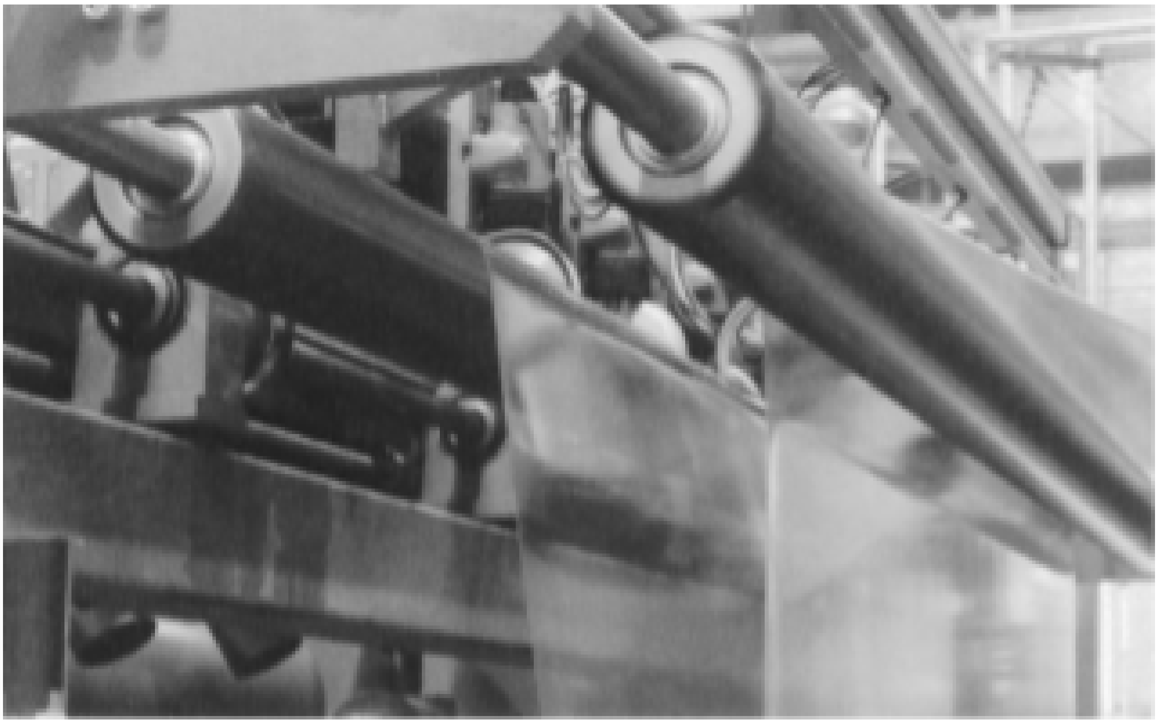


**Table Four (a)** – “Type B” PVC Single Laminates sold by the Nolan Group

| Brand | Nominal finished weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Glen Raven “Seamark” | 543 gsm | 152 cm | 100% woven solution dyed acrylic with fluoro - carbon water repellent finish, with an embossed vinyl laminated to the underside. Fabric is not reversible. Commonly used in marine applications | Commonly used in marine applications Particularly suited where waterproofing is the key objective. |
| “Mariner” Boat Hooding | 695 gsm | 205 cm | 100% woven, mildew treated polyester base cloth with an embossed vinyl film laminated to the surface. | |
| “Road Runner” Tonneau BKG | 695 gsm | 205 cm | Similar in construction to “Mariner”, with the same grey Twill backing. Black vinyl embossed film. | Used for both marine and auto applications. |
| “Road Runner” Tonneau BKB | 750 gsm | 205 cm | 100% woven polyester backing, with “ripstop” weave, dyed black. Laminated to embossed black vinyl film. | Specifically designed for utility tonneau covers. |

**Table Four (b)** – “Type C” PVC Double Laminates sold by the Nolan Group

| Brand | Nominal finished weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Herculite “Riviera” | 509 gsm<br>440 gsm | 200 cm (white)<br>152 cm (Ivory) | UV stabilised, mildew treated, PVC laminated polyester scrim. | Light weight fabric designed for supported marine canopies. |
| “Road Runner” TS | 650 gsm | 205 cm | High strength Polyester scrim with black embossed vinyl laminated both sides. | Heavy duty tonneau or vehicle tray covers |
| Herculite 80 grade | 650 gsm | 152 cm | High Strength Polyester scrim bonded both sides to matt unembossed vinyl. Meets US military specifications. (Milspec) | General purpose industrial, protective covers, trailer and boat covers. |
| Herculite 2000 | 610 gsm | 200 cm | Polyester weft insertion scrim, bonded both sides to unembossed vinyl. Matt finish | |

**Characteristics of Flexible PVC Film**

Polyvinyl chloride is a linear polymer comprised of a linked chain of carbon, hydrogen and chlorine molecules. The addition of plasticisers, which are synthetic oils, softens and adds pliability to the otherwise rigid material. The most commonly used plasticisers are Phthalates e.g. Di Octyl Phthalate (DOP) or now more commonly Diisononyl phthalate (DINP) . Other compounds or elements can be added depending on the desired end-use such as:

1. Adipates – a plasticiser added to maintain stability at low temperatures.
2. Phosphate, Antimony, Zinc and Aluminium – to provide fire retardant properties.
3. Metals e.g. Lead, Barium, Zinc and Tin – to stabilise the PVC structure. (Nolan Group's PVC films do not incorporate these heavy metals.)
4. Calcium Carbonate – a filler to provide bulk, and to improve viscosity.
5. Pigments – for colour or tint.
6. UV Absorbers/Antioxidants – to give outdoor weathering properties.
7. Antistatic additives.
8. Bacteriacides/Fungicides – to inhibit mildew.

The constituents by weight are approximately as follows: Polyvinyl Chloride (66.5%), plasticiser (23% including UV stabiliser), filler (10%) and other additives (0.5%). These additives, although relatively low in concentration, have significant impact on finished product performance and field life. They are also costly, and cannot be discerned by simple visual inspection. Thus, the relative features of competing products of similar appearance can only be compared by careful evaluation of their specifications and comparison of the results of identical tests.

PVC is an unusual material in that in rigid form it is inherently non-flammable, due to the retardant effect of chlorine, but the addition of plasticiser dramatically increases its flammability. Without the addition of flame retardants, flexible reinforced PVC would be unlikely to pass the most basic of regulatory standards. Like all thermoplastic materials, PVC softens under the action of heat, and physical properties are in part temperature dependent. Flexible PVC is not an inert material, and although it has good overall chemical resistance, it can be attacked by powerful oxidising agents, such as hydrogen peroxide, and other chemicals such as acetone, sometimes found in industrial cleaners.

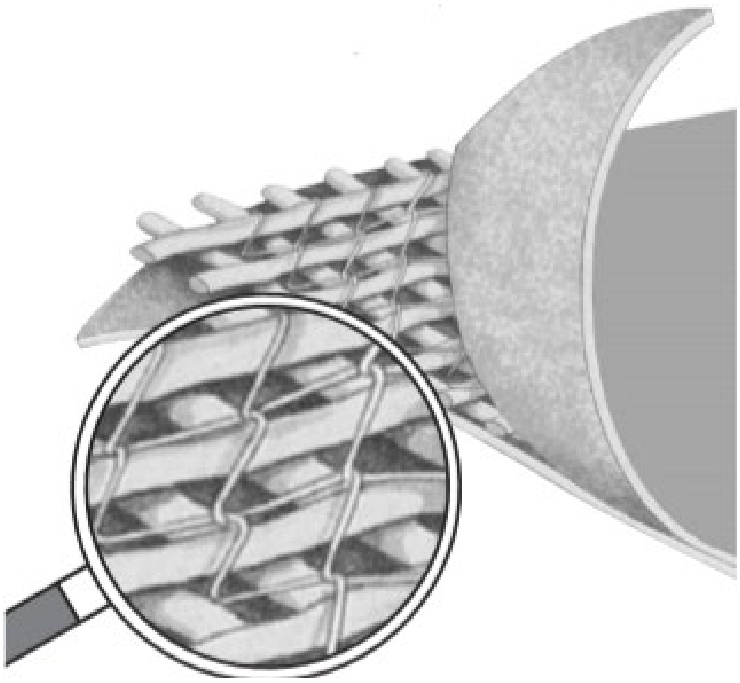
**Characteristics of Polyester Scrim**

The basic building block of scrim is the polyester filament fibre, which is twisted slightly to increase its tensile strength (to form a fibre of "high tenacity") and heat set to control fabric shrinkage during lamination. High tenacity polyester fibre is very stable, and relative to other types of synthetic fibres, has many desirable characteristics, such as good chemical resistance, low moisture regain (0.4%), good elastic recovery, and reasonable tensile strength. As with polycotton canvas, the raw polyester fibres are vulnerable to UV degradation, losing up to 50% of their initial tensile strength over time, but are protected by UV inhibitors in the PVC film.

The filaments themselves are combined into a yarn, either laid loosely in parallel, or twisted together. Once the yarns are made they are formed into a base fabric, either by weaving (usually a "Plain Weave", or simply by being laid one across the other, and tied together with a third yarn ("weft insertion"), as shown in **Figure Eleven.**

The tightness of weave influences the characteristics of the end-product. A loosely woven scrim allows a high adhesion to be developed with the compatible films on either side of the scrim. It has high tear strength, because the looseness allows "bunching" of the yarns under the action of tearing, but relatively low tensile strength because there aren't many of them. On the other hand, a tightly woven scrim has a high tensile strength, but relatively low tear strength for exactly the opposite reason. The films on a tightly woven scrim rely entirely on the chemical bond with the scrim itself. As with canvas, the different relative yarn tension in the warp and weft direction means that the tear and tensile behaviour is also different, with the extension under loading much more pronounced in the weft than the warp for "Plain Weave" scrim.

**Figure Eleven** – Schematic view of a "Weft Insertion" Scrim.



The terminology of "warp" and "weft" is also used to describe weft insertion scrims, but because the yarns deform the same way (by simply stretching), the ultimate load and elongation characteristics are similar in each direction. A weft insertion scrim tends to have lower tear and tensile strengths relative to a plain weave of the same yarn composition. They are however much flatter, since the overall thickness approximates two layers of yarn, compared to three in a woven fabric. This results in a smoother finish of the PVC film, which is particularly important when printing of the surface is envisaged.

**Surface Lacquers**

Most reinforced PVC's have a thin surface lacquer applied in order to provide additional protection to the PVC from UV degradation and improve its cleanability. Types of finishes can be fluoro compounds such as polyvinylflouride (PVF), sometimes known by the tradename "Tedlar", a registered trade name of DuPont, or polyvinyldenefluoride (PVDF); or based on Acrylic or Urethane. These tend to impart a gloss on the surface, but the fact that a product has a glossy appearance does not mean that a surface coating has been applied.

**"TYPE E" COATED PVC FABRICS**

The term "Coated" refers to a method of stabilising and waterproofing the base fabric, by application of a coating compound in liquid or molten form. The basic characteristics of the coated PVC's sold by the Nolan Group are shown in **Tables Five (a) and (b)**.

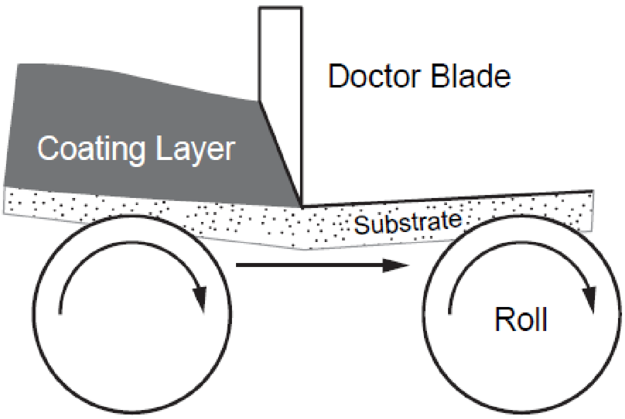
**Coating Process**

The PVC in coated fabrics is most commonly applied as a liquid paste at room temperature directly onto the scrim, the depth of coating controlled by a blade accurately positioned to scrape surplus material from the surface. Coating thickness is also influenced by the blade profile, fabric tension and the viscosity of the applied paste. For thin layers, it can be applied directly to the fabric i.e. knife-over-air **Figure Twelve (a),** but most commonly the moving fabric substrate is usually supported by a roller, i.e. 'knife-over-roller' **Figure Twelve (b)**. The coated fabric is then passed through an oven to permanently thermoset the PVC. Several passes may be involved, on both sides of the fabric, an initial pass being a tie coat that penetrates the interstices of the fabric, and provides an adhesive base for subsequent coats.

Other methods include extrusion, casting and transfer coating. In extrusion coating, the PVC deposited is controlled by a dye rather than a knife. Casting is similar to calendaring, where the vinyl is produced as a molten film, and fused to the scrim via a carrier web, once the film has sufficient cohesion to be peeled off. Transfer coating involves applying the coating to a release paper, and then transferring the film to the Polyester substrate, as shown in **Figure Twelve (c)**. This latter method is usually applied to very open weave scrims, which are not suited to direct coating.

**Figure Twelve – Coating processes**

**(a)** Knife-over-air




**(b)** Knife-over-roller

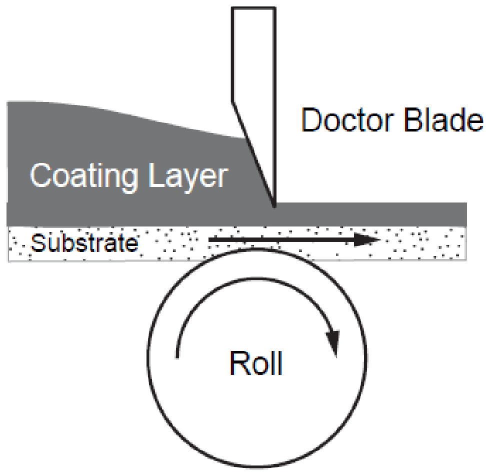


**Figure Twelve (c) – Transfer coating**

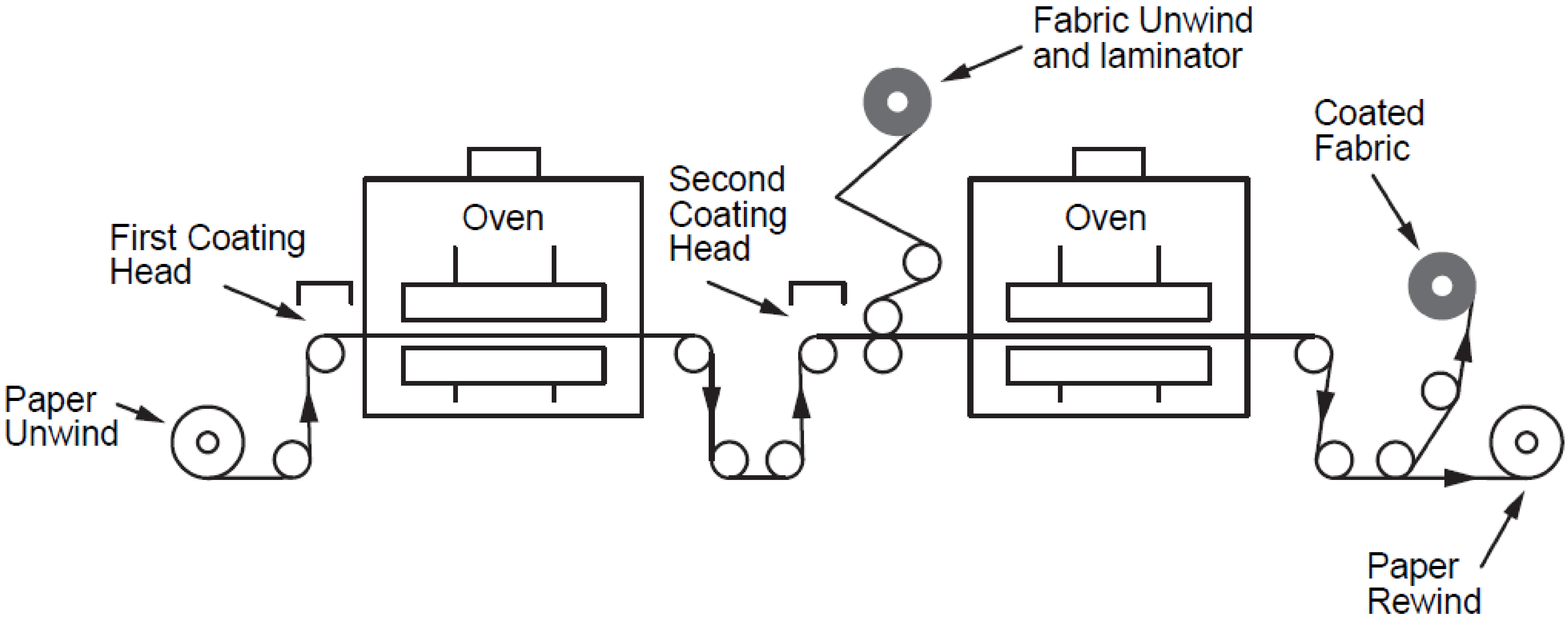



**Figure Twelve (d)**
Liquid PVC poured onto "Release" Paper

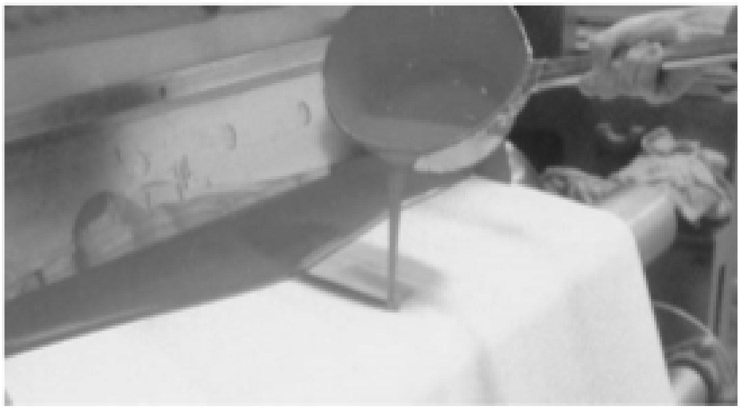


**Figure Twelve (e)**
Release Paper being separated from the Vinyl film

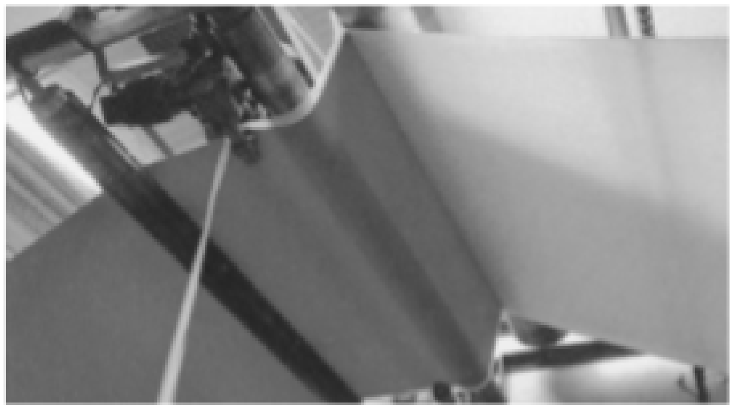


**Table Five (a)** – "Type E" ProTEX® PVC Coated Polyester Fabrics sold by the Nolan Group

| Brand | Nominal finished weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| PT Extra | 500 gsm | 250cm | Plain Weave, high tenacity polyester scrim. Acrylic lacquer both sides. Meets the "Medium Duty" Classification of AS 2930 – 1987 "Textiles – Coated Fabrics for Tarpaulins" | Static roof covers, light weight tarpaulins, canopy covers, temporary work shelters, welding screens, pipeline trench lining. |
| Spanlite | 537 gsm | 250cm | | |
| GP | 680 gsm | 250 or 300 cm | Construction as above. Meets the "Heavy Duty" Classification of AS 2930 – 1987 | Marquees, awnings, jumping castles, tarpaulins, canopy covers. |
| Toughstuff | 610 gsm | 205 gsm | | |
| Side-Curtain | 900 gsm | 320 cm | Panama Weave, high tenacity polyester scrim. Acrylic lacquer both sides. Meets the "Heavy Duty" Classification of AS 2930 – 1987 | Specifically designed for long haul road and rail transport side curtains and roll over covers. |
| TS | 680 gsm | 205 cm | "Tearstop" Weave, high tenacity polyester scrim. Acrylic lacquer both sides. Meets the "Heavy Duty" Classification of AS 2930 – 1987 | Medium weight, additionally reinforced fabric suited for Industrial and transport applications |
| ETS | 680 gsm | 320 cm | | |
| ETS "FRAS | 680 gsm | 250 cm | Construction as for ETS above, but with Fire Retadant and Anti-static properties that meet NSW Government Mine Safety Guideline MDG 3608 | Specifically designed for general purpose applications in underground or Open Cut coal mines. |

**Table Five (b)** – "Type E" Polyplan® PVC Coated Polyester Fabrics sold by the Nolan Group

| Brand | Nominal finished weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| 680 | 670 gsm | 250 cm | Plain Weave, 1100 Dtex high tenacity polyester scrim, with same yarn count in each direction. Acrylic lacquer both sides. | Light weight Architectural fabrics designed for small shade structures and fixed wind rated umbrellas |
| 680 BO | 780 gsm | 250 cm | Construction as for 680 but with Block -out coating | |
| 680 LW | 670 gsm | 250 cm | Construction as for 680 but with low wicking yarn. | |
| 745 | 640 gsm | 300 cm | Similar construction to 680 but Matt finish | |
| 787 | 780 gsm | 300 cm | Similar construction to 680 BO but Matt finish | |
| Candy | 690 gsm | 300 cm | Similar construction to 680 but Translucent | |
| Atlas Type 1 | 700 gsm | 250 cm | PVC Coated, high tenacity, anti-wicking polyester scrim, with a patented "Atlas" weave is designed to promote similar elastic behaviour in the warp and weft directions. Incorporates a weldable PVDF lacquer with Titanium Dioxide finish. | All tensile structure applications. Fabrics meet the specifications of the European Design Code. |
| Type 2 | 900 gsm | | | |
| Type 3 | 1200 gsm | | | |
| Type 4 | 1350 gsm | | | |
| Type 5 | 1550 gsm | | | |

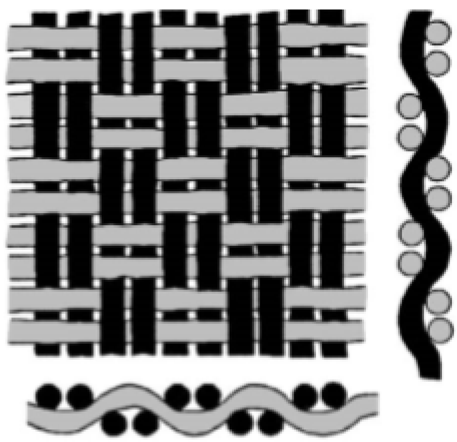
**Types of Scrim in PVC Coated Polyesters**

The polyester yarn used in coated PVCs is an extruded mono-filament, twisted to increase its tensile strength (hence the term “high tenacity”), and then heat set to control shrinkage during the PVC coating process. Because of the need to support the molten PVC as it is applied, the scrim of coated fabrics is almost always a dense plain weave, but in some instances has slight differences in the layout of the yarn matrix designed to enhance strength properties.

Most scrims have a basic one to one ratio in warp and weft directions, but ProTEX “Side-Curtain” has a two by two ‘Panama weave’; and ProTEX TS and ETS have a ‘Tearstop weave’, as shown in **Figures Thirteen (a) and (b)** respectively. Both structures significantly increase tear strength, relative to a plain weave of the same weight, but the doubling up of a heavier denier yarn in the ‘Tearstop’ results in a bulge in the coating **Figure Thirteen (c)**, which affects the appearance, print receptiveness and possibly abrasion resistance.

**Figure Thirteen** – Types of weave

**(a) Panama Weave**



**(b) “Tear-stop” weave**

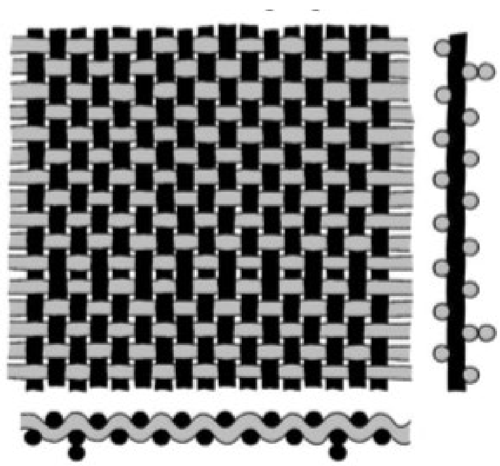
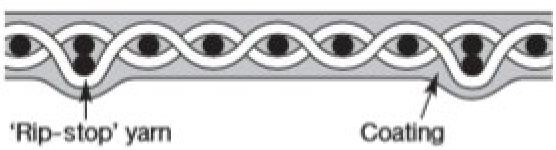


**Figure Thirteen (c) – Bulge in the PVC coating resulting from a “Tear-stop” weave**




**“TYPE E” PVC COATED POLYESTER MESH**

PVC coated polyester mesh is simply an open “Plain Weave” fabric. There are two ways of making it, either by coating each yarn individually, or by dipping a raw polyester substrate in a molten PVC bath.

In the first, each PVC yarn within the matrix is individually extruded and bonded to the polyester core yarn. The PVC coating completely seals the polyester fibre, making it durable and waterproof; and also provides a physical bond between the warp and weft yarns, which introduces remarkable dimensional stability to the entwinned mesh. The strength of the mesh is determined by the denier of the polyester yarn, its “tenacity” and the “pick count” (i.e. how many yarns per centimetre). The heavier the denier and the higher the pick count, the stronger the final fabric and greater its dimensional stability. Both the “Vistaweave” and “Meshtex” ranges sold by the Nolan Group are manufactured in this way.

The basic characteristics of these products are shown in **Table Six (a).**

Vistaweave mesh is designed for use as outdoor blinds, and has a high level of UV inhibitors, flame retardants, and fungicides added to the PVC formulation. In Vistaweave 95, the warp and weft yarns are of similar denier, and the pick count is practically identical in each direction. This means that the appearance and physical properties (i.e. tear and tensile strength) are also similar in each direction. The advantage of this is that this mesh can be “rail-roaded”, that is, aligned with the weft perpendicular to the drop.

The Meshtex ranges are designed for camping, screens, transport and general industrial use, and are less dense, and hence lighter in weight, with sometimes a differing pick count in each direction.

### “**TYPE E” COATED POLYOLEFINS**

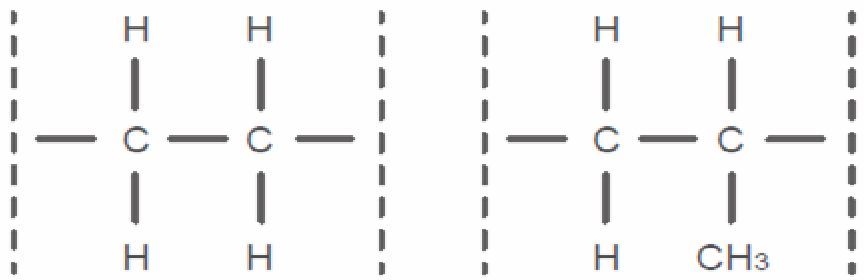
Polyolefin is a commonly used chemical nomenclature that describes a family of similar hydrocarbon polymers, which are continuous chains of a distinct molecular structure linked in a repetitive way. The most well known polyolefins are polyethylene and polypropylene, which are used as both the base yarn and the coating of a number of woven outdoor fabrics sold by the Nolan Group. The basic characteristics of these are listed in **Tables Six (b)** .

### Properties of Polyethylene and Polypropylene

Polyethylene has the molecular structure shown in **Figure Fourteen (a)**. Low density polyethylene (LDPE) and high density polyethylene (HDPE) are almost identical except that HDPE is more linear in structure, with less branching of the polymer chains, which results in better tensile properties. Polypropylene is similar in structure to polyethylene, except that every fourth hydrogen is replaced with a $CH_3$ (or Methyl) group, as shown in **Figure Fourteen (b)**. Although similar in structure, the change in molecular arrangement results in slightly different properties, which can be further altered by other additives, such as UV inhibitors or flame retardants. These differences are reflected in the performance attributes of the finished fabrics.

**Figure Fourteen** – Molecular Structure of Ethylene and Propylene

(a) Ethylene (b) Propylene




*These basic molecules become polymers when the basic structure between the dashed lines become linked into continuous chains.*

**Table Six (a)** – "Type E" PVC Coated Polyester Mesh Fabrics sold by the Nolan Group

| Brand | Nominal weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Vistaweave 95 | 530 gsm | 270cm & 320 cm | A dual yarn weave, with a 37 x 35 pick count and 5% Openness Factor. UV stabilised with Flame Retardants and Fungicides added to the PVC formulation. | Designed for awnings and blinds, and general outdoor applications, including seating |
| Vistaweave 99 | 710 gsm | 300 cm | Similar construction to Vistaweave 95, but with a 36 x 24 pick count and 1% openness factor. | |
| Vistaweave Stripe | 500 gsm | 270cm | Similar construction to Vistaweave 95, but with a 36 x 16 pick count. | |
| Meshtex Micro | 140 gsm | 189 cm | A PVC coated Polyester mesh with a 420 Denier yarn, 24 x 24 pick count | Windows in fixed and roll-up awnings, doors, privacy screens and general camping applications |
| Meshtex Maxi | 180 gsm | 189 cm | Similar Construction with a 250 Denier yarn, 16 x 16 pick count | |
| Meshtex Breeze | 420 gsm | 200 cm | Similar Construction with a 1000 Denier yarn, 16 x 12 pick count | Furniture, Marine and general outdoor applications |
| Meshtex Cover | 420 gsm | 250 cm | Similar Construction with a 1000 Denier yarn, 16 x 16 pick count | Covers and screening |
| Meshtex 401 | 440 gsm | 189 cm | Similar Construction with a 27 x 30 pick count | Commercial and domestic screening |
| Meshtex Truck | 320 gsm | 300 gsm | Similar Construction with a 1000 Denier yarn, 13 x 9 pick count | Permeable Truck and Trailer Covers |

**Table Six (b)** – "Type E" Coated PolyOlefin Fabrics sold by the Nolan Group

| Brand | Nominal weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Polyfab® SolarPro | 180gsm | 183cm,205cm,or270gsm | 10 x 10 pick count, 1000 denier HDPE tape coated with LDPE of 45 micron thickness on both sides | General purpose light weight cover for rural and horticultural applications, camping and Industrial such as machinery covers, tent flooring and emergency roofing tarpaulins |
| Polyfab® Polyshield | 250 gsm | 205 cm | 12 x 12 pick count, 1500 denier HDPE tape coated with LDPE of 55 micron thickness on both sides | |
| Flexicover | 350 gsm | 205 cm | Plain Weave Polpropylene scxrim, also coated both sides with PP. Similar in construction to a PVC coated Polyester. | Specifically designed for large scale, recyclable grain covers. |

When their physical properties are corelated (**Table Seven)**, the intrinsic similarities between the polymers become obvious. The differences are also subtle. Apart from very similar inherent tensile strength, both are chemically inert and do not absorb water. They have good abrasion resistance, uniform elastic properties, and are lighter than water. They both have similar flammability behaviour and rely heavily on added inhibitors for UV stability. Although both are largely unreactive chemically, the presence of the $CH_3$ (methyl) group in polypropylene makes it slightly more susceptible than polyethylene to attack by strong oxidising agents. Its relative advantages are its greater flex crack resistance and its higher temperature resistance, which means it is more amenable to annealing (and therefore tensile strength enhancement) during yarn production.

**Table Seven –** Comparative properties of Polyethylene and Polypropylene yarns

| **Property** | **Polyethylene** | **Polypropylene** |
|---|---|---|
| Tenacity (grams/denier) | 4.0 to 5.5 | 4.0 to 8.0 |
| Melting Point ($^{o}$Celsius) | 110 to 120 | 160 to 170 |
| Specific Gravity | 0.93 to 0.96 | 0.92 to 0.98 |
| Moisture Regain (%) | <0.01 | <0.01 |
| Limiting Oxygen Index | 17 | 17.5 |

**Yarn Production**

There are two types of yarn used in the manufacture of coated polyolefin fabrics – flat tape and multifilament – and the process of manufacture is different for each type. Both commence with extrusion, which as previously mentioned, is a process where pellets of polymer resin are mixed, melted, then forced under pressure through a die by a large worm gear enclosed in a cylinder. UV stabiliser is added to the master batch, and is mixed into the base resin during the extrusion process.

In the case of flat tape yarn, the molten dough is forced through a fishtailed shaped dye to form a thin film, which is cooled in a cold water bath and pulled under tension through a slitter. The slit tapes are then annealed, that is, reheated under tension to orient the long chain molecules in order to increase tensile strength and elasticity, and then wound onto a bobbin. The width of the tape is determined by the width set in the slitting machine.

In the case of multifilament yarn, the molten dough is extruded through fine holes in a spinneret nozzle, the number and size of the holes determining the ultimate composition of the yarn. The twisted viscous filaments are solidified by air cooling and then also annealed, before being wound on a bobbin. Flat tape yarns are used in the manufacture of "Solarpro®", and "Polyshield®"; and multifilament in the manufacture of the scrim of "Flexicover®".

**Weaving and Coating**

Weaving of Polyolefin fabrics follows the same process as other "Plain Weave" textiles, but is complicated when tape yarns are woven. These can be twisted and buckled in the loom, which makes production of a perfectly smooth and homogeneous surface in these types of fabrics virtually impossible.

Coating is by extrusion, but in this case more than one extruder is used at the same time (a process termed "co-extrusion"), which allows a high level of precision. For example, in a single pass, colour pigment can be applied in layers so that more is found at the surface than at the base of the coating. This is an advantage where the coating on the reverse side is a different colour, or a black scrim is used.

Similarly, particular grades of resin can be selected and layered accordingly, say on the basis of adhesion propensity close to the scrim, and heat tolerance at the surface. The coating applied is generally less than 70 microns (0.07mm) in thickness, but represents about half the weight of the finished fabric. It also makes the fabric stiffer and reduces its raw tear strength.

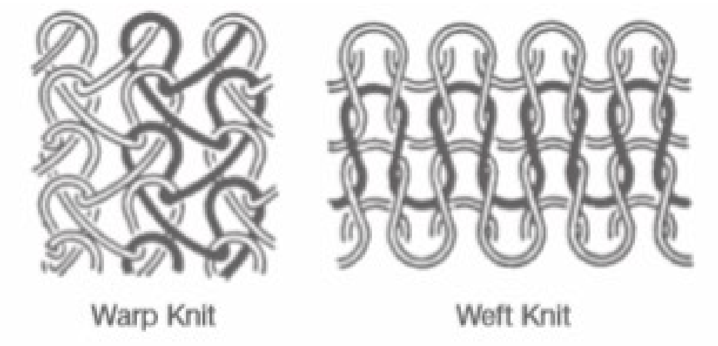
Generally, adhesion, weldability, and water resistance are directly related to coating thickness, although the quality of the resin used is also significant. Because the coating applied has the same chemical composition as the internal scrim, the finished fabrics are homogeneous. This is an advantage in a recycling process, as no separation of the scrim from the coating is required, which is the case with PVC coated polyester.

The inclusion of colour pigments and UV stabilisers alters the intrinsic chemical resistance of the polyolefins. For example, UV stabiliser is attacked by halogens (e.g Chlorine, Bromine), sulphur, and concentrated acids.

"**TYPE F" – KNITTED FABRICS**

Knitting is the process of making a substrate with a continuous yarn looped through neighbouring yarns to make a chain of stitches. The two basic categories of knitting are known as "warp knit" or "weft knit", are illustrated in **Figure Fifteen**. A warp knit has multiple yarns running vertically, each connected to its immediate neighbour (e.g a Tricot knit). A weft knit has a single yarn running in a horizontal direction, looped around the row below.

**Figure Fifteen** – Basic types of knit




Warp knits are made on flat bed machines with parallel lines of longitudinal yarns arranged like those in a weaving loom. Each yarn is controlled by a separate needle which loops it onto itself, at the same time as lateral oscillation to and fro causes connection to its neighbours.

The knitting process can also be used to hold in position two or more sets of parallel yarns, one placed atop and at different angles to the other. Examples of this is the "weft insertion scrim" (figure eleven) often used in reinforced PVC laminate fabrics; and Polyfab Parasol shadecloth, that has a tape insert in the tricot knit that is designed to increase the shade factor of the fabric.

The Nolan Group's horticultural shadecloth products are knitted from polyethylene, as are the heavier shadecloths designed for human protection. The basic characteristics of these products are shown in **Table Eight (a) and (b);** and the specification for each of these products can be found in Technical Guide Number Two "Shady Characters – Polyfab Shadecloth for Human Protection".

**Table Eight (a)** – Polyfab® Knitted commercial shadecloth  sold by the Nolan Group

| Brand | Nominal weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Parasol<br>PolyFX<br>Comshade<br>Comshade Xtra | 325 gsm<br>236 gsm<br>330 gsm<br>400 gsm | 3.0 m<br>3.80 m<br>3.8 m or 6.0 m<br>4.0 m | Knitted HDPE fabric with tape insert. UV stabilised, heat set. Designed to meet the requirements of AS 4174:2018 "Knitted and Woven Shade Fabrics" | Commercial Shade structures, including playgrounds, school yards, etc; either tensioned or frame supported |
| Architec 400 | 400 gsm | 3.8 m | Knitted HDPE monofilament yarn only | Heavy duty structural fabric. |

**Table Eight (b)** – Polyfab® Knitted Horticultural Fabrics sold by the Nolan Group

| Brand | Nominal weight (gsm) | Nominal Width | Description | Recommended applications |
|---|---|---|---|---|
| Covershade Extra-light<br>Light<br>Medium<br>Heavy | 90 gsm<br>170 gsm<br>200 gsm<br>260 gsm | 3.66 m standard. Some colours available in 1.83 m or 6.1 m | Knitted HDPE UV stabilised yarn with shade factor of 26% to 34%<br>Knitted HDPE UV stabilised yarn with shade factor of 50% to 56%<br>Knitted HDPE UV stabilised yarn with shade factor of 64% to 70%<br>Knitted HDPE UV stabilised yarn with shade factor of 74% to 80% | Horticultural and agricultural covers, livestock shading and protection, site screens, and scaffold covers |
| Bird netting | 35 gsm | 5m,10m,15m,or 20m. | Knitted UV stabilised, monofilament HDPE yarn, 12 mm x 12 mm Heaxagonal construction | Crop protection |
| Horticover Light<br>Medium | 90 gsm<br>120 gsm | 3.66m | Knitted UV stabilised HDPE tape | Hothouse igloos |

**FLEXIBLE CLEAR PVC**

Flexible clear PVC is widely used as a glazing material in awnings, tent enclosures, marine canopies and motor vehicle soft-tops. The basic characteristics of the Clear PVC sold by the Nolan Group are shown in **Table Nine.**

There are essentially three types of flexible PVC available on the market, "calendered", "extruded" or "pressed polished", each type named after its form of manufacture.

The calendaring process is the same as that used to manufacture PVC film laminate, as discussed above. The initial calendered thickness is usually no more than 0.1 mm, and greater thicknesses (0.75 mmm or 1.0 mm are typically used in awning and marine applications) is the result of lamination. In extrusion, the liquid is pushed or pulled through a die, which results in a smoother surface finish, and therefore better visual clarity.

In the press polished process, calendered PVC sheets are further processed to improve clarity. These are laid between highly polished stainless steel plates, which are in turn stacked in an hydraulic hot press. As steam is applied, the PVC becomes soft, and under pressure the original calendered sheets are laminated together, and the ultra-smooth surface of the plate replicated on both sides.

Because of cost, the most common form of PVC sheet used in blinds is calendered. Like PVC coated polyester, the PVC mix has UV stabilisers, flame retardants and fungicides added, as well as a tint pigments, which can be of different degree of intensity.

**Figure Sixteen** – Press Polished Sheets being removed from the stainless steel plates

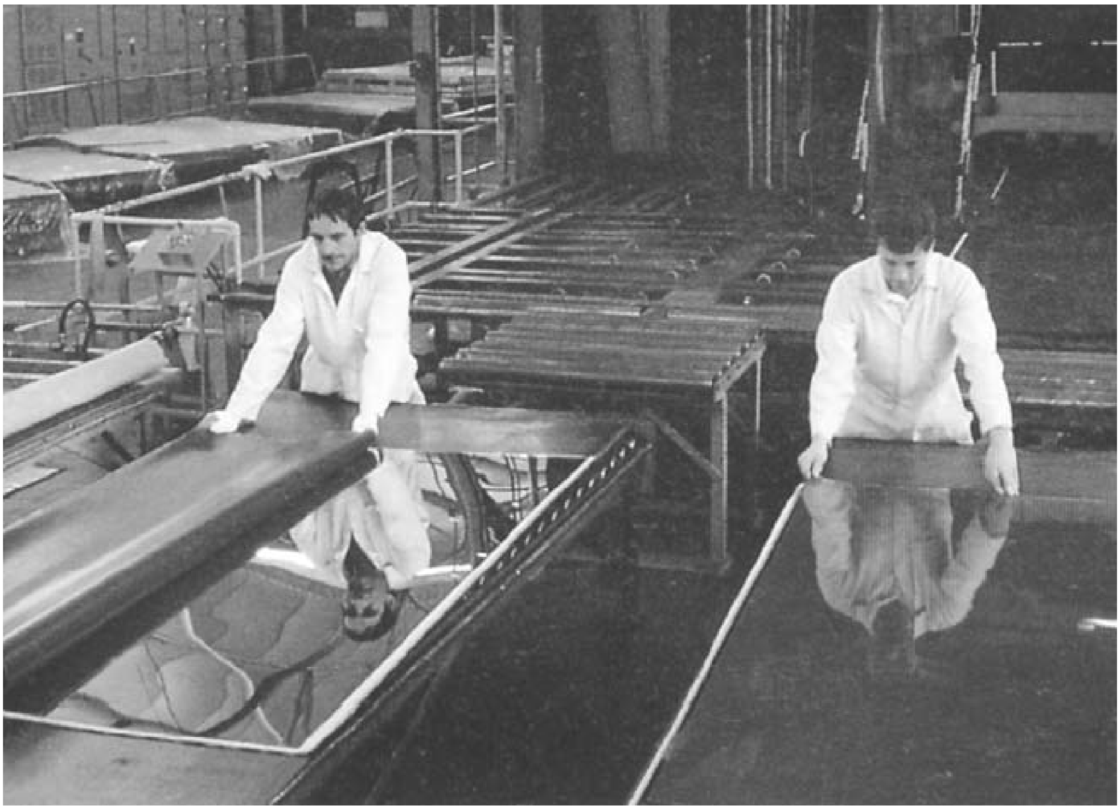


**Table Nine** – The types of Flexible Clear PVC sold by the nolan Group

| Nolan brand | Manufacturing process | Thickness (mm) or gauge (inches) | Dimensions | Tint Colour (if applicable) | Features and applications |
|---|---|---|---|---|---|
| ACHILLES:- | | | | | |
| Rollclear SLS | Calendered | 0.5mm (.020") | 137cm x 40m roll | | The SLS additive prevents sticking, enabling problem free rolling. Product noted with an asterisk is specially formulated to be dimensionally stable (DS). A budget priced product and suited for applications where visual clarity is not the prime motive for product selection. |
| | | 0.75mm (.030") | 137cm x 30m or 40m roll | | |
| | | 1.00mm (.040") | 137cm x 25m roll | | |
| Rollclear Tint | Calendered | 0.75mm (.030") | 137cm x 30m roll | Bronze | |
| | | 0.75mm (.030") | 137cm x 30m roll | Smoke | |
| | | 1.0mm (.040") | 137cm x 25m roll | Smoke | |
| Rollglass | Extruded | 0.75 mm (.030") | 137cm x 30m roll | | Excellent visual clarity. Ideally suited for large flybridge enclosures, which require a minimum of joins. |
| | | 0.75 mm (.030") | 137cm x 20m roll | Black | |
| | | 1.00mm (.040") | 137cm x 14m or 20m roll | | |
| | | 1.00mm (.040") | 137cm x 14m | Smoke | |
| | | 1.00mm (.040") | 183cm x 14m | | |
| Rollglass plus | | 0.75 mm (.030") | 137cm x 20m roll | | The 'plus' option has higher levels of UV inhibitor and extended warranty. |
| | | 1.00mm (.040") | 137cm x 14m roll | | |
| HERCULITE:- | | | | | |
| Crystal Clear | Press Polished | 0.5mm (.020") | 137 cm x 280 cm sheet | | Excellent visual clarity and dimensional stability. Suited for all marine flexible glazing applications. |
| | | 0.75 mm (.030") | 137 cm x 280 cm sheet | | |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | | |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | Light Smoke | |
| NOLAN GROUP:- | | | | | |
| Vybak | Press Polished | 1.00mm (.040") | 137 cm x 280 cm sheet | | Vybak has a 'soft' formulation and proven performance in Australia over many decades. |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | Smoke | |
| HERCULITE:- | | | | | |
| Strataglass | Press Polished & PU Coated | 0.75 mm (.030") | 137 cm x 280 cm sheet | | Incorporates scratch resistant surface coating on both sides, which also reduces plasticiser migration, and extends life. |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | | |
| | | 1.50mm (.060") | 137 cm x 280 cm sheet | | |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | Light Smoke | |
| | | 1.00mm (.040") | 137 cm x 280 cm sheet | Dark Smoke | |

## TYPES OF UPHOLSTERY COVER MATERIALS

There are six types of upholstery seating which have been sold by the Nolan Group during its long history.

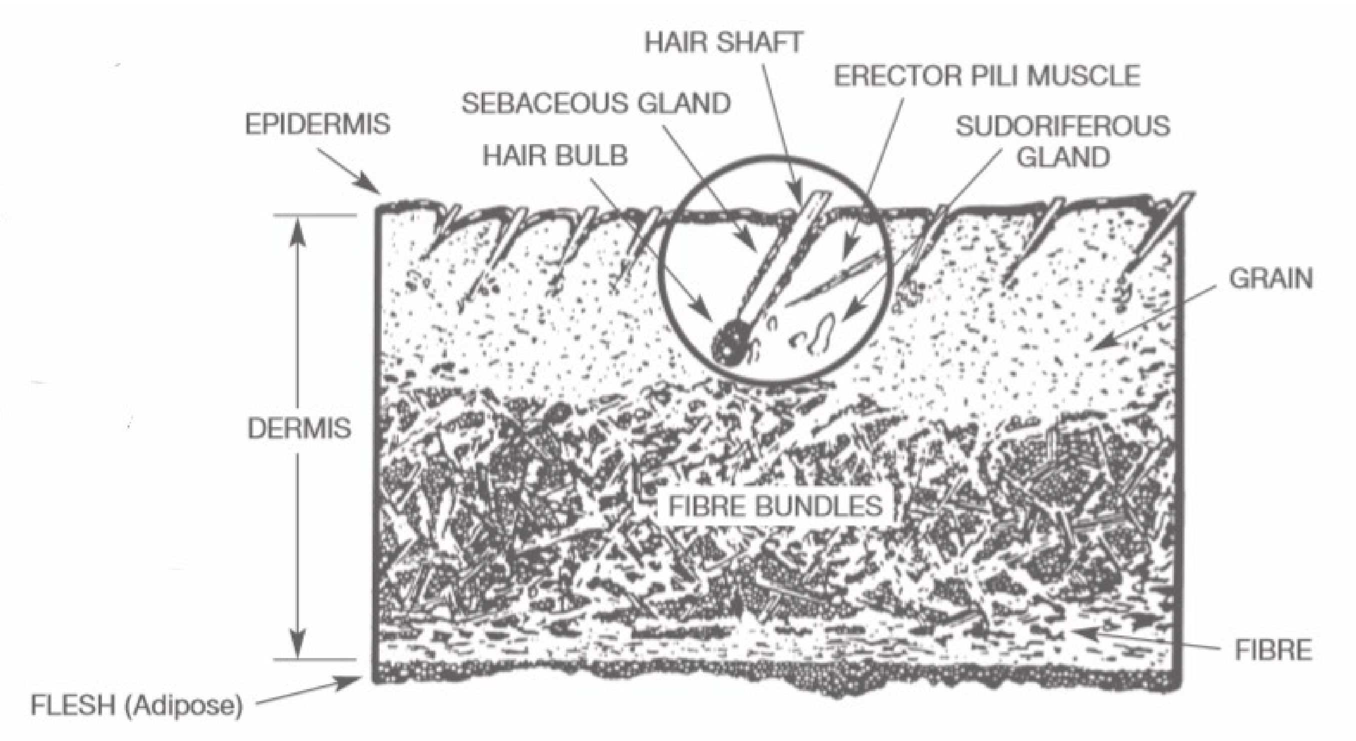
- Leather
- Polyurethane
- Velours / Velvets
- Non-wovens
- Woven Fabrics
- Expanded Vinyl

The basic characteristics of the current ranges of Upholstery and Mattress Ticking fabrics are listed in **Tables ten (a)** through **(c).**

### Leather

Both Leather and suede are manufactured from cattle hide (refer **figure Seventeen**). During the tanning process, the hide is cleaned and stabilised through chemical treatment; then mechanically stretched and softened to improve its feel; and ultimately split horizontally into two halves. The top side of the Dermis becomes Upholstery and Automotive leather, and suede is manufactured from the bottom side.

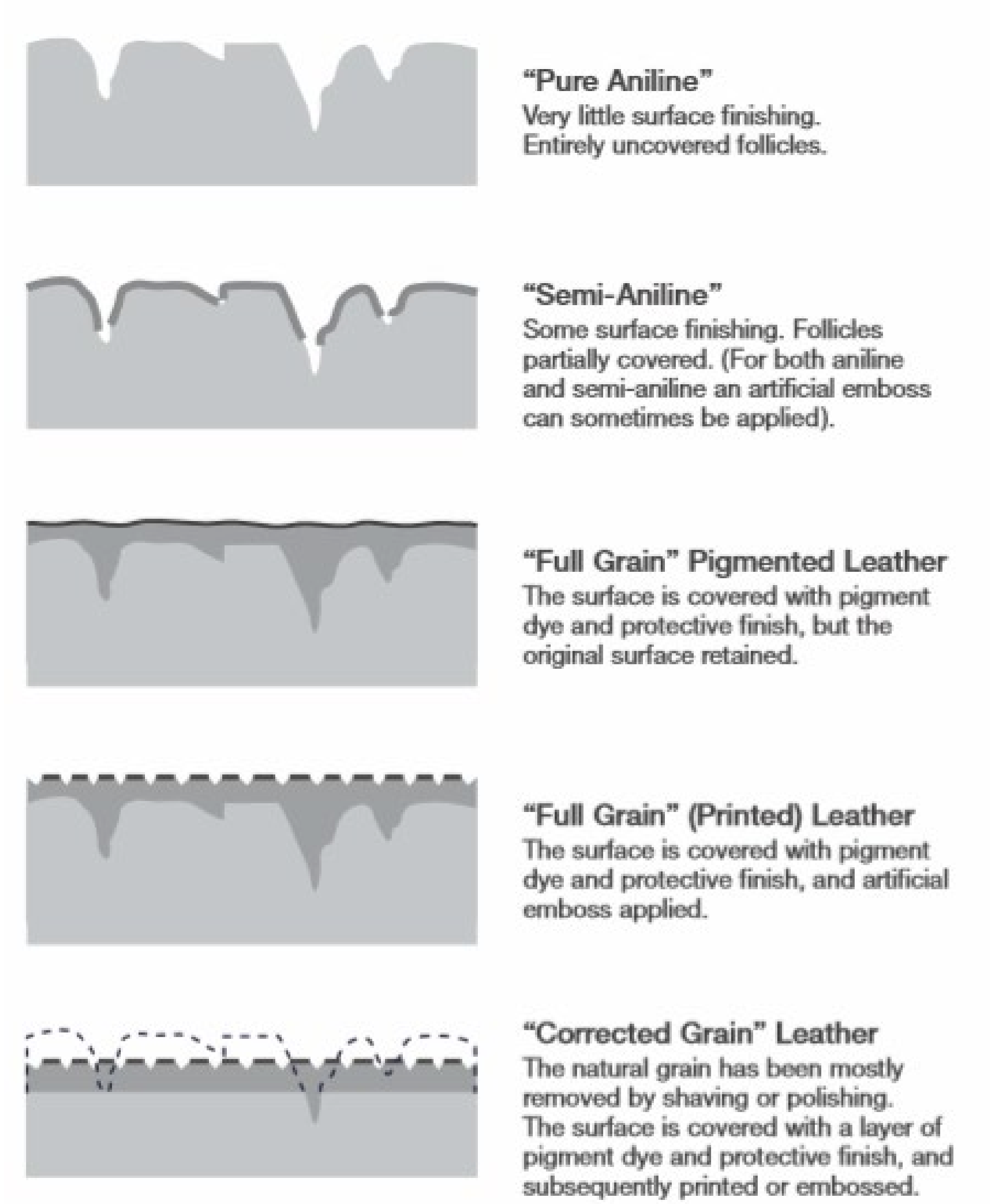
**Figure Seventeen** – Raw hide characteristics




The quality of the stabilised, uncoloured upholstery hide, which is dictated by the extent of natural scarring and marking, determines the extent of further finishing required. Leather "breathes" through the follicles or the hair sockets of the original hide, and the extent to which these are preserved dictates seating comfort. Thus, the less the surface treatment, the more natural and comfortable the leather; but the extent of the original scarring and marking is obvious, and it is less durable than leather that undergoes further processing. The nomenclature describing the types of leather, and the extent of that further processing is illustrated in **figure Eighteen**.

Because natural marking and scarring is usually significant, only a few hides are destined to become "Pure Aniline". Most necessarily have to undergo further treatment to disguise the marks, and improve the leather's durability. Automotive leather, which experiences significant abrasion in service, is almost always "Corrected Grain". The follicles in this treatment are completely filled in or removed, which is why the squabs of Automotive seats are sometimes perforated to improve breathability.

**Figure Eighteen** – Types of leather upholstery




**Polyurethane Fabric**

Polyurethane (PU), sometimes known as 'Faux Leather', is a composite material made of one or more layers of polymer resins joined by urethane links; and a woven or non-woven textile backing such as polyester, cotton, nylon, or ground leather. Top coats enhance abrasion resistance, flame retardation, lightfastness, and cleanability.

PU is a rubberlike polymer needing few additives. It has high tensile strength, elongation, good recovery after stretch and performs well in low temperatures with little change in hand or flexibility. It is prone to puddling unless highly resilient underlying foams are added to return upholstery to its original shape when a seat occupant rises. However, when exposed to heat and humidity, Polyurethane can de-polymerize, producing a flaking, brittle surface (termed Hydrolysis Failure). The type of resin used in the formulation is crucial in the prevention of the problem.

There are three basic types of polymer resins, namely Polycarbonate (PC), Polyether (PET), and Polyester (PES), that can be used individually or in combination, and the cost of the Polyurethane upholstery fabric is directly correlated to the quality of the type used. Polycarbonate Resin is the most expensive and has the highest resistance to hydrolysis. At the other end of the scale, Polyester Resin is the least resistant to hydrolysis, and is only suitable for low activity commercial applications (e.g. headboards and pillows).

There are two processes available for manufacturing polyurethane coated fabrics, referred to as “Wet” and “Dry.” The “Wet” PU manufacturing process consists of coating a coagulated base on a substrate backing. An adhesive layer is then applied to the base and another layer, or top coat is decorated with colour and design. The wet process can use any of the resin types or combinations of them, and is used to produce the vast majority of PU upholstery available on the market today, including the Nolan Group’s “Dolce” range (refer **figures Nineteen (a) and (b)**)

**Figure Nineteen (a)** – How Polyurethane Upholstery Fabric is Made (Phase one)

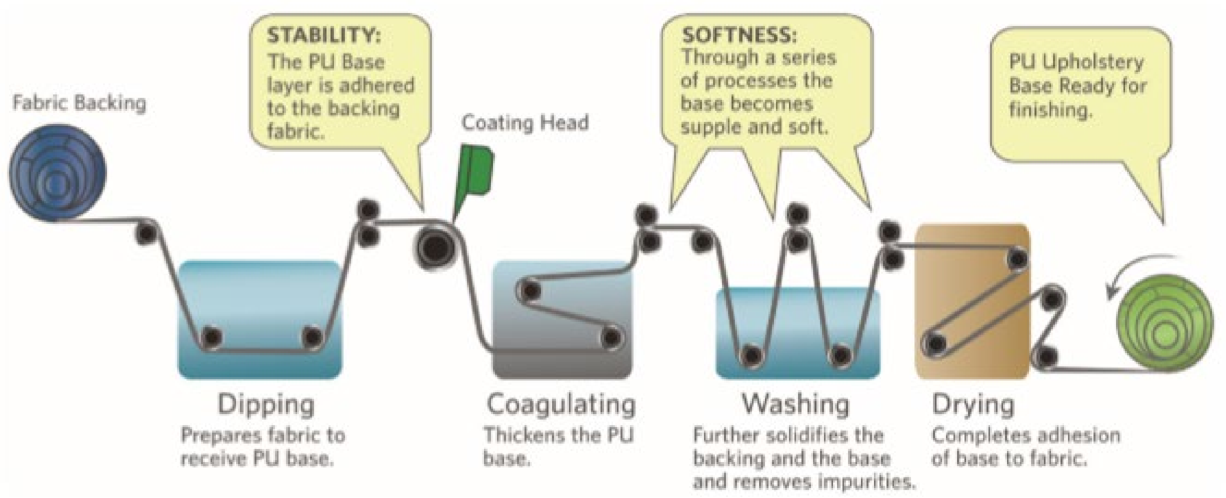
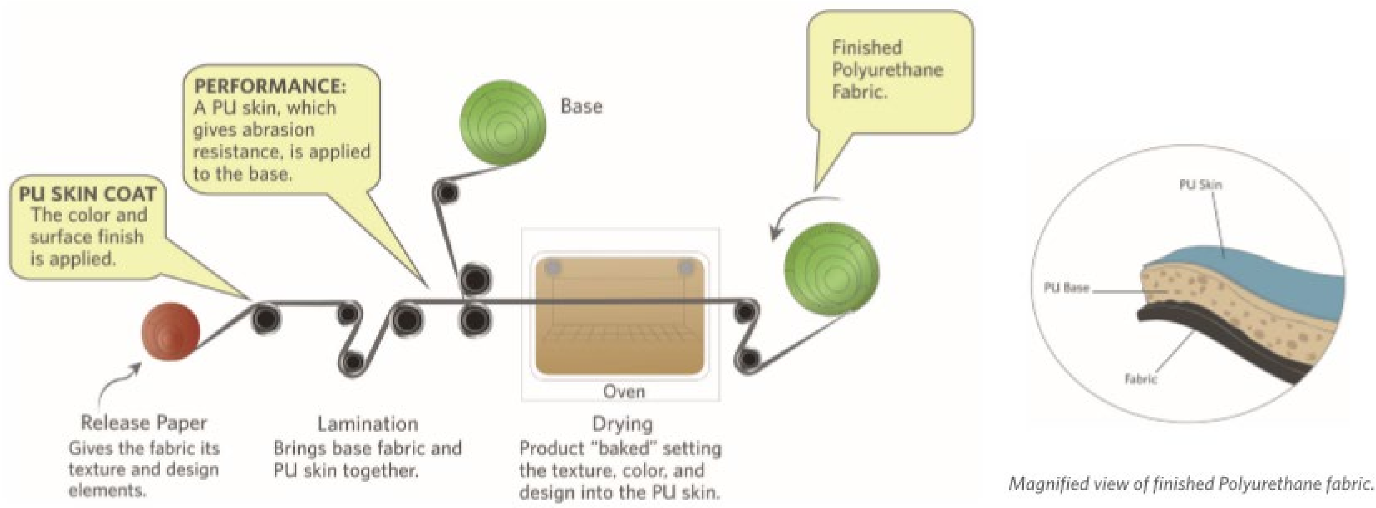



**Figure Nineteen (b)** – How Polyurethane Upholstery Fabric is Made (Phase Two)




In the “Dry” PU manufacturing process, the coagulated base is totally eliminated, and the PU is coated directly on the face of the backing. The chemical reaction in the dry process provides enhanced strength and performance. The resin system can be either a two-component, reactive polyether-polycarbonate or high solid polycarbonate. The “dry” process is a cleaner and more environmentally sound than the “wet”, as it uses about 25% less energy, and over 99% of solvents used are captured and recycled.

All the Healthcare mattress ticking PU fabrics sold by the Nolan Group are manufactured from Polycarbonate resin using the “dry” process.

**Velours / Velvets**

Both velours and velvets are fabrics that have a pile finish, which is the result of shearing woven or knitted tufted threads, in a similar way to that of pile carpet (**figure Twenty six**). The top surface can be crushed, embossed or brushed for further effect. Velours are widely used as automotive "Insert Cloth" or Headlining, and are manufactured from polyester fibre, usually laminated to thin (4.0mm) polyurethane foam base. The headlining velours sold by the Nolan Group also have a further lamination of a tricot knit to the bottom of the foam, to provide additional reinforcing and stability to the fabric.

**Non-woven ("TYPE G") Fabrics**

The term "non-woven" refers to fabrics made primarily of textile fibres not processed on conventional looms or knitting machines, but held together by a bonding agent applied to the fibres, or by entanglement or fusion of the fibres themselves. Typically, the first part of any production process is the formation of a loose gossamer web of randomly oriented of fibres, which is overlain or cross-lapped into several layers. These are compressed and then joined either mechanically (needle-punching or stitch bonding), or chemically (by application of adhesives), or thermally (through the use of low-melt fibres) or through a combination of all these processes.

**Woven Upholstery Fabrics**

There is little distinction between the process of weaving canvas and that of upholstery. The essential difference is the denier of the yarns used and the extent of surface finishing. The diversity of the Sunbrella acrylic upholstery range (sold by the Nolan Group in conjunction with '3 Beaches Textiles') is achieved by varying the size and colour of yarns, and altering the settings of the loom, which provides variation in surface texture. Sunbrella upholstery fabric is not proofed, but otherwise has the same features as the acrylic used for awnings and marine, (i.e. woven from solution-dyed yarn), which has excellent UV stability and colourfastness. The fabrics are easily cleaned, and can be treated with bleach diluted with water.

**Expanded Vinyl**

An expanded vinyl is a composite product consisting of three parts - a backing, which is usually a knitted polyester, or polyester/cotton fabric; PVC foam (the centre section); and a vinyl skin surface. The backing provides dimensional stability and tear strength; the foam, softness and handle; and the skin, durability.

The top PVC surface film of expanded vinyl can be produced by either calendering or cast coating, the same processes used to produce PVC coated polyester, as previously described. The calendered or cast film is then laminated to the substrate. The application of heat during the lamination process causes the foam to "expand", hence the term "expanded vinyl."

The laminated product is passed through a press roller, to provide an emboss. Some product is further finished by transfer printing a pattern on the surface, which is protected by the final application of a urethane or similar coating.

Expanded vinyl has UV inhibitors, flame retardants, bacteriacides and fungicides added, the extent of which is dictated by the products end use, with that designed for Commercial and outdoor use (e.g. marine) applications having a greater degree by volume than those used in less stressful environments.

Spradling International manufactures all (except Capri) of the Commercial Grade vinyl upholstery sold by the Nolan Group. Spradling's brands of urethane surface treatment are PermaBLOK, which is designed to enhance resistance to abrasion and staining; and PermaGUARD, which provides an additional stain resistance and anti-graffiti protection. If treated promptly, most stains like grease, suntan lotion, crayon, felt tip pens, etc are removed easily with soft tissue; and stubborn soiling eliminated with a mix of isopropyl alcohol and water.

In the heavy duty commercial ranges, Spradling also uses Silver ion technology (branded SilverGUARD) to enhance the inherent resistance to microbiological attack that is provided by the chlorine atom that forms part of the vinyl chloride molecule. SilverGUARD consists of small (0.03% by weight) concentrations of silver, that forms cationic silver $Ag^+$ ions that are a very potent anti-microbial agent which has relatively low toxicity for human tissue cells, and is approved for use by the US Food and Drug Administration.

**Table Ten (a)** – Specific features of the Nolan Group's Healthcare Mattress Ticking Ranges

| Brand | Weight (gsm) | Width (cm) | Construction | Features | Applications |
|---|---|---|---|---|---|
| ULTRA*tick* | 340 | 109<br>218 | Extrusion Coated PVC on polyester base cloth. | Anti-Static, Fluid Proof, Anti-bacterial, Stain Resistant. Complies with the Building Code of Australia Flammability Requirements for fixed upholstery seating in Class 9B Buildings. | Medium duty impermeable mattress ticking for Healthcare, hostels, stretchers, Children's mattresses. |
| Sure-chek 44XL<br>Sure-chek 80 | 440<br>600 | 100<br>127 | PVC laminated (both sides) polyester scrim | Anti-Static, Fluid Proof, Anti-bacterial, Stain Resistant. Highbreak strength and tear resistance. | Heavy duty impermeable mattress ticking for Healthcare, stretchers, Correctional and Institutional facilities. |
| Sure-chek *Clearchek* | 370 | 208 | Polyester scrim laminated both sides with clear PVC film | Anti-Static, Fluid Proof, Anti-bacterial, Stain Resistant. Transparent material designed to allow ready identification of contraband hidden in mattresses | Heavy duty impermeable mattress ticking for high security Correctional and Institutional facilities. |
| Ultra 450 | 440 | 220 | Extrusion Coated PVC on polyester base cloth. | Anti-Static, Fluid Proof, Anti-bacterial, Stain Resistant. Reversible | Mattress bases and General purpose mattress covers |
| Ultra*soft* | 510 | 137 | Cast PVC film, laminated to Polyester base | Anti-Static, Fluid Proof, Anti-bacterial, Stain Resistant. Soft handle. | Medium duty impermeable mattress ticking for Healthcare, hostels, stretchers, Children's mattresses. |
| Ultra*thane Classic* | 180 | 220 | Coated Polyurethane elasticised polyester base | Fluid Proof, Fire Retardant, Hypoallergenic / Non-irritating, Anti-bacterial; Breathable, Soft Handle, Multi-directional Stretch, Autoclavable | Healthcare Mattress Covers, Pressure Management, High Level Infection Control, Healthcare Chairs, Support Cushions, childcare mattresses |
| Ultrathane *Cover* | 265 | 220 | | A heavy duty version of Ultra*thane* Classic | |
| Ultrathane *Supreme HR* | 220 | 220 | Coated Polyurethane elasticised polyester base. Hydrolysis Resistant formulation | Exceptional Hydrolysis Resistance, Soft Handle, Multi-directional Stretch, Fluid Proof, Fire Retardant, Hypoallergenic / Non-irritating, Anti-bacterial, Breathable, Low Water Vapour Transmission, Chemical Resistant, Autoclavable | |
| Ultrathane *Ultimate HR-S* | 200 | 220 | Coated Polyurethane elasticised polyester base. Hydrolysis Resistant formulation, with 'Silversan' anti - microbial additive | Silver anion anti-microbial protection, Exceptional Hydrolysis Resistance, Soft Handle, Multi-directional Stretch, Fluid Proof, Fire Retardant, Hypoallergenic / Non-irritating, Breathable, Low Water Vapour Transmission, Chemical Resistant, Autoclavable | |

**Table Ten (b)** – Specific features of Spradling Contract Upholstery Vinyl

*Note: All ranges have a "Hi-loft" knitted polyester backing, and are 137 cm in width*

| Range | Overall Weight (gsm) | Treatment | Features | Suitable Applications |
|---|---|---|---|---|
| Renaissance | 790 | PermaBLOK | UV stabilised pigments, Anti-bacterial, Anti-fungal, Mildew resistant, Stain Resistant, Fire Retardant, (incl US Federal Aviation Specification) | Corporate, Restaurant, Hospitality, Automotive, Recreational Vehicles |
| Kilkenny Tweed<br>Intaglio Designs (Finite, Scribe, Sphere, Trax) | | | | As Above. Also suited for Marine |
| Silvertex | 740 | PermaBLOK<br>Silverguard | | |
| Hitch | 670 | | UV stabilised pigments, Anti-bacterial, Anti-fungal, Mildew resistant, Stain Resistant, Fire Retardant | |
| Chambray<br>Interlace<br>Kaleidoscope<br>Network | 720 | PermaBLOK<br>PermaGUARD | | Office, Education, Healthcare, Hospitality, Restaurant. |
| Inclination<br>Invision<br>Sequins | 740 | PermaBLOK<br>PermaGUARD<br>Silverguard | UV stabilised pigments, Anti-bacterial, Anti-fungal, Mildew resistant, Stain Resistant, Fire Retardant (incl US Federal Aviation Specification). | |
| Reflex | 740 | PermaBLOK<br>Silverguard | | Automotive, Recreational Vehicle |

**Table Ten (c)** – Specific features of the Nolan Group's *"Vytex"* Upholstery Vinyl Ranges
*Note: All ranges are 137 cm in width*

<table>
<tr><th>Brand</th><th>Weight (gsm)</th><th>Backing Composition</th><th>Features</th><th>Applications</th></tr>
<tr><td>Capri</td><td>615</td><td>Flat-Knit polyester</td><td>UV stabilised, abrasion resistant, colourfast. Plain and matching Pebble emboss. Complies with the Building Code of Australia Flammability Requirements for fixed upholstery seating in Class 9B Buildings.</td><td rowspan="3">Corporate, Restaurant, Hospitality, general commercial use. Also suited for Marine and other outdoor upholstery</td></tr>
<tr><td>Cordova "Ultra"</td><td>680</td><td>Hi-loft knitted polyester</td><td>UV stabilised, SilverGuard anti-bacterial finish, Permashield anti–graffiti coating, Fire Retardant. Complies with the Building Code of Australia Flammability Requirements for upholstery in Class 9B Buildings.</td></tr>
<tr><td>Slivertex</td><td>740</td><td>Hi-loft knitted Polyester</td><td>As for Cordova Ultra (with the exception of BCA compliance). Fabric emboss.</td></tr>
<tr><td>Carbon Fibre</td><td>750</td><td rowspan="3">Flat-Knit polyester</td><td>UV stabilised, abrasion resistant, colourfast. Distinctive stipple emboss</td><td>Automotive and Marine.</td></tr>
<tr><td>Duratrim</td><td>650</td><td>UV stabilised, abrasion resistant, colourfast.</td><td rowspan="2">Automotive</td></tr>
<tr><td>Roadrunner<br>Basketweave</td><td>615<br>900</td><td>As for Duratrim. Colours and patterns match specific early GM, Ford and Toyota models.</td></tr>
</table>

**THREAD**

The types of thread sold by the Nolan Group is summarised in **Table Eleven.**

Polycotton threads are manufactured by spinning a staple wrapper of cotton around a continuous high tenacity polyester filament (refer Figure Three (b)). Several of these wrapped yarns, each known as a ply, are then twisted together and heat set. The continuous filament core provides the thread's strength and durability, and the fibrous surface its lubrication. Bonded polyester threads comprise a number of filaments bonded together, without twist.

Polycotton threads have good inherent resistance to heat caused by needle friction. Polyester threads are lubricated and have a protective coating (part of the 'Bonded' finish), which enhances abrasion resistance and ply integrity. Cotton has good absorption characteristics, and consequently polycotton threads are easily 'Vat' dyed. On the other hand, Polyester threads have low moisture regain, and need to be dyed with pigments under high pressure and temperature.

PTFE (polytetrafluorethylene) is a thermoplastic polymer with a very low coefficient of friction, is chemically inert, and very UV resistant. PTFE threads can be a single extruded monofilament, or several filament plies bonded or twisted together. They are basically self lubricating, and are translucent, thereby readily blending with any fabric colour, although some coloured variants are available.

Thread size is generally distinguished by Tex, which is expressed as grams / kilometre. Obviously, the higher the Tex, the heavier the thread. Metric Number, defined as 1000/Tex, is also used but often confused with 'ticket Number', which is simply the manufacturer's reference number. Tex and Metric number can easily be co-related with other commonly used measures such as D'Tex and Denier.

The difficulty of using Tex to compare threads of different composition is that the measure does not differentiate between the relative densities of the base materials. Given that Tex also equals the cross-sectional area of the thread multiplied by its density (per kilometre length), then threads of same Tex but different density will have different diameters. This is not a problem when comparing Polycotton to Polyester, because the density of Polyester is similar to that of cotton. Hence, the diameters of Polycotton and Polyester threads of similar Tex will also be similar, as will be the appropriate needle sizing.

However, PTFE has a higher density than polyester, and therefore PTFE threads will have a noticeably thinner diameters than polyester threads of the same Tex, and smaller needle sizes. PTFE also has a lower tenacity than Polyester, and therefore PTFE threads will have less initial strength than Polyester threads of the same Tex. But, unlike polyester, PTFE does not suffer strength loss under the action of Ultra -violet light (refer **Figure Twenty**),and will retain its initial strength over its effective life.

The type and size of the thread is only one the factors that determine seam strength, which is also dependent on the type and weight of the fabric, the stitch and seam construction, the number of stitches per unit length, and the thread tensioning. There is an empirical formula for estimating seam strength:-

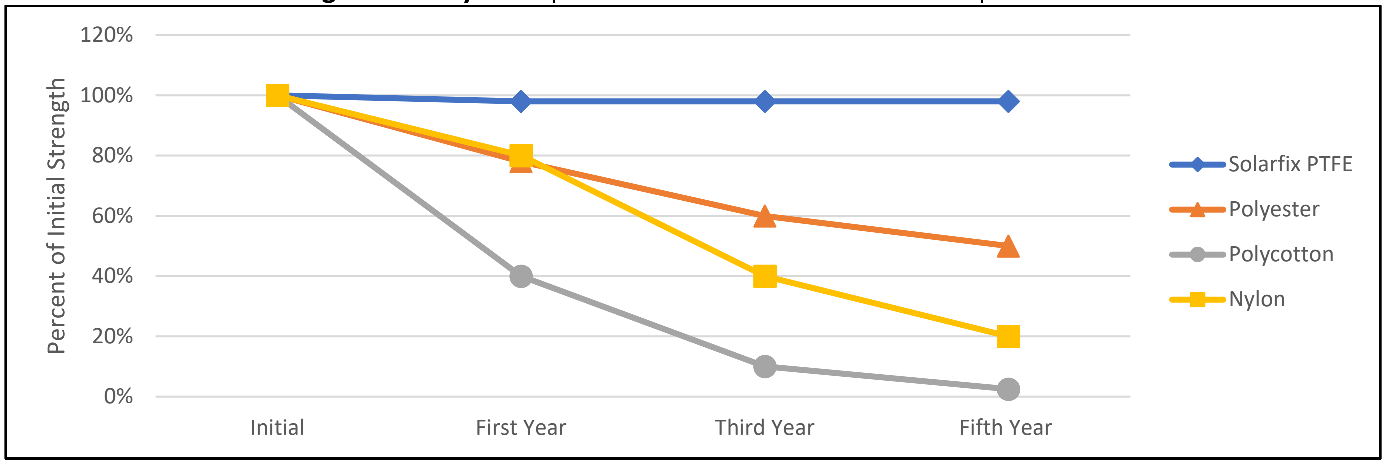
Seam Strength (lbs/in) = SPI x $T_s$ x F

Where SPI = Stitches per inch
$T_s$ = Thread Tensile Strength (lbs)
F = Average loop strength ratio
= 1.5 (for 301 Lockstitch)
= 1.7 (for 401 Chainstitch)

**Table Eleven** – Specific features of the Thread sold by the Nolan Group

| Description | Tex | Tensile Strength | | Recommended Needle Size | | Composition | Features | Recommended applications |
|---|---|---|---|---|---|---|---|---|
| | grams/km | kg | lb | US (Singer) | Metric (Nm) | | | |
| Terko 36 | 80 | 3.7 | 8.2 | 18-21 | 110-130 | High Tenacity Polyester Filament with corespun cotton wrap | Cotton wrap absorbs water and swells to seal needle holes | Automotive Interiors, polycotton tarpaulins, general purpose (e.g. bags, saddlery, horse rugs, ) |
| Terko 25 | 105 | 5.3 | 11.7 | 19-22 | 120-140 | | | |
| Terko 20 | 150 | 7.0 | 15.5 | 19-22 | 120-140 | | | |
| Terko 12 | 210 | 10.6 | 23.3 | 21-23 | 130-160 | | | |
| Dabond V138 | 135 | 9.0 | 21 | 22-25 | 140-200 | Bonded High Tenacity Polyester filaments | High UV resistance. Bleach, Mildew and rot resistant | Awnings, Marine |
| Dabond V207 | 210 | 14.1 | 31 | 25-27 | 200-250 | | | Heavy Duty Awnings, Marine |
| Sunguard B138 | 135 | 9.5 | 21.0 | 22-25 | 140-200 | | As for Dabond, but with colours that exactly match Sunbrella Acrylic fabrics | Awnings, Marine |
| Sunguard B207 | 210 | 13.6 | 30.0 | 21-25 | 200-250 | | | Heavy Duty Awnings, Marine |
| Solarfix PTFE | 150 | 4.5 | 10.0 | 16-20 | 100-125 | Extruded Polytetrafluorethylene Filaments | Exceptional UV and chemical resistance. Retains initial strength for its working life | All outdoor applications, especially marine, heavy duty awnings and shadesails |
| Solarfix PTFE | 264 | 7.7 | 17.0 | 18-22 | 110-140 | | | |
| Solarfix PTFE | 300 | 8.6 | 19.0 | 19-22 | 120-140 | | | |

**Figure Twenty–** Comparative life of different thread compositions



**CARPET AND CARPET TILES**

**Raw Carpet Fibres and their Relative Performance Characteristics**

The main fibres used in carpet are wool, nylon, polypropylene, polyester and to a lesser extent, acrylic. The relevant basic properties of raw fibres are summarised in **Table Twelve** and the following comments relate to significance of these on finished product performance. Note that some of the basic properties of the individual fibres can be altered by additives or surface treatment. For example, the moisture absorption characteristics of wool fibre can be altered by application of a fluorocarbon finish, or the UV resistance of Nylon and polypropylene can be enhanced by addition of stabilisers.

**Table Twelve – Comparative properties of raw fibres used in carpets**

| | Wool | Nylon | Polypropylene | Acrylic | Polyester |
|---|---|---|---|---|---|
| Relative Density | 1.32 | 1.14 | 0.92 | 1.18 | 1.22 -1.38 |
| Tenacity (mN/TEX):- | | | | | |
| When Dry | 135 | 700 | 350 | 300 | 440 |
| When Wet | 100 | 700 | 350 | 270 | 440 |
| Abrasion Resistance | Good | Excellent | Very good | Poor | Very good |
| Moisture Regain (%) | 18.0 | 4.5 | 0.0 | 1.3 | 0.4 |
| Fungal Resistance | Poor | Not affected | Not affected | Not affected | Not affected |
| Sunlight Resistance:- | | | | | |
| Without Additives | Poor | Poor | Poor | Excellent | Fair |
| With UV Inhibitor | Good | Good | Good | Excellent | Fair |
| Melting point ( ºCelsius) | Non melting | 235 | 165 | 230 | 240 |
| Burning Behaviour of Fibre:- | | | | | |
| In Flame | Burns slowly | Melts and Burns slowly | Melts and supports combustion | Melts and supports combustion | Melts and burns slowly |
| On Flame Removal | Self-extinguishing | Usually self-extinguishing | Sometimes self-extinguishing | Burns strongly | Self extinguishing |
| Chemical Resistance:- | | | | | |
| To Acids | Good | Fair | Excellent | Good to most | Good |
| To Alkalis | Poor | Good | Excellent | Good to weak solution | Good |
| To Organic Solvents | Good | Good to most | Good to most | Good | Good |

"Relative Density" is weight relative to that of water, which weighs one tonne per cubic metre. Polypropylene is the lightest of the three fibres. Weight per se is not significant because other factors such as tensile strength and abrasion resistance determine performance. Titanium for example, is much lighter than steel, but has significantly greater tensile strength. This is one of the reasons why comparison of gross carpet weight, widely utilised in the industry, is not necessarily an indicator of relative performance. The other is related to the backing, which can contain "fillers", essentially chalk that has no purpose other than bulking the weight of the finished product.

"Tenacity" is a measure of the tensile strength of the fibres, expressed as milliNewtons per Tex. A "Tex" is a weight per length (grams/1000m) similar in concept to a "denier". Nylon has the highest tenacity, being five times that of wool, and up to twice that of polypropylene. Significantly, both nylon and polypropylene retain their strength when wet, unlike wool, which suffers a thirty percent decline. The abrasion resistance of both nylon and polypropylene fibre is better than that of wool.

“Moisture regain” is the percentage of moisture a fibre will absorb above its bone dry weight at a temperature of 20º Celsius and at 65% relative humidity. Unlike wool and nylon, polypropylene fibre does not absorb water at all, which is a major relative advantage of using it in carpet. Since most stains are water borne, the fibre in the carpet will not be affected, and they are easily removed from the fibre matrix.

Fungi and bacteria require a moist environment, and without it cannot survive. Unlike wool, synthetic fibres are also inherently resistant to fungal attack. In their raw state, none of the fibres are particularly resistant to UV degradation and are subject to chemical attack to some degree. Polypropylene and Nylon are unaffected by commonly used cleaners, disinfectants, and diluted bleach.

All fibres burn. Wool is recognised however, as being intrinsically flame retardant. Synthetic carpet fibres burn to a greater degree, but the propensity to burn can be modified with additives, sufficient to meet stringent Building Code of Australia requirements.

Each fibre has inherent advantages and disadvantages, which flow through to the finished product. One of the advantages of polypropylene fibre included in carpet is its resistance to staining. This is due to its hydrophobic characteristics and lower electrostatic propensity since dirt particles can be attracted by electrostatic charge. The polypropylene fibre used in Nolan Carpets is UV stabilised and is solution dyed, which means colour is an integral part of the fibre structure, and not just impregnated into the surface. The UV stabiliser is a sacrificial component, acting similarly to zinc in galvanised iron, and the life of the product in an outdoor environment depends on the amount of stabiliser in the fibre.

All the carpet ranges sold by the Nolan Group (refer T**able Thirteen)** are manufactured from UV stabilised, Flame retarded Polypropylene and polyester by the needle-punch process. The Toli Carpet tile ranges (**Table Fourteen**) are all tufted nylon.

**How needle-punched carpets are made**

The first stage of manufacture is the selection of the appropriate fibre mix, by both colour and fineness (denier) – the higher the denier, the coarser the fibre. The appropriate mix for each product is developed through testing and experience, designed to achieve optimum performance characteristics, and typically comprises fibres of 18, 30 and 60 denier.

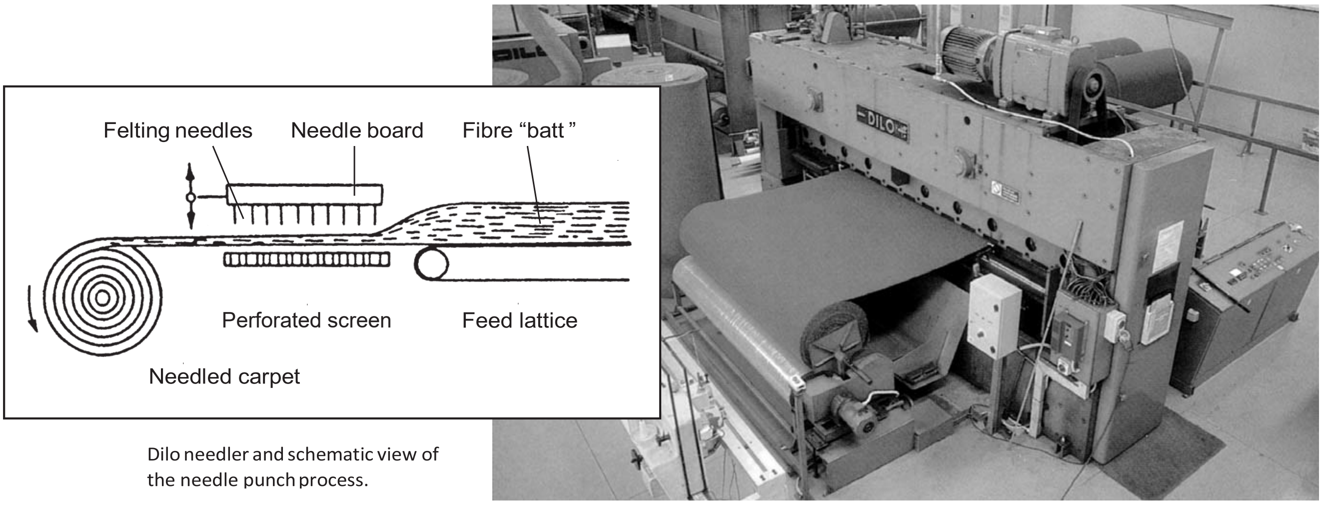
The fibres are batched by weight, mixed and then air driven through a series of different types of machinery to get as much uniformity and consistency of blend as possible. As with all manmade colour blends of solid materials, there is the possibility of minor variation in colour between batches. This is the reason laying instructions stress that all product for a particular job be from the same batch, as well as a particular procedure for sequential laying of each roll. This minimises the likelihood that any variations will be noticed in the finished job.

After blending, the fibres are fed into a large holding hopper that delivers a specific weight of fibre per minute to the next "Carding Process" which produces a fine web of fibre of uniform weight and mix. This web is then overlapped ("Cross-lapping") in perpendicular directions to form a bulky fibre "batt" which is fed to the "Needle Looms". Simplistically, a needle loom comprises two beds of finely barbed needles, each bed mounted horizontally facing the other, and are moved up and down through the thinly layered fibres of the "batt", compressing and interlocking them into a dense mass. (refer **figure Twenty One**) When special finishes are required, the needle loom process can entail use of up to five separate machines prior to being delivered to a final "Texturing Needle Loom".

The modern Dilo needlers allow precise control of the needling process, which results in a very fine surface finish. The process is controlled so that the bulk of the fibre is positioned at the surface and not at the base, an important factor in maximising wear. The resultant matrix is flexible and has a good deal of dimensional freedom, and can be easily formed over convoluted surfaces. In this form it is ideal for use as hull lining for boats ("Performer" "Flex") and wall lining ("Vertiface"), but carpet is stabilised by applying a backing

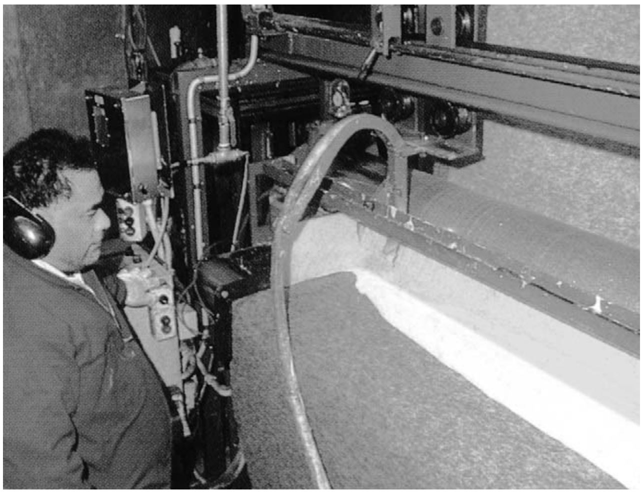
All carpets have a latex or synthetic rubber backing, which is applied in a liquid form and cured in an oven (refer **figure Twenty Two**). After the backing is applied, the product is trimmed to the specified width, cut to length and rolled. Because of the complete interlocking of the needle punched matrix, the carpet does not rely on solely the backing for its integrity, as does a tufted product. The fibres are not continuous or directional, which means they cannot be unravelled. Cuts and joins can be made in any direction without the edge fraying, and no seaming or stabilising of the edges is required.

**Figure Twenty One** – Dilo Needler and a schematic view of the Needlepunch process




Dilo needler and schematic view of the needle punch process.

**Figure Twenty Two** – Applying Latex backing to the needle punched substrate. The liquid backing is cured in an oven.



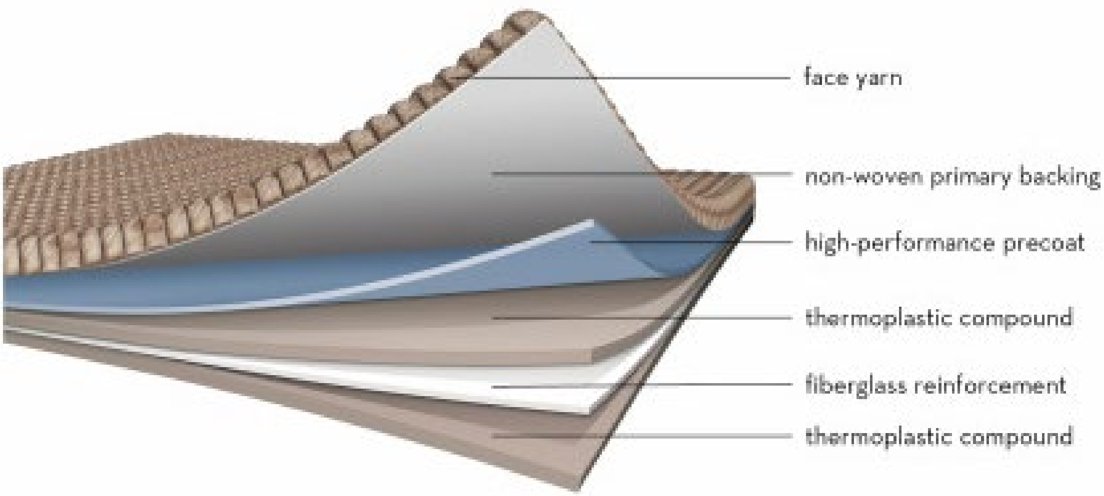
**How Tufted Carpet Tiles are made**

Carpet Tiles are simply carpet squares cut from a roll of tufted carpet. But, the cutting dimensional tolerances are very demanding to ensure precise joins in the laying process; and compared to roll carpet, the structure of a carpet tile can be quite complex, with a range of secondary layering possible (refer **figure Twenty Three**), each one designed to enhance the stability and performance of the finished product.

Generally, the Nylon yarns used in tufting are two-ply yarns comprising both staples and filaments, in order to get a textured, natural looking finish in the carpet. The staple fibres, which average 18 cm in length, if drawn from separate bales, are first blended together to make a single batch. Then, after lubrication, they are spun into long, loose ropes called slivers by a carding machine, which are then pulled, straightened, and spun into single yarn that is wound onto spools. This re-spun filament and the extruded continuous filament are twisted together to form a thicker two ply yarn; which is bulked through steaming, and then heat set at 132°C to 138°C to maintain its twist. After cooling, these yarns are wound onto cores and transported to the tufting machines.

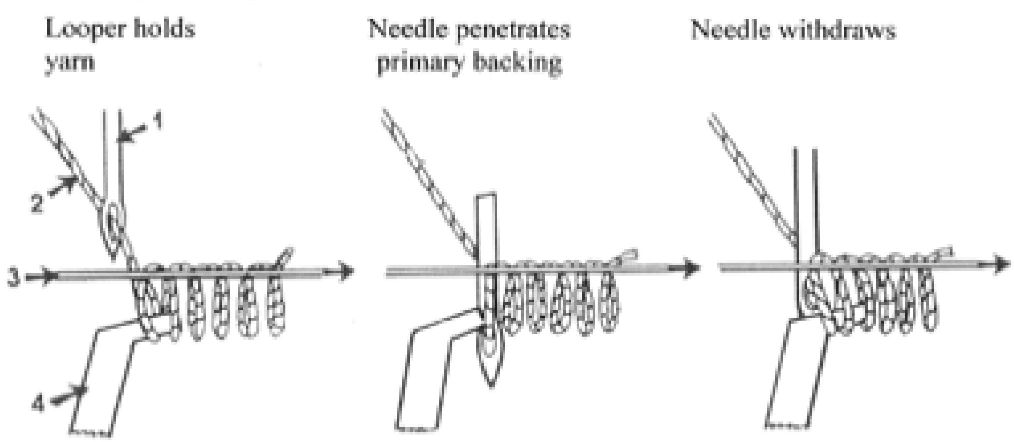
Most carpets are dyed after tufting, but sometimes the yarns are dyed first. Several methods are possible, such as pressurised vats, continuous baths, and even printing. All yarn that has been dyed is then steamed, washed, and dried. Of course, solution dyeing of the filament yarns is also an option.

**Figure Twenty Three** – Cross-sectional view of a carpet tile, illustrating the potential extent of secondary backing




The yarn is now ready for tufting. It is put on a creel behind the tufting machine, then fed into a nylon tube that leads to the tufting needle. The needle pierces the primary backing and pushes the yarn down into a loop. Photoelectric sensors control how deeply the needles plunge into the backing, so the height of the loops can be controlled. A looper, or flat hook, seizes the loop of yarn while the needle retracts. Once it has, the loop is released, the backing is shifted forward to the next tufting position, and the process is repeated. (refer **figure Twenty Four**). In the manufacture of cut pile, a looper facing the opposite direction is fitted with a knife that acts like a pair of shears, snipping the loop (**Figure Twenty Five**).

**Figure Twenty Four** – The loop pile Tufting Process

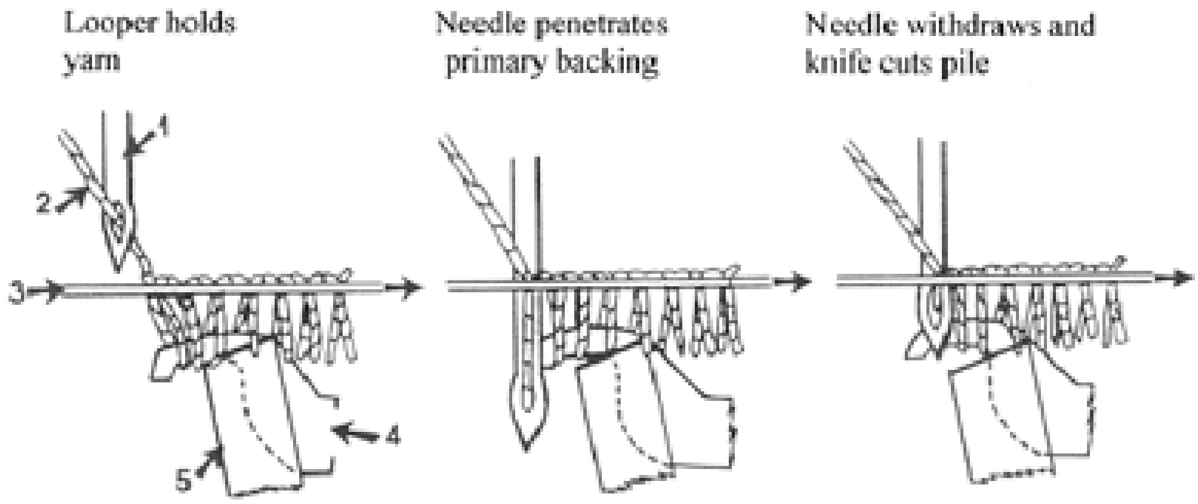



1. Needle
2. Pile Yarn
3. Primary backing
4. Looper

The tufting process is carried out by several hundred needles, up to 1,200 across the standard twelve foot (3.7 metre) width loom, and several hundred rows of stitches are carried out per minute. One tufting machine can thus produce several hundred square metres of carpet a day.

The cut and loop pile manufacturing process is very versatile, and various patterns and surface profiles can be achieved by altering the length of the loops, the extent and depth of cut, the twist and orientation of the yarn, and of course the colour of them. The dyeing process is similarly versatile, and is again used to create a multiplicity of design options.

**Figure Twenty Five** – The cut pile tufting process




1. Needle
2. Pile Yarn
3. Primary Backing
4. Looper
5. Shearing knife

The dyeing of carpet of a single colour is usually carried out over several hours in vats containing a heated mixture of the necessary pigments and water. After dyeing, the carpet is steamed to fix the colour; excess colour is washed off, and the carpet is dried and rolled. Alternatively, the carpet can be dyed using a process similar to screen printing, or physically printed using embossed rollers.

Once dyed, a latex backing is applied to the carpet to lock the individual tufts into place, and to provide a substrate to which a secondary backing can be coated or laminated. The secondary backing, joined using a "marriage roller" is designed to impart dimensional stability. Historically, this has been made of jute, a material of high lignin content derived from a fibrous plant native to India, Bangladesh, and the Far East; but Jute backing has had several major problems, including mildewing, staining and rotting. Most secondary backing to-day is woven or spun -bonded polyolefin or fibreglass. The secondary backing of carpet tiles, because of their small size, is normally a composite of several layers, and can include a polyurethane foam cushion backing as well as PVC base.

Even though the surface finish may seem similar, the cross-sectional profile of Needle-punched carpet is very different to that of a cut pile tufted carpet, as illustrated in **figure Twenty Six**

**Figure Twenty Six** – The difference in cross-section between a needle-punched and a tufted carpet.

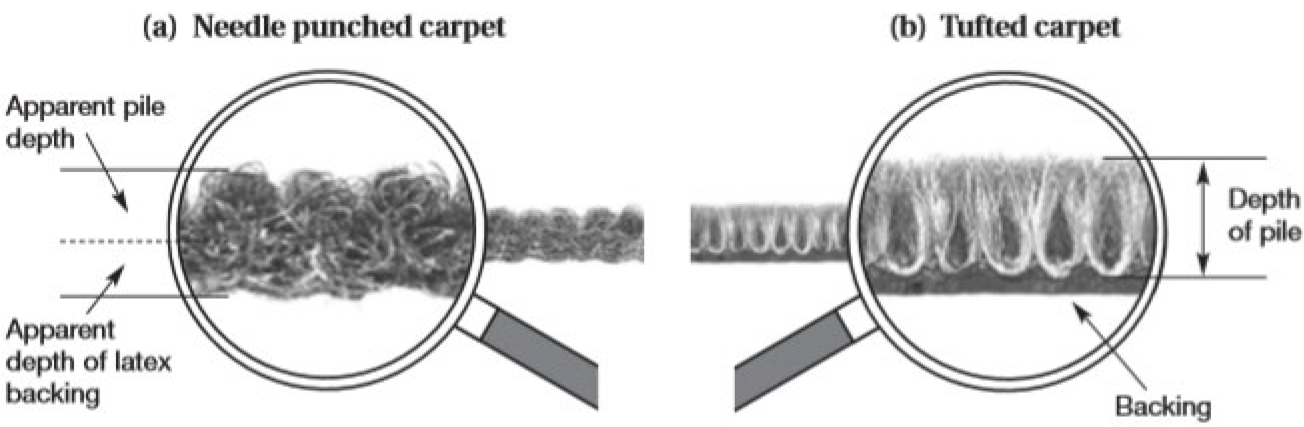


**Table Thirteen** – Fibre Bonded Carpets sold by the Nolan Group
*Note: All Product Width is 200 cm*

| Range Name | Total weight (gsm) | Construction | UV Warranty | | Product Features and applications<br>(all products latex backed unless stated otherwise) |
|---|---|---|---|---|---|
| | | | Interior Use | Exterior Use | |
| Flex & Cabinliner | 425 | 100 % UV resistant Solution Dyed Polyester | 2 years | No Warranty | Unbacked. Suited for Hull lining and other internal applications. |
| Encore II | 350 | | | | Designed specifically as speaker lining material. |
| Linerload | 570 | | | | Automotive and Marine Trim. Suited for interior only. |
| Performer | 700 | | | | |
| Four Seasons & Reef and Raider | 835 | 100% UV stabilised Solution Dyed polypropylene. Stain Resistant, Static Neutral, slip resistant | 5 years | 2 years | Available in a matching plain and ribbed pattern. No contrast in colour of the ‘valley’ between ribs. Suited for Marine and Light Commercial. |
| Images | 1020 | | 10 years | 3 years. | Velour finish. Suited for Marine and Medium Duty Commercial |
| Decord | 1300 | | | | Heavy ribbed pattern with strong colour contrast in the ‘valley’ between ribs. Suited for Marine and Medium Duty Commercial |
| Broad Rib Avondale | 1020 | | | | Medium Ribbed pattern with no colour contrast. Suited for Marine and Medium Duty Commercial |
| Hobnail | 1020 | | | | Cobbled diamond pattern. Suited for Marine and Medium Duty Commercial |

**Table Fourteen –** Nylon Carpet Tiles stocked by the Nolan Group
*Note: All Tiles are 500 mm x 500 mm and are specifically designed use in for commercial interiors*

| Range | Finish | Solution Dyed Yarn | Yarn Weight | | Thickness | Commercial Rating | Features |
|---|---|---|---|---|---|---|---|
| | | | Oz / yd$^2$ | gsm | mm | | |
| Bark GA3600 | Textured loop Pile | Yes | 15.3 | 520 | 6.8 | Extra Heavy Duty | Reinforced PVC Backing. Antistatic, Stain Resistant, Environmental Certification, 15 year warranty |
| Bright Plan GA 100T | Textured loop Pile | No | 17.4 | 590 | 7.8 | Heavy Duty | |
| Mild Brick GA 100 | Textured Loop pile | No | 16.8 | 570 | 7.8 | Heavy Duty | |
| Sandbank GA 100W | Multi level loop pile | Yes | 19.8 | 670 | 7.0 | Extra Heavy Duty | |
| Shadow Block GA 100W | Textured loop pile | No | 17.1 | 580 | 7.0 | Extra Heavy Duty | Hi-loft pile in “Dust Control” range reduces dirt and soiling from foot traffic. |
| Silky Line GA 100W | Multi-level loop pile | no | 17.4 | 590 | 6.5 | Extra Heavy Duty | |
| Yutaka YU 1300 | Level loop pile | yes | 14.7 | 500 | 6.5 | Heavy Duty | |
| Dust Control DC 1100 | Multi-Cut and loop | Yes | 28.0 | 950 | 10.0 | Extra Heavy Duty | |

**DESCRIPTION OF THE METHODS OF TESTING FABRICS**

**Definitions**

A "Specification" is a document outlining quality benchmarks or procedures.

A "Standard" is a formal specification usually prepared by an independent organisation such as The Standards Association of Australia. The standard may be for a method of test, or a complete specification for a material. If this is the case, the standard has three essential elements;

- An inventory of the material's physical properties
- Methods of testing those properties
- Minimum pass or fail criteria

and may refer to other standards. For example, the Standard AS 2930-1977 "Textiles – Coated Fabrics for Tarpaulins" lists ten properties that define the physical performance of the material (such as tear strength, breaking force, etc) including flammability. The method of test for flammability is specified as AS 2755.2, another standard, and the criteria for pass or fail is "a test specimen shall not burn to the first marker thread after a 15 second flame application."

"Regulations" are issued by statutory authorities enforcing Acts of Parliament, or acting under delegated authority. These may refer to particular Standards, or specify tighter criteria. An example is the National Construction Code (NCC), produced every three years by the Australian Building Codes Board, which determines the Flammability Requirements for residential and commercial buildings. The NCC in turn refers to "Deemed to Satisfy" results based on the testing of the AS 1530 "Methods for Fire Tests on Building Materials, Components and Structures".

**Testing the physical properties of fabrics**

There are two sets of Australian Standards that are commonly used for testing the physical properties of Outdoor Fabrics, namely AS 2001.2 "Methods of Test for Textiles", which is relevant to "Plain Fabrics" and knitted textiles; and AS 4878 "Methods of Test for coated fabrics", which is also relevant to PVC laminates. This latter standard is identical to the International Standard ISO 4674:1977.

In each of these series of standards, the test methods for measuring physical properties are similar, although there can be differences, such as in sample size. The samples for any tests are first "conditioned", that is stored in an environment of controlled temperature ($20^{o} \pm 2^{o}$ Celsius) and relative humidity (65% ± 3%) for a specified period of time, and then tested under the same conditioned environment. The nominal **mass per unit area** is measured by weighing samples taken at random through the roll.

**The Breaking Force or Tensile Strength** is measured by gripping a 200mm x 50 mm sample in the two jaws (of 75mm width) of an hydraulic machine and pulling in opposite directions at a uniform rate of 100 mm per minute until failure. This test is designed to measure ultimate strength of fabric (**figure Twenty Seven (a)**) , and the results are expressed as a force per unit length in Newtons/50 mm. The **extension at break** is also measured, as a percentage of the original sample length (**Figure Twenty Seven (b)**).

There are a number of methods of measuring **tear strength** (figure **Twenty Eight)**, but the most common is 'wing rip'. In AS 2001.2.10-1986, the sample size is 130 mm in width, and 200 mm in length, with an initial cut of 50 mm. Five samples are tested, and the results averaged, with the force required to initiate tear expressed in Newtons. The "wing-rip" test of AS 4878.7 (Method A2), is the same, but the sample size is 225 mm in length, and the depth of cut is 80 mm. This same standard (method A1) also details a "Tongue Tear" Test. The sample size is identical, as is the depth of incision, but there are two cuts, each 25mm from the respective edge of the sample. Obviously, the test results from the different tests are not directly comparable. Logically those from a "Tongue Tear" test will be higher than a "Wing-Rip" test carried out on the same material.

**Hydrostatic Burst or resistance** is a measure of the pressure the fabric can sustain before failure. The test is conducted by clamping a specimen of fabric to form a diaphragm over a chamber connected to a glass column, which is progressively filled with water, schematically illustrated in **Figure Twenty – Nine (a)**. The "bursting" pressure is expressed in kilopascals (kPa) or centimetres of water. A similar method is used to assess **Water Penetration**

**Resistance**, but the test is completed when droplets appear on the underside of the fabric. The maximum capacity of the testing machine is 250 kpa, which is the pressure equivalent of a water depth of 26 metres. This method is clearly not applicable for porous fabrics such as shadecloth. AS 4174 – 2018 "Knitted and Woven Shade Fabrics" stipulates that knitted shadecloth be tested to either AS 2001.2.4, (method A), or AS 2001.2.19, both of which are a measure of **bursting pressure**. The former test utilises a hydraulic diaphragm, with the result at failure expressed as a pressure (kPa); and the latter a steel ball, with result at failure expressed as a force (Newtons).

**Figure Twenty Seven** – Breaking Force and extension at break.
(Note that the fabric stretches in the direction of load and contracts in the other transverse direction).

(a) Break Force (b) Extension at Beak

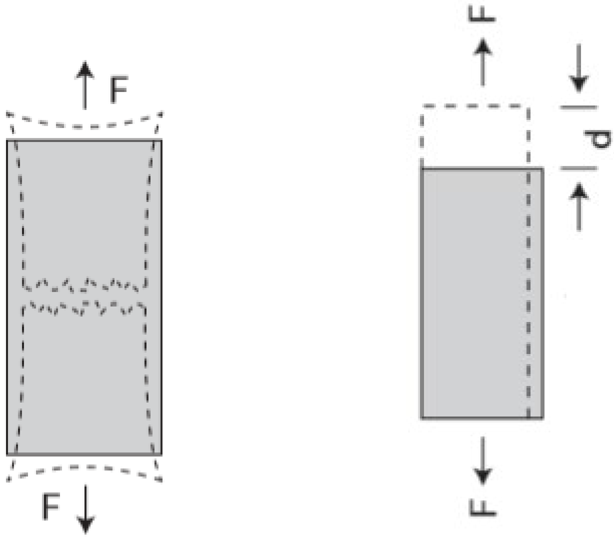



**Figure Twenty Eight –** Different types of tear tests

(a) Wing Rip (b) Trapezoidal tear (c) Centre slit (d) Tongue tear

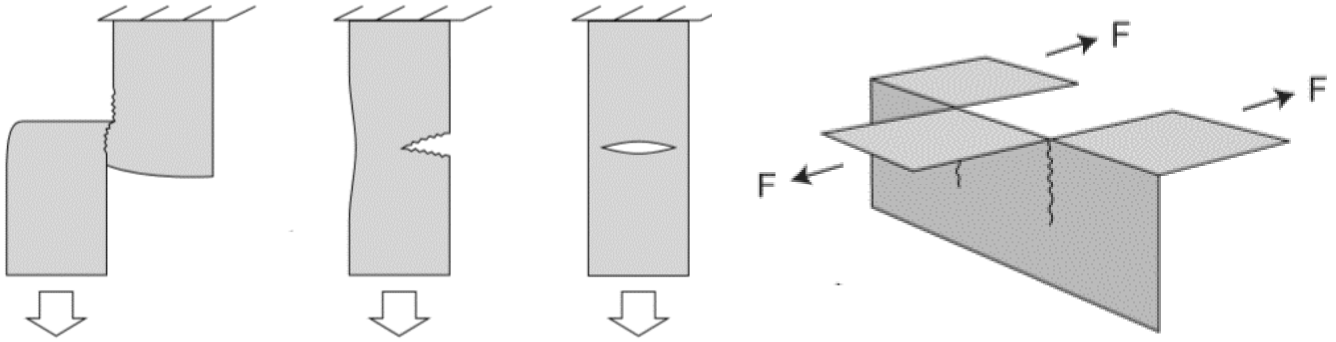



**Figure Twenty Nine (a)** Hydrostatic Burst and water penetration resistance

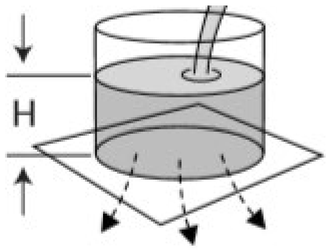



**Figure Twenty Nine (b)** Abrasion Resistance

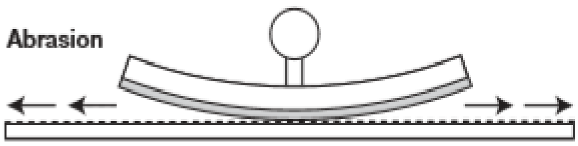
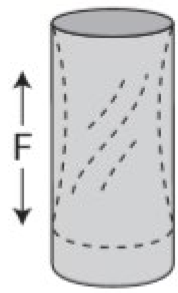



**Figure Twenty Nine (c)** Flex Cracking



**Resistance to Wear** is determined by the Wyzenbeek method. In this test, a sample 5cm x 20cm is held on a heavy inverted pendulum and mechanically cycled under pressure across an abrasive surface, (in this case a coarse 600gsm canvas), for 50,000 cycles and then examining it for loss of grain or discolouration. Each cycle consists of a complete "to and from" rub, (i.e. a "double" rub), schematically shown in **Figure Twenty Nine (b)**.

**Flex cracking** is a measure of the resistance to repeated reciprocating movement. A sample piece is mounted between two spoundrels, one of which is moved up and down in a repetitive motion for a specified number of cycles, as shown in **Figure Twenty Nine (c)**. The sample is then visually examined for evidence of cracking.

In the test for **Colour Fastness to Light**, the fading of a sample under natural or artificial light is compared to the change in colour of a blue wool control piece, which has known light fastness characteristics. The result is expressed as a rank ranging from one (least stable) to eight (most stable). **Cold Cracking** is a measure of resistance to low temperature. A sample is folded in two and creased after exposing it to a temperature of $-10^{o}$ Celsius for 30 minutes, and then visually examined for signs of cracking.

PVC Coated and Laminated Polyester Fabrics have additional tests designed to assess the stability of the composite fabric structure. In the test procedure outlined in AS 4878.8 "Determination of **Coating Adhesion**", two specimens 200mm x 75mm are joined by adhesive over part of their length and allowed to set. One tongue of the sample is then folded back on itself, and the coating at the join carefully separated from the substrate with a razor blade. The specimen is then mounted into a machine similar to that used to measure tear strength, and the force required to continue the separation measured.

**Flammability Tests for fabrics and Upholstery**

The test methods specified in Building Code Regulations for fabrics and upholstery are either AS 1530 part II or AS 1530 part III, or both. These are distinctly different tests. Part II is a "Strip Flame" test in which a small piece ('strip') of material is subjected to an alcohol flame for several seconds, and the burning behaviour observed **(Figure Thirty)**. An empirical "Flammability Index" is calculated from measurements of how quickly or to what extent the specimen burns, and the heat generated. This "Flammability Index" is expressed on a scale of zero (low risk) to 100 (high risk).

The AS 1530 part III test (**Figure Thirty One**) is designed to simulate the characteristics of materials subjected to the effects of radiant energy from a fire developing elsewhere in the room. A test specimen 600mm x 600mm is subject to an intense source of radiated heat and its burning behaviour from ignition to extinction observed. The results are expressed in the form of four indices, sometimes termed "Early Fire Hazard Indices" (which should not be confused with the "Flammability Index" of AS 1530 pt II.) Only two of these indices – the "Spread of Flame Index", and the "Smoke Developed Index" are referred to in the National Construction code. The "Spread of flame Index" is a measure of how quickly a fire propagates, expressed on a scale of 0 to 10. The higher the value, the worse the result. The "Smoke Developed Index" is also expressed on a scale of 0 to 10, with each increment representing a bifold increase of the smoke emitted.

**The Flammability Test for Floor Coverings**

The Australian Building Codes Board (ABCB) has adopted Australian Standard AS ISO 9239.1-2003 "Reaction to Fire Tests for Floorings" for regulating the fire hazard properties of floor linings and floor coverings. It is identical to the European Standard of the same name and ISO number. It specifies a method for assessing the wind-opposed burning behaviour and spread of flame of horizontally mounted floorings. A schematic view of the test apparatus is shown in **figure Thirty Two**. The results are expressed as the "Critical Heat Flux at Extinguishment (CHF)", which is the applied Heat Flux in $kW/m^2$ at the surface of the specimen where the flame ceases to advance (or goes out); and the "Smoke Value", which is a measure of the light obscuration caused by the smoke emitted expressed as percent-minutes.

**Figure Thirty –** AS 1530 pt II Test Apparatus

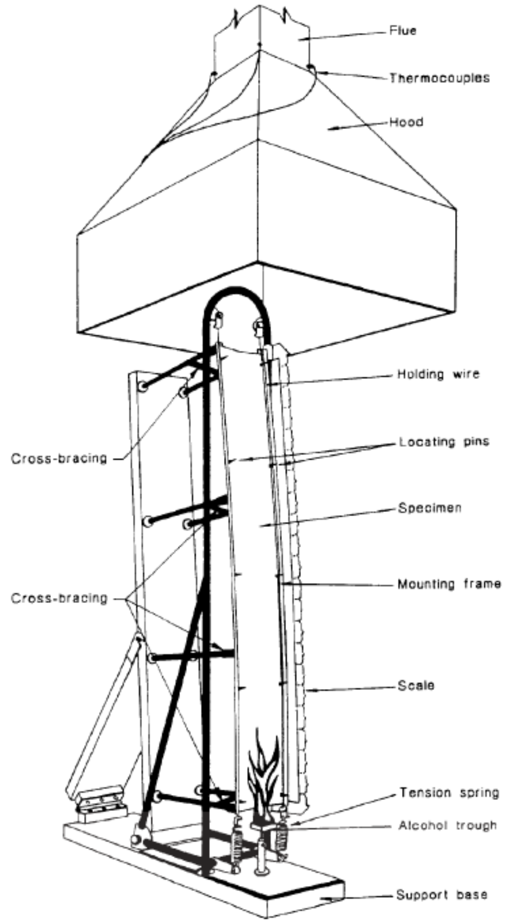



**Figure Thirty One** AS 1530 pt III Test apparatus

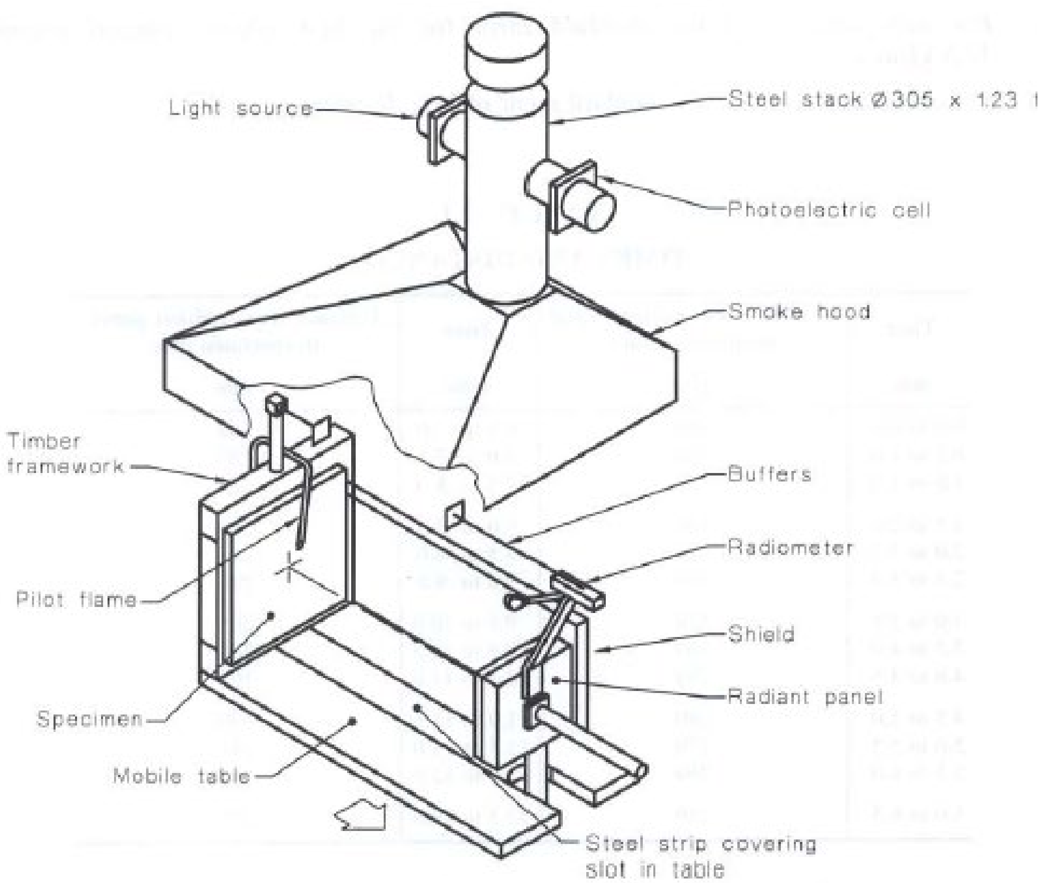
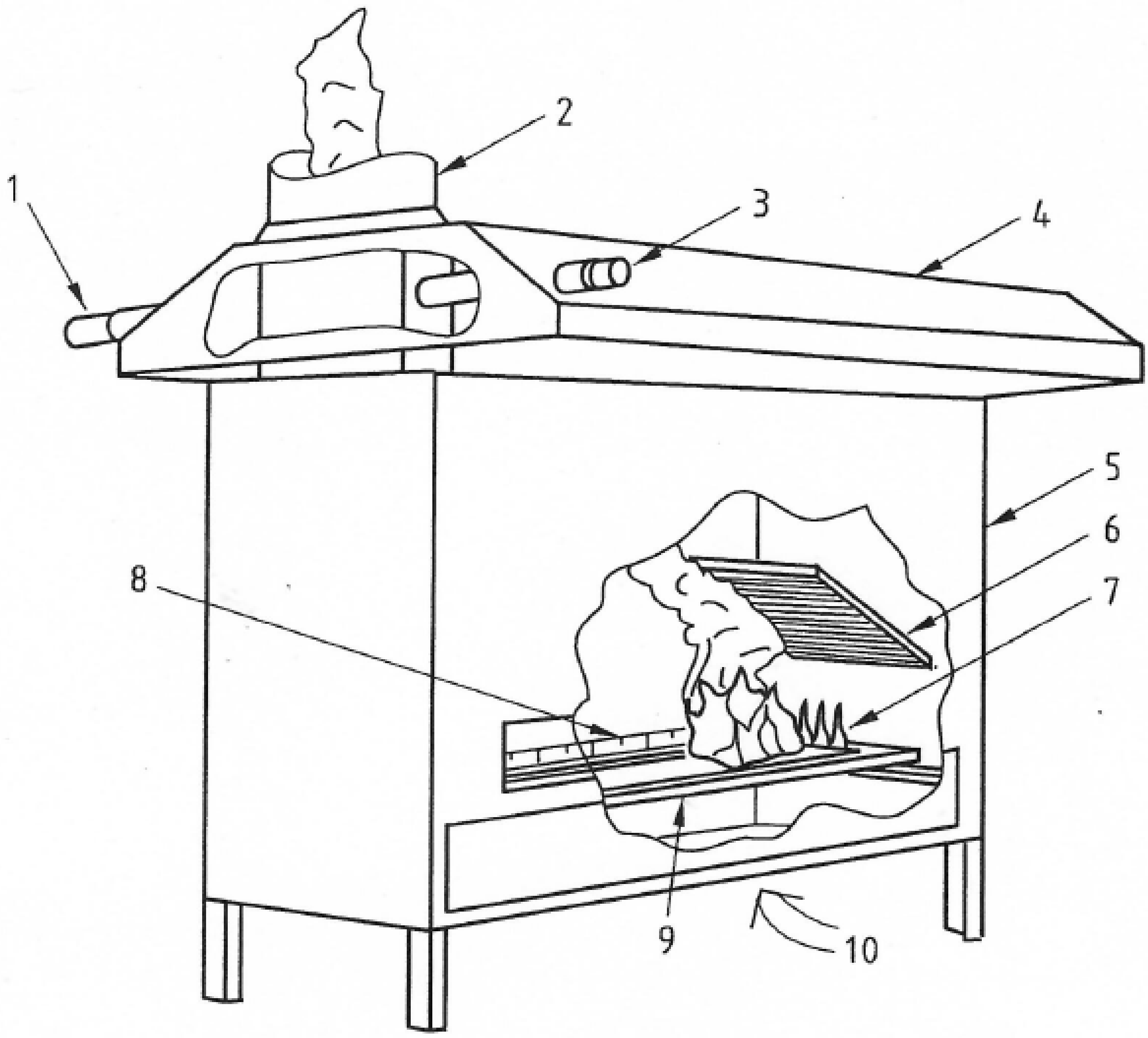


**Figure Thirty Two –** AS ISO 9239.1 – 2003 Test Apparatus




**Key**

| | |
|---|---|
| 1 | Illumination unit |
| 2 | Exhaust duct |
| 3 | Light receiver |
| 4 | Exhaust hood |
| 5 | Test chamber |
| 6 | Gas fired radiant panel |
| 7 | Pilot flames from line burner |
| 8 | Scale |
| 9 | Specimen holder with specimen together with sliding |
| 10 | Air inlet all around specimen at bottom of chamber |

**AUSTRALIAN FLAMMABILITY REGULATIONS**

**The National Construction Code**

The National Construction Code (NCC), also referred to as the Building Code of Australia (BCA), sets the minimum design and construction requirements for buildings, including flammability regulations . It is produced every three years (the current version promulgated in May 2019) by the Australian Building Codes Board (ABCB), which as representative of the Federal, State and Territory Governments, attempts to maintain uniform standards across the country. Nonetheless, there are some provisions included that are specific only to a particular State or Territory. An example is the flammability requirements for closed back upholstery seating in class 9(b) buildings used as an entertainment venue in NSW, which override the general BCA provision in this context.

**Flammability Requirements for Commercial Upholstery**

The general BCA provision for upholstery is detailed in Volume One (page 68) Section C1.10 (a) (v) “Fire Hazard Properties”. It states that in Class 9 (b) buildings (i.e. an “Assembly Building”) used as a theatre, public hall or the like, any part of the fixed seating in the audience area or auditorium must comply with Specification C1.10, specifically Clause 7 (page 106), which requires a “Spread of Flame Index” of zero, and “A Smoke Developed Index” of no greater than Five. Note that the regulation applies only to “fixed seating” and not removable and stackable chairs.

In NSW, the requirements (which override the above) are subtly different. Clause NSW C1.10 (a) (v) “Fire Hazard Properties” (page 423) states that in “class 9b buildings used as an entertainment venue, a material used to cover closed back upholstered seats” must comply with Specification C1.10 (i.e. Clause 7 and the same indices noted above). However, unlike the general provision, the NSW requirement can be interpreted to include removable and stackable chairs. An “entertainment venue” has the specific meaning as proscribed under the Environmental Planning and Assessment Regulation 2000 and means “a building used as a cinema, theatre, or concert hall or an indoor sports stadium”.

Although confusingly not referred to in NSW C1.10 (a), the State also has its own specification, i.e. NSW Specification C1.10 “Fire Hazard Properties” (page 425), which has different wording and flammability indices. It adds after “…closed back upholstered seats” the following “..in any part available to the public where (a) smoking is permitted or (b) flame is exposed in connection with the preparation of meals”. The requirements are that the Spread of Flame Index must be no greater than six, and the Smoke Developed Index no greater than five.

Neither the general nor specific NSW requirements apply to commercial establishments such as offices, hotels, cafes, restaurants and bars (other than those located in class 9b buildings). Hence, apart from the specific BCA regulation for class 9b buildings outlined above, there are no requirements for upholstered seating used in any domestic or commercial application, including hospitality and healthcare.

**Flammability Requirements for Awnings and External Blinds**

There are no specific flammability regulations for Awnings and External Blinds attached to Class One buildings. A class one (a) building is a single dwelling including a detached house, terrace, town house or villa unit. A class One (b) is a hostel, Boarding or guest house that would ordinarily accommodate not more than twelve people and with total floor area not more than 300 $m^2$.

There are regulations that govern the attachment of Awning and Outdoor Blinds on Class Two through Nine buildings, which effectively prohibits the use of traditional fabrics above the ground floor. Class Two through Class Nine buildings incorporate all possible types of high density and commercial buildings including multiple occupancy units, hotels, hospitals, nursing homes, schools, Universities, offices, shopping complexes, etc.

Because of amendments made in 2018, and perpetuated in the 2019 version of the BCA (Volume One), the regulations require that “Ancillary Elements”, (which include an awning, sunshade, canopy, blind or shading hood), that are installed on “non-combustible” façades, other than at ground level, also be “non-combustible” (Clause C1.14 (a) page 69). The code’s definition of “non-combustible” refers to results of a test (i.e. AS 1530 part I), which is utterly inapplicable to fabrics and materials commonly used in awnings, shutters and outdoor blinds.

Those “ancillary elements” attached at ground level must comply with Table 4 of Specification C1.10 (page 106) and have a “Spread of Flame Index” no greater than nine; and a “Smoke Developed Index” no greater than eight, if the “Spread of Flame” Index is more than Five.

Unfortunately, there is also considerable confusion surrounding the requirements with regard to Internal blinds, shutters, etc; as “Ancillary Elements” attached to the “internal parts of an external wall”,( which has wrongly been interpreted by some architects and specifiers as being an internal wall), are also required to be “non-combustible.”

However, this interpretation needs to be taken in the context of the Code's definition of an "External Wall", and the special provisions for "attachments for floors, ceilings, internal walls, common walls, fire walls and to the internal linings of external walls" (Clause C 1.10 (VIII)).

Clearly, these are unintended consequences of well-meaning regulatory change introduced as the result of the Grenfell disaster in London, and similar, but fortunately less tragic cladding fires in Melbourne.

For this reason, the Blind Manufacturers Association of Australia (BMAA) commissioned Ignis Consulting to undertake full scale fire tests to AS 5113 on externally mounted awnings, blinds and shutters, so that the current flammability requirements of the National Construction Code (or Building Code of Australia) could be critically assessed. The tests were undertaken in conjunction with other products, such as Aluminium panels, and co-related with the results of smaller scale fire testing (i.e. AS 1530 parts II and III) that has traditionally been applied to Awning and Blind fabrics.

Ignis Consulting, which specialises in Fire Engineering, and has its own Fire Safety Testing laboratory. The BMAA received a draft report in January 2020, which confirmed that the awnings, blinds and shutters do not significantly exacerbate the risk of fire spread across a building façade.

Consequently, the consultant has recommended that BMAA make a submission to the Australian Building Codes Board (ABCB) to amend the code, based on three specific recommendations:-

1. "Curtains, blinds and the like used on the interior of a building which are a non-building fixture or fitting be exempt from having to comply with the requirements of fire hazard properties.

2. "Shutters, blinds, awnings and the like used on a the exterior of Class Two to Nine Buildings above ground floor level, should have a Flammability Index not greater than five; as well as a Spread of Flame Index not greater than 9; and if the Spread of Flame Index is more than 5, a smoke developed Index not greater than 8. Where the material satisfies these fire hazard properties, no restriction in the use on buildings or its continuous installation should occur".(These indices relate to the results of AS 1530 part II and Part III tests).

3. "Shutters, blinds, awnings or the like used only on ground level should not have any restriction."

These recommendations can be justified by the results of testing undertaken, and are logical in the context of the regulations that apply to other fabric style materials, such as sarking.

There are some implications for the Industry if these recommendations are accepted. With the exception of Acrylic and Clear Flexible PVC, all of the materials commonly used in Awning and Blinds would comply, including PVC coated mesh; and PVC, polyurethane and Aluminium shutters. An acrylic or Clear PVC used on upper floors of Class Two to Nine Buildings, would need to be Flame Retarded.

The submission to the ACBC will take time to put together. In the interim, The BMAA will be using the report and the services of Ignis Consulting to provide its members with a template for a "Performance Solution" to deal with current requests for fire certificates.

A "Performance Solution" means a method of complying with the NCC requirements through technical assessment and expert judgement. The testing and report form the basis of this, and if supported by other specific information, is the documentation necessary to demonstrate compliance with CP2 "Spread of Fire"; and CV 3 "Fire Spread via External Walls". The other specific information required is a description of the project, class of building, location, material used, supplier, manufacturer, installer, etc. The report can then be adapted for that particular project, and certified as compliant by Ignis Consulting. It is only valid for that particular project. There will be a fee for each certification, yet to be determined.

BMAA have asked Ignis to develop the necessary Template and application form. However, before they proceed, Ignis need to get clearance from their professional indemnity insurance provider. The plethora of claims regarding poor quality buildings has spooked the insurance industry. Assuming there are no problems in this context, BMAA expect to be ready to launch this service in calendar year 2020.

**Flammability Requirements for Shade and Tension Structures**

Shadesails and Tension Membranes that are attached to Classes Two through Nine buildings are also classified as an 'Ancillary Element', and also are required to be 'non-combustible' unless located at ground level.

Thus, issue of compliance for shadesails and Tension Membranes located on the upper levels of buildings is as problematic as it is for awnings and blinds. 'Non-combustibility' is defined by the results of test method AS 1530 part I; and because of the nature of the sample to be tested (i.e. a cylinder of height 50mm, and diameter 45mm), it is simply not possible to test shadecloth or Coated PVC using this procedure. Even if it was possible, the stringency of the pass / fail criterion would make it unlikely that any product would comply.

In summary, there is no issue if the shadesail or Tension Membrane is attached to the soffit of class Two to Nine buildings just above ground level. Similarly, A stand alone tensioned membrane would be classified as Class 10a "non-habitable building", and like single, detached domestic dwellings (Class One buildings), are not subject to any specific flammability regulatory requirement.

**Flammability Requirements for Flooring**

The NCC requirements for Floor Linings and Floor Coverings are listed in Clause 3 Specification C1.10 "Fire Hazard Properties" (pages 103 and 104), and is summarised in **Table fifteen**. The "Critical Radiant Flux" is the same as the "Critical Heat Flux at Extinguishment" (CHF) measured by AS ISO 9239.1-2003 "Reaction to Fire Tests for Floorings". An additional requirement for buildings that are not protected by a sprinkler system is that the "Smoke Development Rate", which is the same as "Smoke Value" measured by AS ISO 9239.1- 2003, must be less than 750 percent-minutes.

**Table Fifteen** – Minimum Critical Radiant Flux (kW/m$^2$) for Floor Coverings in Class Two Through Nine Buildings

| Class of Building | General | | Fire Isolated Exits |
|---|---|---|---|
| | Un-sprinklered | Sprinklered | |
| Class 2,3,5,6,7,8,or 9b (excluding Accommodation for the aged) | 2.2 | 1.2 | 2.2 |
| Class 3 Accommodation for the aged | 4.5 | 2.2 | 4.5 |
| Class 9a Patient Care Areas<br>Class 9a Other Areas | 4.5<br>2.2 | 2.2<br>1.2 | 4.5<br>4.5 |

Flammability Requirements for Temporary Structures

The ABCB has produced a Temporary Structures Standard, the latest version dated 2015, which outlines the flammability requirements for Marquees and the like. The roof and/or wall coverings of a temporary structure (including any additional lining attached to the structure) must comply with the AS 1530 pt II and pt II results reproduced in **Table Sixteen**.

**Table Sixteen** – Maximum Allowable Flammability Indices specified in the "Temporary Structure" Code

| Location | AS 1530 Pt II | AS 1530 pt III | |
|---|---|---|---|
| Roof or wall Coverings:- | Flammability Index | Spread of Flame Index | Smoke Developed Index |
| (a) Within 4m of the base of a temporary structure and for air-supported temporary structures (without other supporting framework) | 6 | 9 | 8 |
| (b) In every other case | 25 | 9 | 8 |

**GLOSSARY OF TECHNICAL TERMS**

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|---|---|
| Aging | The effect on materials of exposure to a testing environment for an interval of time. |
| Antimicrobial (Biocide) | A compound commonly added to a polymeric compound or coating to inhibit the growth of bacteria, fungi, and algae on the surface of a finished product. |
| Aniline or semi-aniline | A term that describes a high grade finished upholstery leather that has very little surface treatment and high breathability. |
| Artificial Aging | The accelerated testing of materials to determine the changes of properties. |
| Artificial Weathering | Exposure to laboratory conditions, which may be cyclic, involving changes in temperature, relative humidity, radiant energy, and any other elements found in the atmosphere in various geographical areas |
| Blocking | Unintentional adhesion between plastic films or between a film and another surface. |
| Breathability | The propensity of a fabric to allow moisture vapour, (as opposed to water droplets) to pass through it. |
| Calendaring | Process of forming a plastic film by passing molten material through a series of heated rollers with designated speeds and gaps to determine the product thickness. |
| Cast Coating | A process where a liquid coating is spread on a reusable release paper, fused or dried in an oven, and then removed from the release paper as a solid film and adhered to a substrate. |
| Coated Fabrics | Base fabrics impregnated with a liquid plastic solution, on one or both surfaces. |
| Coating | The process of applying PVC, Polyurethane, or polyolefins in liquid form to a substrate in a precisely controlled manner, using either “knife-over-roller” or “Knife -over-air” production techniques. |
| Coextrusion | Process of extruding multiple films from different extruders that pass through a single die into a merged film/sheet consisting of individual welded layers. |
| Colourants | Pigments or dyes used to impart the Colour to a material. They can be from natural or synthetic sources and can be organic or inorganic in composition. |
| Composite | A construction consisting of two or more polymeric films laminated together or laminated to a substrate such as a fabric. |
| Conditioning | Placing a material into a set of standard environmental or stress conditions prior to testing the product. |
| Core spun | A type of thread or yarn that has a central filament around which are twisted other filaments or staples |
| Corrected Grain | A term that describes a class of finished upholstery leather that has had its natural surface removed during processing and replaced an emboss. |

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| Cross Direction | The horizontal Direction across a roll of extruded or laminated plastic, which is perpendicular to the “Machine Direction” |
| D’tex | A measure of weight per length of a yarn namely, grams/ 10,000 metres. Refer also D’Tex, Denier and Metric Number. |
| Delamination | A term used to describe the separation or breakdown of the surface coating from the base fabric. |
| Denier | A measure of weight per length of a yarn namely, grams/ 9,000 metres. Refer also Tex, D’Tex and Metric Number. These can be compared by careful conversion of the units used, which are usually rounded. For example, 1100 denier is equivalent to 120 Tex, 1200 D’Tex and Metric Number 8. |
| Dope Dyed | (or Solution Dyed) A process whereby colourant is added to the polymer resins prior to extrusion into a filament |
| Drape | A term to describe the way a fabric falls while it hangs; the suppleness and ability of a fabric to form graceful configurations. |
| Embossing | The process of imparting a specific pattern or graining to the surface of the material. This can be done during the film formation process or at a later operation. It generally requires the material to be at an elevated temperature during the process and then cooled to set in the embossing pattern. |
| Extruder/Extrusion | A process in which heated or unheated plastic is forced through a shaping dye in one continuously formed shape, such as a film. |
| Knitted Fabric | A Fabric formed by a single yarn or multiple yarns making interlocking loops. |
| Faux Leather | A upholstery grade expanded vinyl or Polyurethane that is designed to simulate the look and feel of leather |
| Non-woven Fabric | A fabric formed by laying a continuous web of randomly spaced Fibres to form a uniform batting, which are then bonded by chemical adhesion, thermally or mechanical processes. |
| Needle-punch | A mechanical process used to produce non-woven fabrics |
| Woven Fabric | A Fabric formed on a loom with two separate yarns (warp and Weft) that are at right angles to each other. The two yarns go over and under each other in a designated pattern. |
| Filament | A continuous length of extruded yarn, and / or of staple fibres that have been spun together. |
| Fill | Horizontal direction across a roll of fabric. Also known as “weft” |
| Film | A thin sheet of uniform gauge without any underlying support fabric. |
| Full Grain Pigmented | A form of treated leather upholstery that has its original surface retained. |

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|---|---|
| Full Grain Printed | A form of treated leather upholstery that has its original surface retained, but with an applied emboss. |
| Greige | Refer Loomstate |
| Hand | The tactile qualities of a fabric, coated fabric and/or film, perceived by touch e.g., softness |
| Hydrophobic | A tendency to repel of fail to mix with water. The opposite characteristic is Hydrophilic. |
| Hydrolysis | A brittle surface failure of a polyurethane fabric caused by de-polymerisation when exposed to heat and humidity. |
| Lacquer | A solution of a resin(s) in a volatile solvent that when applied to the surface of a material forms an adherent film when the solvents have evaporated. |
| Laminated Fabric | A Product consisting of two or more calendered or extruded films which are bonded together by an adhesive, heat, and/or pressure. |
| Laminating | The process of combining two or more natural or synthetic layers together. |
| Laminator | A machine used to combine multiple layers of polymer film or a polymeric film with a fabric, using adhesives or simply heat and pressure to combine the multiple layers. |
| Latex | A synthetic rubber used as backing for carpets and carpet tiles. |
| Limiting Oxygen Index (LOI) | The minimum percentage of oxygen that must be present in the atmosphere surrounding the fibre for it to ignite and burn. The proportion of oxygen in the air is normally 21%, and therefore fibres which have an LOI above this level do not ignite readily. |
| Loomstate | Woven canvas directly off the loom prior to colouring and finishing |
| Machine Direction | Machine direction is parallel to the orientation through the equipment by which a film is manufactured. Cross Direction is perpendicular to machine direction. |
| Metric Number | A ratio of yarn length to weight, expressed as Kilometres / Kilogram |
| Moisture regain | The amount of water absorbed by a fibre when initially dry, then exposed to 65% humidity at 20°C. |
| Newtons | A measure of force, equivalent to a kilogram force, which is mass in kilograms time the acceleration due to gravity. |
| Panama Weave | A type of heavy duty weave where yarns are woven in a two x two pattern. It is typically specified in a 900 gsm Truck Side Curtain fabric. |
| PET | An abbreviation of the chemical formula of Polyester, namely Polyethylene Terephthalate |

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| Pic (or Pick) Count | The number of yarns per unit length of the fabric, usually quoted *per centimetre*. However, some Asian and all North American manufacturers quote *per inch.*( Rarely is the unit length given, a scrim being described for example, as simply 9 x 9 x 1100 denier. This could mean nine yarns per cm each direction, or nine yarns per inch. Given that there are 2.5 centimetres in an inch, there is a significant difference, which may be fairly obvious when visually inspecting physical samples, but not when simply comparing written specifications). |
| Plain Weave | The simplest form of a woven fabric, where the warp yarns are held tightly stretched in the loom and the weft yarns inserted over and under every alternate one. |
| Plasticiser | A substance incorporated in a material to increase its workability, flexibility, or distensibility. |
| Plastisol | A vinyl homopolymer or copolymer suspension containing plasticizer(s) and other needed additives. The plastisol can be used in varied manufacturing processes including coating or casting a film. |
| Polyvinyl Chloride | A polymer that has vinyl chloride as the sole monomer, which is a simple compound of two Carbon, three Hydrogen, and one Chlorine atoms. |
| Polymer | A continuous chain of a distinct molecular structure linked in a repetitive way. |
| Polyolefin | A commonly used chemical nomenclature that describes a family of similar hydrocarbon polymers, the most well-known being polyethylene and polypropylene. |
| Pound force (lbf) | The force exerted by a mass of one pound under the action of gravity. |
| Primer | A coating applied to the surface of a film to improve the receptivity of the surface for further coating application or improve bonds to an adhesive. |
| PTFE | An abbreviation of the chemical formula polytetrafluoroethylene. |
| Press Polished | A process of manufacturing clear PVC sheets of exceptional clarity, specifically designed for marine applications |
| PVC | An abbreviation of Polyvinyl Chloride |
| Rail-Roading | The practice of fabricating the Fabric, mesh or clear PVC blinds with the weft in the direction of the drop. |
| Scrim | The base textile of a laminated or coated fabric |
| PVF and PVDF | Surface lacquers applied to coated PVC's, particularly those used in an Architectural Application. PVF (polyvinyl fluoride) is sometimes known by the tradename "Tedlar", a registered trade name of DuPont. PVDF is polyvinylidene fluoride |
| Sliver | A loose rope of integrated staple fibres created as part of the spinning process. |

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| Specific gravity | The density of a material relative to water, which weighs One tonne per cubic metre. |
| Stabilizer | Additive being used in polymers to prevent degradation during processing and product life against heat, mechanical and ultraviolet stress. |
| Spread Coating | Refer “Coated Fabrics” |
| Staple Fibre (or simply staples) | A strand of short length, either natural (e.g Cotton or Wool) or sheared filaments (e.g. acrylic) |
| Substrate | Base Fabric used in a composite |
| Surface Tension | A measure of the surface energy of a film or liquid. For a liquid, the surface tension is the forces which holds the liquid together as a drop and prevent it from wetting a surface. |
| Tearstop Weave | A type of weave where a yarn is duplicated, or a heavier yarn inserted periodically in the weave matrix. Also known as “Ripstop”, which is a trademark owned by Bradmill Textiles |
| Tenacity | The tensile strength of a yarn, expressed as grams/denier |
| Tex | A measure of weight per length of a yarn namely, grams/ 1,000 metres. Refer also D’Tex, Denier and Metric Number. |
| Top Coat | A term used to signify the coating applied to the surface of the plastic material. |
| Transfer Coating | A process of making coated fabrics. (Refer Cast Coating) |
| VOC | Volatile organic compounds that flash off from a coating when it dries. |
| Warp | Longitudinal direction along a roll of fabric. In plastics, this referred to as the “Machine Direction” |
| Weft | Horizontal direction across a roll of fabric. In plastics, this referred to as the “Cross Direction” |
| Weft Insertion | A type of scrim where the weft yarns are laid on top of those of the warp, and knitted together at the overlap points by a third, lighter denier tie yarn. |
| Whitening | Marking of the surface of a film, coated fabric, or composite when it is either bent or flexed. |

**SYNOPSIS OF THE TECHNICAL GUIDE SERIES**

**How to Tell a Good Yarn – Textile Manufacture and Testing**
**Technical Guide Number One**

The textile and flooring products mainly used in an outdoor environment are first classified by their basic construction and design function. Then the processes of production and finishing are described, including the implications on product performance of different types of yarn and yarn blends, the matrix of the weave, coating lamination and finishing. The products included are canvas, PVC coated or laminated polyesters, coated polyolefins, clear PVC, knitted shadecloth, expanded vinyl, leather, polyurethane fabrics, needle punched carpet and tufted carpet tiles.

A description of the test procedures used to assess quality attributes are described, and linked to the published specifications of the products; including the relevant Australian Fire tests and the outcomes required by the National Construction Code for Commercial Upholstery, Awnings and Outdoor Blinds, Shade and tension Structures, Flooring and Temporary Structures. A glossary of technical terms used in the textile industry is also included. Although specific to the brands sold by the Nolan Group, the information is sufficiently generic to be applicable to similar products generally used by fabricators in the Textile Conversion Industries.

**Shady Characters – Polyfab Shadecloth for Human Protection**
**Technical Guide Number Two**

Beginning with the basics, the two different types of knit construction which fundamentally affect the relative shading efficiency of the various Polyfab brands, or indeed any brand of shadecloth are described and illustrated. Then the concept of shade design, with the need to accommodate the daily and seasonal movement of the sun, is noted, with the consequent risk of lack of protection highlighted.

More technical information is provided on engineering design, including the behaviour of the fabric under two dimensional loading, how to derive the Elastic Parameters from Biaxial Testing, and guidelines for fabrication and installation. Standard design details for a typical hypar and frame supported structure have been developed, and the procedure for gaining engineering certification for the use of these drawings anywhere in Australia is explained.

The specifications of the Polyfab products are compared with the requirements of AS 4174 – 2018 "Knitted and Woven Shade Fabrics", including physical properties and the degree of UV protection. The ratings outlined in that standard and how they are integrated into the product warranties are explained. Additional technical information such as Solar heat transmission, flammability and chemical resistance of the products are also included.

**What Blind Freddy Knew – Awning and Outdoor Blind Fabrics**
**Technical Guide Number Three**

The primary aim of this guide is to detail the information supporting the Nolan Group's "Fit for Purpose Statement", which is in turn designed to clarify the specific meaning of the terms used in the Consumer Act of 2011, and the Nolan Group product warranties.

The terminology related to the different types of Awnings and Blinds is explained and illustrated, as is the basic construction and finish of the fabrics typically used, their specifications, as well as guidelines for fabrication and installation; and care and maintenance. Fabrics included are Acrylic and Polycotton Awning Canvas, PVC coated polyester mesh, and Flexible Clear PVC.

The results of the testing for Solar Absorption, Reflection and Transmission for Vistaweave Mesh (to US standard ASHRAE 74-75 1988) and Dickson Acrylic (to European Standard EN 14500 and EN 14501), are provided and ranked by colour.

**Head above Water - Marine Fabrics and Fasteners**
**Technical Guide number Four**

In their dealings with the consumer, the Marine Trimmer has a difficult task in explaining the severity of the boating environment, particularly the effects of UV exposure on fabrics and flexible clear PVC. Starting with illustrations of the types of canopies and the terminology used to describe them, this guide progressively details information relevant to the materials commonly used. Based on protracted laboratory testing, the detail of which is contained as an appendix, it contains a simple table that outlines the comparative characteristics of different canopy materials, which is designed to facilitate appropriate product selection.

Included are product specifications, guidelines to fabrication of canopy materials and flexible clear PVC, Marine carpet and hull lining, upholstery; together with the appropriate use of foam underlay, fasteners, zippers, adhesives and thread. Detailed care and cleaning instructions, and copies of product warranties are provided. The warranties are formatted to the Nolan Group's "Fit For Purpose Statement", and relates the detail of the product's specification to the terms used in the Consumer Act of 2011.

**Got you covered – Polycotton Canvas, Coated or Laminated Industrial and Architectural Fabrics**
**Technical Guide Number Five**

Proofed cotton canvas was first developed for use by the British Army in the Crimean War, and has been used ever since for temporary outdoor protection. The invention of polyester did not just improve the matrix of canvas, but coupled with PVC, allowed the development of synthetic tarpaulin and tenting fabrics that are widely used in transport, agricultural covers and structures. Similarly formulated polyolefin fabrics provide a lighter weight option.

This guide goes into the detail of the composition and structure of these types of fabrics, their technical specifications, and chemical resistance. It provides advice on product selection and fabrication, including allowance for dimensional change, welding and functional design, such as avoiding tear, flex cracking and potential mildewing. The reasons for the complexity of printing on plastics is explained, and also why the common practice of cutting 'wind holes' in banners is unnecessary.

The concept of anticlastic geometry, which is integral to the design of tension structures, is discussed; and European guidelines for fabric classification, fabrication tolerances and pre-stress are included; together with an explanation as to how biaxial tests results can be interpreted. References are provided to the calculation of Elastic Parameters for the Sattler "Atlas" range available with biaxial test results, which are available on the Nolan Group's website.

Similarly, the concept design of Grain Bunker Storages is provided, and a calculator that allows the sizing of covers and groundsheets for particular crops and stack heights has been developed and is also available on the company's Website.

**Not Flawed – Commercial Carpet, Carpet Tiles and Acoustics**
**Technical Guide Number Six**

Designed for Architects and Specifiers, this guide provides the technical data necessary to support the environmental guidelines of the Carpet Institute's Certification Scheme, which in turn underpins the Green Building Code rankings. It also contains the detailed product specifications and results of performance testing, including those of flammability required by the National Construction code. Similarly formulated materials are used as acoustic walling, and data regarding the effectiveness of these products is presented.

**Nolan Group locations**

Nolan Group

Your Textile Partner For Success

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**BRISBANE**
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**MELBOURNE**
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