Fiberglass vs. Polyester:

Properties of Coated Yarns

White Paper

There has been much debate in the solar shading textile industry over whether a fiberglass core fabric or a polyester core fabric is superior. It has been the job of the architect, fabricator or designer to determine which is better for their project. Manufacturers claim that the major difference between fiberglass and polyester is their strength. There have been many one-sided arguments trying to defend these two materials, but the fact is, they have been tested in ways that favor one or the other creating an invalid argument when it comes to solar protection. To fully comprehend the materials, a designer must know the chemical composition and physical properties that make up each before formulating any beliefs. The real subject always seems to be evaded, this being how the final product performs for the end userFor the intended application, the material properties must be analyzed as they relate to the actual performance of the final product for the end user: As a shade in a window.

Composition

Fiberglass is a fiber mainly produced from silica (sand). The pure raw materials are melted at very high temperatures. The basic glass strand is made by drawing molten glass from the holes of a bushing at high speed. This forms several hundred filaments at a time. Typical fiberglass core yarn, used in solar shade construction, has 200-400 filaments.

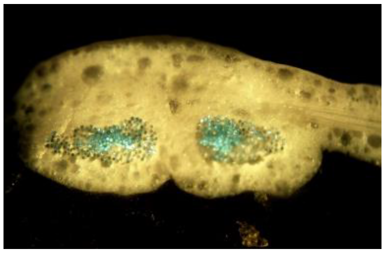

Image 1: Fiberglass Core Yarn Cross-Section (200x)

Polyester is a synthetic fiber derived from coal, air, water, and petroleum. Polyester pellets are melted and forced through tiny holes of a spinneret. The resulting filament is drawn significantly to align the molecules of the fiber into long chain synthetic polymers that have ester linkages Typical polyester core yarn has 50-100 filaments.

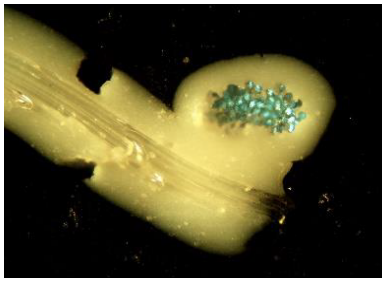

Image 2: Polyester Core Yarn Cross-Section (200x)

Both fiberglass and polyester cores are composed of filaments, or continuous strands. The filaments support theyarn through its entire length because the core's composition is not made ofstaple fibers.

Coating

By definition, a core yarn is a yarn with an inner core material and a different outer coating. Both polyester and fiberglass are used as core materials. For solar protection, these core materials are coated by PVC (vinyl) to create a core yarn. The core acts as the skeleton of the fabric and the coating acts as the protective outer tissue.

The PVC coating on polyester and fiberglass core yarns is essentially the same. The coating provides the color, durability, UV resistance, and other properties: antimicrobial effectiveness, fungal resistance, colorfastness, lightfastness, and washability. The main difference between a fiberglass core fabric and a polyester core fabric is the proprietary blend of UV stabilizers, pigments, plasticizers, and fire retardants that give the unique properties of performance that differentiate from one coating to the next, although both can look and feel the same. The coating thickness determined by their respective cross sections, is relatively the same for both polyester and fiberglass, though the coating to core weight ratio is characteristically different.

Table 1: Coating/Core Ratio By Weight (Industry Average)

Yarn	Core	Coating
Fiberglass Core	36%	64%
Polyester Core	20%	80%

Comparison

Fiberglass and polyester have physical differences that make them uniquely designed for specific applications. This paper will look at some of the most frequently expressed physical testing of the two and analyze their relevance for the application of solar shading. The results shown below are based on industry trends and data for a typical fiberglass core fabric and polyester core fabric. Both fabrics have a vinyl coating, whose composition shall be considered equivalent. The primary focus is the difference introduced by the core yarn selection. This data does not intend to endorse a specific product or brand in its comparison.

Sample Selection

The samples used for testing, with the following methods, were selected to create as much homogeneity between the core fabrics being compared. Both fabrics have a 2x2 basketweave pattern, similar openness factor, and color. The fiberglass core fabric was taken from a roll manufactured by Mermet and the polyester core fabric was sourced from the market. The actual openness factor of both fabrics was measured and was found to be approximately 4.5% for each.

Table 2: Average Yarn Diameter (Industry Average) and Holes per Sq. In. (2x2 Basketweave, Selected Sample Fabrics)

Yarn	Yarn Diameter (mm) Industry Average	Yarn Diameter (in) Industry Average	Openings Per in^2 Selected Sample Fabrics
Fiberglass Core	0.325	0.0128	750
Polyester Core	0.500	0.0197	520

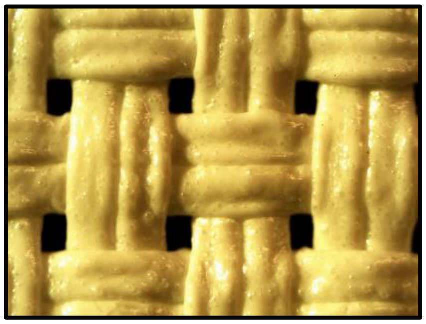

Image 3: Fiberglass Core Fabric Surface (80x)

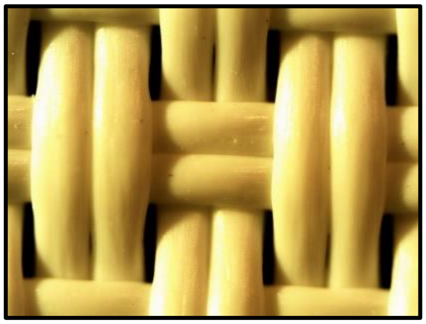

Image 4: Polyester Core Fabric Surface (80x)

Fiberglass core yarns tend to be finer than polyester core yarns. To achieve a given fabric openness, you must use a greater number of finer yarns, which in turn will produce a fabric with more holes per square inch. The outward view, or view-through, of a fabric is greatly affected by this. By having more holes per square inch, finer yarns create a shade with a crisp view through. This concept is similar to the higher resolutions of a TV or monitor. The more pixels, the crisper the view. While the openness of the two selected sample fabrics was nearly identical, the shape and size of the openings, created by the weave pattern, are different (Images 3 and 4). In the sample fabrics chosen, the polyester core fabric has rectilinear openings (0.14mm x 0.58mm), and the fiberglass core fabric has an opening much closer to a square shape (0.20mm x 0.26mm). The view-through is improved by a higher number of openings with a more square-like shape.

Image 5: Fiberglass Core Fabric Surface (1.0 in^2)

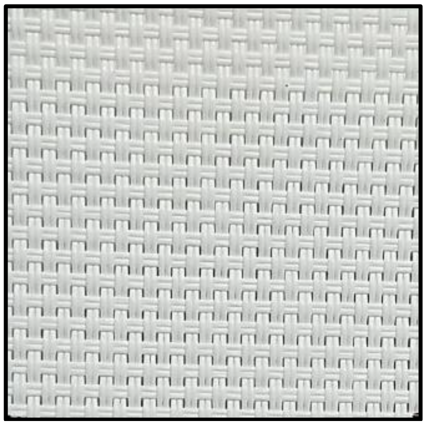

Image 6: Polyester Core Fabric Surface (1.0 in^2)

Table 3: Fabric Mass (2x2 Basketweave, Selected Sample Fabrics)

Fabric	Picks/in	Ends/in	Mass (g./sq.m.)	Mass (oz./sq.yd.)
Fiberglass Core	49	54	405	11.9
Polyester Core	37	56.5	436	12.9

Table 4: Fabric Thickness (2x2 Basketweave, Selected Sample Fabrics)

Fabric	Thickness (mm)	Thickness (in)
Fiberglass Core	0.51	0.020
Polyester Core	0.66	0.026

In general, fiberglass core fabrics are lighter and thinner than polyester core fabrics with the same weave pattern. As a shade material, fiberglass fabric will have a smaller weight-to-size ratio. A thinner material allows for a lower total fabric thicknessas it rolls up on a shade tube. This allows for larger shades, smaller roller tubes, more compact installation, and generally less stress on thehardware components. A higher weight and thickness can constricta project by requiring more expensive fabrication and materials.

Table 5: Tensile Strength (ASTM D5035) (2x2 Basketweave , Selected Sample Fabrics)

	Tensile Strength (Newtons -N)		Tensile Strength (Pound force -lbf)	
Fabric	Warp	Weft	Warp	Weft
Fiberglass Core	1139	874.1	256.1	196.5
Polyester Core	907.9	581.8	204.1	130.8

Tensile strength is a measure of the force required to break a fabric. The results shown in Table 5 were measured by applying a force in each direction of the fabric weave. In the samples provided for the test above, the selected 2x2 basketweave sample fabric with a fiberglass core performed with a higher breaking strength than the polyester core fabricin both the warp and weft directions This demonstrates the physical property differences between fiberglass and polyester. Due to polyester’s long polymeric chain structure, it will elastically deform and stretch under loads.

Table 6: Tensile Breaking Elongation (ASTM D5035) (2x2 Basketwe ave, Selected Sample Fabrics)

Fabric	Warp Elongation	Weft Elongation
Fiberglass Core	3.0%	2.5%
Polyester Core	14.8%	10.8%

In the tensile test, elongation of the samples was also recorded at breaking loads. Fiberglass core fabric only elongated around 3% of its length, in both warp and weft directions, during the course of the test. Polyester core fabric elongated at least four times more than fiberglass core fabric during this test. Polyester behaves this way because the molecules that make up the polymer stretch when a force is applied. Fiberglass is a homogeneous solid through its filaments and elongates much less. The force required to elongate fiberglass core fabrics is greater than for polyester core fabrics. Therefore, the results of this test are not directly comparable because the ultimate tensile strength of polyester core fabric is less than fiberglass core fabric However, it clearly shows the ability of fiberglass core to resist elongation under loads.

Image 7: Single Column Tensile Tester

Table 7: Elastic Modulus

Core Material	Modulus (GPa)
Fiberglass	73.0
Polyester Fiber	8.5

Elastic modulus is an important property to consider with tensile strength because it is a direct measure of a material's resistance to deformation, also referred to as stiffness. Fiberglass has a very high elastic modulus, compared to polyester fibers and other polymers. This means that it requires large loads to elastically deform. Polyester will deform much easier, which makes it well suited for applications that require flexible properties, rather than rigid. High modulus makes fiberglass ideal for maintaining its shape at any force below its breaking strength. The flatness of the fabric is much more of a visual concern, than say break or tear strength.

Table 8: Ball Burst Strength (ASTM D3787) (2x2 Basketweave , Selected Sample Fabrics)

Fabric	Bursting Strength (N)	Bursting Strength (lbf)
Fiberglass Core	687.7	154.6
Polyester Core	963.5	216.6

The ball burst test is used to determine the force required to rupture a fabric by forcing a 1in diameter steel ball through the fabric. Similar to the tear strength test, polyester core fabric performs well in this test due to its high ability to stretch. This test is designed to test fabric intended to bear weight or withstand bursting forces. Therefore, textile applications like apparel and upholstery need to perform well in this test. This test is less applicable to shade fabrics whose main function is solar protection. Shades need to hold flat and true in a window, but do not need to withstand direct large sudden bursts of penetrating force.

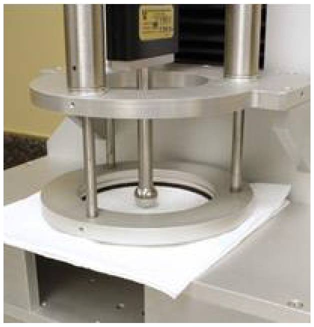

Image 8: Ball Burst Tester

Table 9: Tear Strength (ASTM D5587) (2x2 Basketweave , Selected Sample Fabrics)

	Tear Strength (N)		Tear Strength (lbf)	
Fabric	Warp	Weft	Warp	Weft
Fiberglass Core	54.5	49.9	12.26	11.22
Polyester Core	122	60.4	27.38	13.58

Another test used to evaluate textile products for performance and quality is the tear strength test. In this test, a load is applied to a piece of fabric, which has been partially cut in its center, until the slit propagates perpendicularly across the entire sample. This test evaluates how well a fabric will perform in an application where cuts or rips may occur. Industrial textiles must perform well in this test to ensure that any punctures or damage to the fabric does not propagate. Fiberglass core fabrics perform poorly compared to polyester core fabrics for tear strength. One explanation for the results are based on the ability of polyester to deform under given loads. Polyester fabric will deform before it propagates a tear.

Tear strength also increases as fabric thickness increases which gives polyester additional tear resistance. However, solar shade applications do not experience the potential punctures and damage that are characteristic of an industrial environment. In addition, due to the high loads that are required to break or tear a shade fabric, these values are not typically the cause of shade failure in solar shading applications.

Abrasion Resistance

There are many abrasion tests that compare fabrics for their ability to withstand an abrasive force. For example, ASTM D3884 utilizes two abrasive wheels, with a specified load; to simulate accelerated wear at all angles on the material. This test, while not necessarily estimating a fabric's lifespan, can compare the performance of one fabric to that of another. Abrasion tests are useful in comparing products that experience unwanted frictional rubbing during their normal use or are required to perform well upon extended exposure to the elements. Solar shading applications are less likely to experience significant abrasion during their lifecycle and are often used in controlled environments. Abrasion resistance of a core fabric is influenced more by the quality and thickness of the vinyl coating, which is present on both fiberglass core and polyester core fabrics.

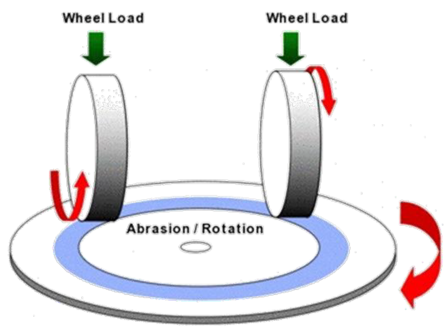

Image 9: Taber Abrasion Test Diagram (ASTM D3884)

Thermal Properties

Table 10: Thermal Properties

Material	Melting Point (°C)	Melting Point (°F)
Fiberglass	840	1544
Polyester	270	510

A major distinct difference between fiberglass and polyester cores is their melting temperature. Fiberglass has a much higher melting point than polyester and therefore a much higher resistance to deformation at high temperatures. Polyester will begin to deform when exposed to lower levels of heat. In solar shading applications, polyester can experience deformation as the sun heats a shade due to the thermoplastic nature of the core and coating. Solar energy is absorbed by the PVC coating. Images 10 and 11, below, show a fiberglass core fabric and a comparable polyester core fabric which have been experimentally heated, on one side, at 140°F for 1 hour. The polyester fabric shows deformation at its edges and a wrinkle near the bottom left, while the fiberglass fabric remained flat and true as a shade. The polyester shade may be able to recover if allowed to cool, but if the wrinkled shade is rolled up while still hot then the shade may retain the deformation. This action could cause a temporary deformation to become permanent as the rolling action, followed by cooling, prevents the wrinkle from relaxing.

Image 10: Fiberglass Core Fabric in Heatbox

Image 11: Polyester Core Fabric in Heatbox

Elongation Test

The effects of heat are amplified when the fabric is loaded or is under tension. A test was conducted in which identical sized panels of a fiberglass core fabric and a comparable polyester core fabric were loaded with weight for 24 hours (Image 12) at room temperatures. After this duration, the fiberglass core fabric had 0.50% growth, while the polyester had 1.7% growth. The test was then repeated with new panels for 6 hours, with the addition of a 140°F heat source (Image 13). After only 1 hour in the heated test, the polyester core fabric met and exceeded the previous 24-hour unheated stretch distance. The fiberglass core fabric, by comparison, did not stretch more because of the heat Image 14 shows stretch results of the unheated 24-hr test, which are significantly less, for the polyester core fabric, than the results of the heated test at the 1-hr point shown in Image 15.

After 6 hours in the heated test, the fiberglass core fabric had less than 1% growth, while the polyester had 4% growth. The addition of heat caused the polyester core fabric to elongate much further because the increasing temperature effectively decreases the modulus of the thermoplastic polyester.
The heat does not affect the fiberglass core fabric because fiberglass is composed of homogeneous filaments with a high melting and softening point. The very slight increase in growth can be attributed to the thermoplastic nature of the vinyl coating.

This test also demonstrated how the effects of tension and heat could affect dimensional stability. The application of a load can lead to hour-glassing of a polyester core fabric, and heating can cause this change to be permanent. Hour-glassing is caused by poor dimensional stability and is characterized by inward curvature on the sides of the panel. The sum of the curvature peaks was measured to quantify the change. The curvature sum was approximately 3.2 cm for the polyester core fabric and 0.7 cm for the fiberglass core fabric. Once allowed to cool, the permanent curvature deformation, on each side, for the polyester core fabric is approximately 1.5 cm, while the permanent deformation for fiberglass core fabric is only 0.2 cm. Although this test was accelerated by a sizable weight load, the test shows that when taken to an extreme situation fiberglass core fabric will not change, while polyester core fabric will elongate and take an hourglass shape. In less demanding situations, fiberglass core fabric will not stretch, but over time polyester core fabric will deform due to gravity under its own weight.

Image 12: Weighted Elongation (Room Temp-24hr)
Polyester (left), Fiberglass (Right)

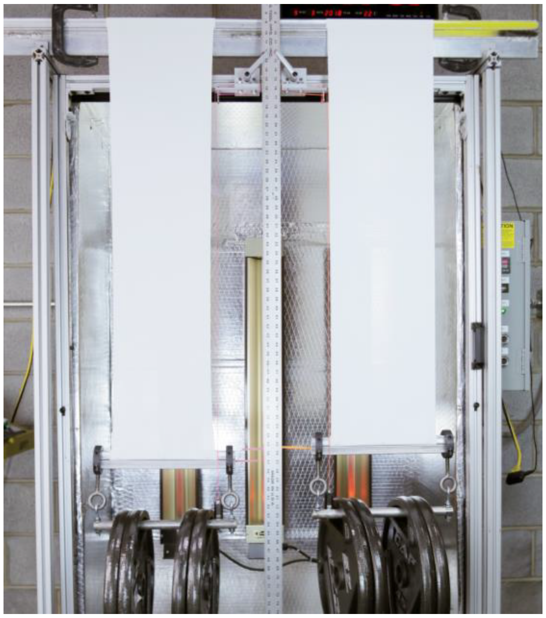

Image 13: Heated Elongation (140°F-1hr)
Polyester (left), Fiberglass (Right)

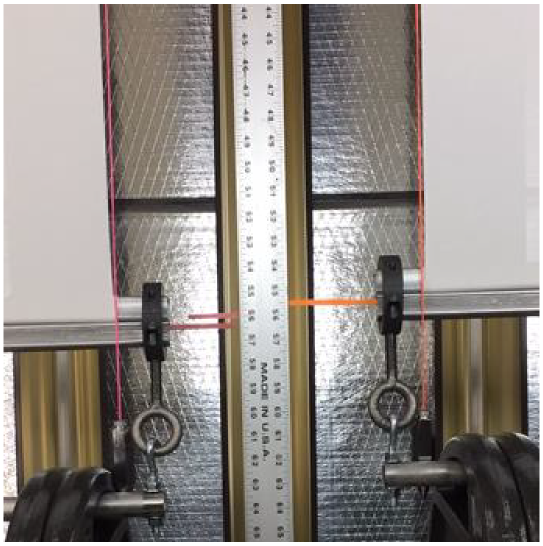

Image 14: Weighted Elongation Comparison (24hr)
Polyester (left), Fiberglass (Right)

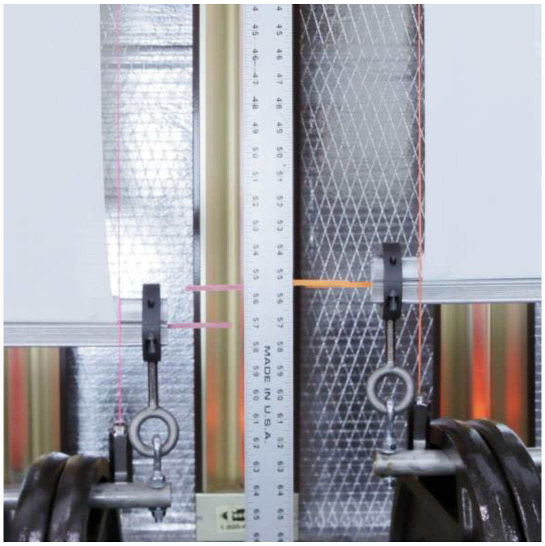

Image 15: Heated Elongation Comparison (6hr)
Polyester (left), Fiberglass (Right)

Cutting

The difference in core yarn can also affect how the fabric responds to cutting. Polyester yarn can provide a clean cut edge on a shade when cut ultrasonically because its low melting point allows a heat source like a flame or ultrasonic blade to melt and seal the fibers in place. It is common practice to use some type of flame source on the cut edge of the shade to shrink and remove any remaining exposed polyester fibers. Fiberglass, on the other hand, does not respond to heat, and frayed edges cannot be melted. If the vinyl coating is stripped away from the fiberglass yarn, such as in the case of a dull blade being pulled through the fabric, small fiberglass fibers may also be visible on the shade's edge. If noticeable, these fibers would need to be trimmed, typically with scissors or an electric trimmer. Neither core yarn will continue to fray once initially trimmed because of the filament nature of the core.

Conclusion

Polyester core fabric and fiberglass core fabric have physical differences that make them uniquely designed for specific applications. Polyester core fabric outperforms fiberglass core fabric when it comes to burst strength and tear strength. These properties are thanks to polyester's innate ability to deform under a load. Polyester will stretch and bend before it will break, especially when exacerbated by heat. Testing also shows that polyester has a greater ability to recover to its initial size and shape once it is deformed. These aspects of polyester make it the best material choice for products that need to deform under weight, but also return to its original shape. These products include clothing, upholstery, and carpeting.

Fiberglass core fabric has its own strengths including tensile strength, low elongation, deformation resistance, lower weight, finer yarns, and high melting point. High deformation resistance allows fiberglass fabric to remain flat and unwrinkled even under high loads and high heat. The physical size of the fiberglass core yarns increases the view-through clarity of the fabric. Finally, its high melting point makes fiberglass thermally stable when exposed to high heat or extended exposure. These properties make fiberglass excellent for products that need to hold a particular shape without deforming, provide a transparent barrier, and withstand regular solar heating. It is important to understand and consider the different strengths of polyester and fiberglass core fabrics in order to choose the right material for an application.

References:

Images 1-6: Internally taken
Image 7: Single Column Tensile Tester Link
Image 8: Ball Burst Tester Link
Image 9: Taber Abrasion Tester Link
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"Fiberizing your ideas", Booklet, Page 15, 2015-2016, Verotex, Saint-Gobain
"E-Glass Fiber", "Properties", Matbase.com, Link
Polyester Value
Teijin Mechanical Properties of Selected Fibers Table, Link
Table 8: External Test Results (Diversified Testing Laboratories, Inc.) , Link
Table 10: Fiberglass Value
"Fiberizing your ideas", Booklet, Page 16, 2015-2016, Verotex, Saint-Gobain
Polyester Value
"Polyester Fiber", "Properties", Matbase.com, Link (Within the accepted range)
"Polyester Fiber | PET | Physical Properties of Polyester Fiber | Chemical Properties of Polyester Fiber", Textile Learner, Link