Tedlar®

polyvinyl fluoride film

Product and Performance Guide for *Tedlar*® PVF Film in the Flexible Sign and Awning Market

Understanding *Tedlar*® Film

Tedlar® polyvinyl fluoride (PVF) film was commercialized by DuPont in 1961. Its unique balance of weather resistance, inertness, non-staining properties, and chemical and graffiti resistance, as well as its ability to maintain toughness and flexibility over a wide temperature range, has made it the ideal choice for demanding indoor and outdoor applications. Initially developed for residential siding, *Tedlar*® film has expanded into many markets, including aircraft interiors, wall coverings, truck/trailer sides, graphics, highway sound barriers, architectural building panels, air supported structures, and flexible signs and awnings.

While *Tedlar*® film has been used as the external surface of PVC fabrics in the flexible structures market for 15–20 years, it was introduced in the flexible sign and awning market approximately 10 years ago. It has seen wide acceptance and rapid growth due to its ability to provide an easily cleaned, low maintenance surface. *Tedlar*® film helps keep outdoor vinyl fabrics looking newer longer.

The fluorocarbon nature of *Tedlar*® film is the basis for the film's outstanding durability and resistance to a variety of solvents and harsh chemicals. It is impermeable to greases and oils and has excellent resistance to sunlight degradation. *Tedlar*® film stands up well to atmospheric pollutants and resists acid rain attack and mildew. Most airborne dirt does not adhere to *Tedlar*® film; if soiling does occur, rainwater or a commercial cleaner can be used to restore the surface to its original appearance. *Tedlar*® film improves the cleanability of PVC fabrics. Plasticizers in uncoated PVC can migrate to the surface of the fabric and collect dirt, making cleaning difficult. *Tedlar*® film has high tensile strength, good abrasion resistance, and is flexible.

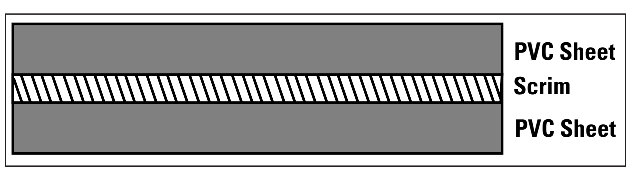
Tedlar® film is available as a pigmented film or a near-colorless, transparent film. The pigmented films offer the highest level of protection from ultraviolet (UV) light degradation, as the pigments block nearly all UV and visible light from passing through the *Tedlar*® film. This means that the materials underneath the film will not be exposed to high-energy, destructive light. The transparent films are available in an enhanced UV-screening formula that *initially* blocks nearly all of the UV light up to 350 nm. These UV-absorbing films screen out progressively less UV light at the less harmful, lower energy end of the UV spectrum (350 to 400 nm) and block very little visible light.

Tedlar® film is available to the vinyl fabric market as a biaxially oriented film (Type 3) or an unoriented film (Type 8 or 9; also called *Tedlar*® SP PVF film). Both film types offer outstanding color stability, chemical resistance, and ease of cleaning. Because of differences in process technology, *Tedlar*® SP film is available as a translucent film for backlit applications, while the oriented films are typically available as a transparent or opaque film only. *Tedlar*® SP film colors are bright and sharp and can be produced in varying gloss levels.

Understanding Laminates Surfaced with *Tedlar*®

Manufacturers have a good deal of flexibility in fabricating a vinyl fabric surfaced with *Tedlar*® PVF film. The typical building block of the vinyl fabric is a fabric scrim sandwiched between two layers of PVC (see **Figure 1**).

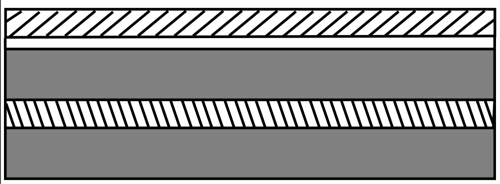
Figure 1. Construction of Typical Substrate



There are a number of ways to construct a colored finished laminate. Some of the prevalent methods include lamination of the following materials to the vinyl and scrim substrate (see **Figure 2**):

- Clear, UV-screening *Tedlar*® PVF film over
  - pigmented vinyl or
  - ink
- Pigmented *Tedlar*® film

Figure 2. Construction of Typical FInished Laminate



Inks can be applied to the *Tedlar*® or substrate with a wide variety of techniques, depending on the application. These coloring and imaging techniques include coating, heat transfer and screen, ink jet, and electrostatic printing.

An adhesive is required to bond *Tedlar*® film to the substrate. The adhesive chosen must be durable in the environment that it will be used. This typically means that it should be hydrolytically stable as well as thermally stable. The chemistry of the adhesive must also be compatible with the other components of the laminate so that interactions do not lead to aesthetic or functional problems.

Tedlar® *film will not improve the performance of a laminate manufactured with materials that are inadequate for the system*. Overall performance of a *Tedlar*® PVF surfaced vinyl fabric material is dependent on the quality and compatibility of the laminate materials and the consistency of the process used to manufacture the product. Weathering studies in south Florida have demonstrated considerable differences in both color retention and adhesion of ink-coated *Tedlar*® films laminated to different vinyl scrims.

As with the adhesive, the other components of the laminate (i.e., inks and/or vinyls) must be stable in the intended environment. Thermal stability and resistance to UV and visible light are essential characteristics. Pigment stability in acidic environments is also critical. As vinyl ages, it can slowly start to degrade and create acidic conditions (evolution of HCl). The acidic environment can lead to breakdown of pigments and, hence, discoloration of the laminate.

Laminates must be tested prior to commercialization to assist in evaluating the performance of a given vinyl fabric construction surfaced with *Tedlar*® PVF film. These tests may include the following: Dry bond and wet bond tests can be used to judge the *initial* bond strength of *Tedlar*® film to the substrate. Oven aging tests run at in-use temperatures can give an indication of the relative thermal stability of the vinyl alone as well as a sign of interactions between materials in the laminate that might be initiated by heat. Accelerated weathering is the most comprehensive test that can be run, short of exposure in a real environment. Although this is a time-consuming test, it is highly recommended as a way of evaluating *long-term* bond performance, thermal stability, UV and visible light resistance, and potential component interactions of the entire laminate. Accelerated weathering tests in Atlas' carbon arc and Xenon arc have predicted instances of film delamination, fading, and darkening of laminates. It is advisable to weather samples until the point of failure prior to making any performance claims.

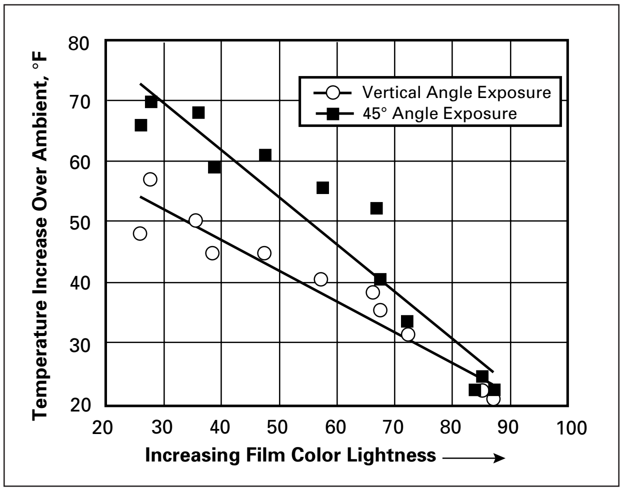
Understanding the Flexible Sign and Awning Application

A flexible vinyl fabric used outdoors is inherently subject to a wide range of environmental conditions. In addition to the design and quality of the laminate system, thermal history is one of the most significant factors affecting the life of the material. Ambient temperature, moisture, exposure angle, exposure direction, color, and material contact with metal framing all play a role in determining how hot the fabric becomes.

Exposure angle of a flexible awning can vary from a vertical to a horizontal position, while flexible signs are typically vertical only. A vertical orientation is the least harmful exposure angle, as the laminate receives less exposure to direct sunlight; a horizontal orientation is usually the most severe exposure angle. In the northern hemisphere, laminates that face south are subjected to more direct light radiation than those facing any other direction and will weather at a more rapid rate. Darker colored laminates absorb and retain more heat than lighter colored ones. Surface temperatures as high as 71°C (160°F) have been measured in the field on dark-colored awnings.

In a study designed to better understand how exposure angle and color impact surface temperature, it was found that in a moderate climate: 1) the surface temperature of dark colors, such as brown and gray, can reach as much as 39°C (70°F) hotter than the ambient temperature when exposed at a 45° angle, while the surface temperature of light colors, such as white, under identical conditions may only reach 11°C (20°F) over ambient temperature; and 2) dark colors at a 45° exposure angle can be as much as 11°C (20°F) hotter than those at a vertical angle, while light colors at a 45° angle may only be several degrees more than those at a vertical angle (see **Figure 3**).

Figure 3. Temperature Increase of Vinyl Laminates Surfaced with *Tedlar*® PVF Film versus Film Darkness



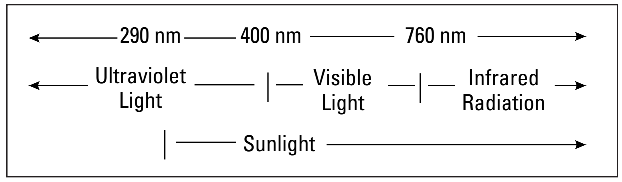
Designing vented awning structures to avoid heat buildup may be beneficial in extending the service life of a flexible vinyl fabric surfaced with *Tedlar*® film. Additionally, the design of a thermally stable construction, as discussed in the previous section, is mandatory.

The laminate exposure location, angle, and direction also dictate the amount of direct UV and visible light radiation the components of the fabric see. While pigmented *Tedlar*® films offer superior protection of the substrate materials to photolytic degradation, a clear, UV-screening *Tedlar*® film is a popular choice for the flexible sign and awning market because of the versatility it offers. A transparent film can be used as an overlaminate to provide an easy-to-clean surface for both solid colors and images.

Clear, UV-screening *Tedlar*® film protects the components behind it differently than a colored film. The pigments in colored *Tedlar*® film act as blockers to UV and visible light and are longer lasting than are the additives used to screen out UV light in the transparent film. Because the clear films do not contain pigments, they rely on these special additives to help keep harmful UV light from affecting the film and the adhesive. A brief explanation of the function of a clear, UV-screening *Tedlar*® film follows.

Sunlight at the earth's surface emits *ultraviolet light* in the wavelength range of 290 to 400 nm, as well as *visible light* over the range of 400 to approximately 760 nm, and *infrared radiation* at wavelengths above 760 nm (see **Figure 4**). The most damaging of these energy sources to flexible signs and awnings is ultraviolet light, which is highest in energy.

Figure 4. Energy Spectrum



Clear *Tedlar*® film with UV absorber additives initially blocks greater than 99% of the UV light over the energy wavelength range of 290 to 350 nm. Lower energy light in the range of 350 to 400 nm is blocked to a lesser extent by the film. As with all other transparent *Tedlar*® films, the UV screening film transmits visible light (see **Figure 5**).

The UV absorber additives in *Tedlar*® film are not permanent. Over a period of time, they are gradually depleted, and the more destructive, higher energy light is allowed to pass through the film. Studies of free-standing, 1 mil thick, UV-screening *Tedlar*® film (TUT10BG3) weathered in south Florida at a 45° angle facing south indicate that under these conditions, the UV absorbers will be slightly less than 50% depleted after 5 years (see **Figure 6**). This rate of UV absorber depletion may be increased when the film is laminated to a substrate. The temperature of a laminate will typically be hotter than a free-standing film. This difference in temperature can accelerate UV absorber degradation.

Delamination and embrittlement of clear *Tedlar*® film typically mark the end of useful laminate life. Studies have indicated that this time period is extremely dependent on exposure conditions and laminate construction. Correctly designed laminate systems surfaced with 1 mil thick UV-screening *Tedlar*® film (TUT10BG3) have demonstrated from 5 to 10+ years of service life, depending on the severity of exposure conditions.

Figure 5. Spectral Transmission of Clear, UV-Screening *Tedlar*® Film

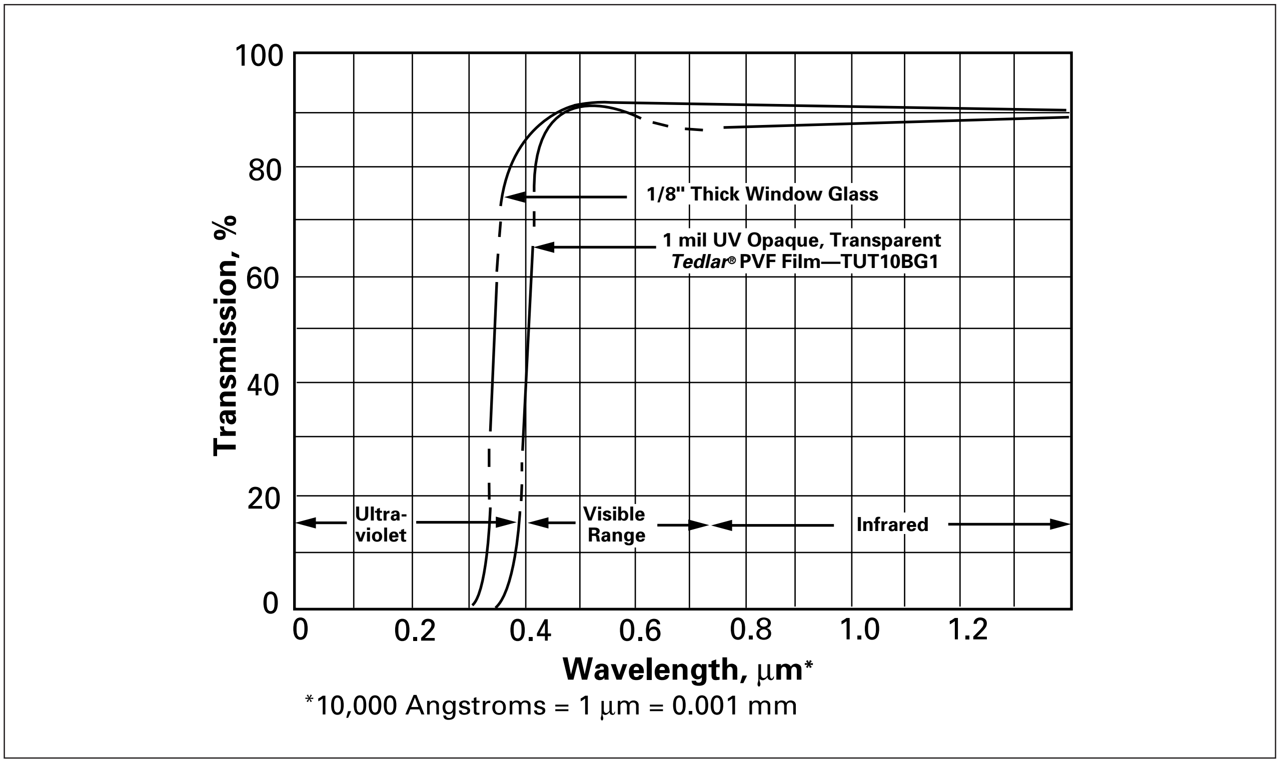


Figure 6. Average Rate of UV Absorber Degradation in Free-Standing *Tedlar*® PVF Film (TUT10BG3) Exposed in Florida

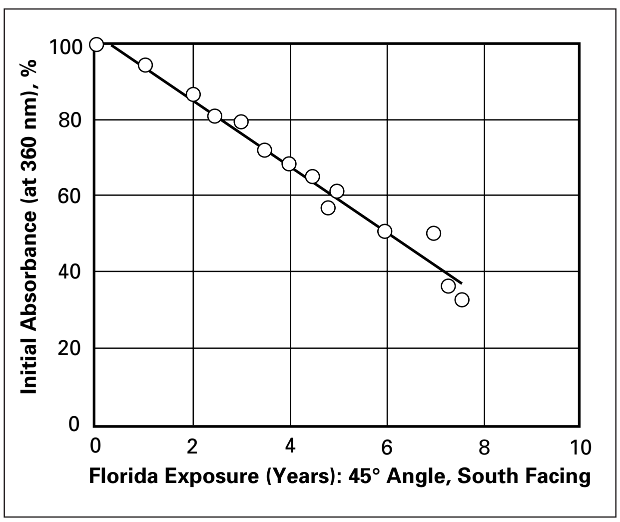
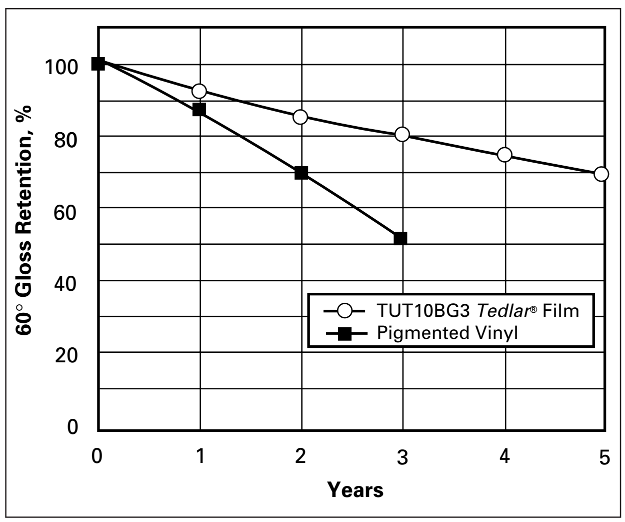


Figure 7. Percent Gloss Retention in South Florida Weathering at 45° Angle Southern Exposure



Unprotected vinyl fabrics exhibit a much different weathering pattern. They typically deteriorate in appearance gradually, marked by gloss loss and accumulation of dirt (see **Figure 7**). A material that loses gloss will appear lighter and less colorful to the eye. Vinyl that is embedded with dirt also will appear less colorful. The benefit of *Tedlar*® film is that once it becomes dirty, the initial appearance can be restored easily, without harsh chemicals.

Design Criteria

Proper design of a flexible vinyl fabric surfaced with clear, UV-screening *Tedlar*® film can enhance the product's performance and prevent field issues, such as discoloration of the laminate and delamination of film from the laminate. The following design criteria should be considered to obtain maximum value from the fabric system.

Discoloration can manifest itself in two forms: darkening of vinyls or adhesives and fading of pigments. These problems can be alleviated by selecting laminate components that are compatible and stable in the environments to which they will be exposed. This means selecting materials that are:

- Thermally stable at temperatures that the fabric will reach (71°C [160°F] or more)
- Not sensitive to visible light and near visible ultraviolet light
- Stable in acidic environments
- Not going to interact negatively with each other

As a first step, it may be helpful to work with suppliers in selecting materials that meet the criteria of a successful system. After that, it is advisable to evaluate the system as discussed in the earlier section, "Understanding Laminates Surfaced with *Tedlar*® PVF Film." It is especially critical to test materials in an accelerated weathering environment that emits radiation consistent with sunlight (such as Xenon arc) until the point of failure. There is a high probability that this testing will give an indication of potential inadequacies. Each unique construction should be evaluated, as vinyl formulations or pigment combinations can vary greatly in performance. Field weathering evaluations are recommended also, to develop a correlation between accelerated and real exposure time.

Delamination of *Tedlar*® can result from a poor initial bond between the film and the substrate or a breakdown of the bond over time. Poor initial bond is typically a result of improper surface treatment of *Tedlar*® film, contamination of the *Tedlar*® film or vinyl surface, or inadequate activation of the adhesive during lamination. Poor long-term adhesion can be caused by migration of additives in the vinyl, such as plasticizers, substrate degradation, or photolytic degradation.

The most common cause of delamination is photodegradation. The nature of the UV-screening clear *Tedlar*® PVF film is that the additives become depleted over time, allowing more UV light to pass through the *Tedlar*® film. As this happens, the materials beneath *Tedlar*® film are subjected to increasing amounts of UV light, which can compromise the adhesive-to-film bond and result in delamination. To postpone the occurrence of *Tedlar*® film delamination:

- Use a clear, UV-screening *Tedlar*® film that is designed for the exposure conditions.
- Protect the lamination surfaces of the *Tedlar*® film and the vinyl substrate from contamination.
- Select only those adhesives that provide an acceptable long-term bond, as evaluated in weathering tests.
- Follow the manufacturer's recommended process conditions for activating thermal adhesives.
- Do not use *Tedlar*® film on the back side of the fabric construction. Surfacing both sides of a vinyl scrim with *Tedlar*® film can result in film delamination from trapped plasticizers.

Cleaning Laminates Surfaced with *Tedlar*® Film

Tedlar® film is easy to clean. *Tedlar*® film is so smooth and inert that an annual soap and water washing may well be all that is needed to keep signs and awnings looking clean and bright. Paint or sprayed on graffiti can be easily removed with suitable commercial solvents without damage to fabrics protected by *Tedlar*® film.

The procedures for removing stains can be divided into three categories, depending on the staining agent. In all cases, cleaners should be applied generously using a soft cloth with very light pressure to avoid polishing the stained area.

- Easy Procedures (Cloth Only, Wet or Dry)

  Many staining agents can simply be wiped from the *Tedlar*® film using either a wet or dry cloth.

- Mild Procedures (Soaps, Household Detergents)

  Some staining agents require the use of warm, full-strength solutions of standard detergents, such as Fantastik.* These stains should be removed with a soft cloth and detergent solution and given a final rinse with clear water to effect maximum stain removal.

- Moderate Procedures (Solvents)

  Many staining agents, especially those with heavy oil or grease bases, will require the use of a solvent for removal. To remove asphalt, tar, road oil, grease, fresh paint, or caulking compounds from *Tedlar*® film, use a good grade of mineral spirits, kerosene, naphtha, turpentine, or commercial automotive or road-oil removal agent. Follow the procedure with a detergent rinse and a clear water rinse. Commercial fabric cleaning fluids may also be used to remove stains. For the most stubborn stains, solvents such as acetone, toluene, or methyl ethyl ketone (MEK) may be used.

*Fantastik is manufactured by Texize Inc., Greenville, SC.

For more information on *Tedlar*® PVF films: **(800) 255-8386**

DuPont *Tedlar*®
P.O. Box 88
Sheridan Drive and River Road
Buffalo, NY 14207-0088

Fax: (716) 879-4545

Europe

DuPont de Nemours Int'l SA
2, chemin du Pavillon
P.O. Box 50
CH-1218 Le Grand-Saconnex
Geneva, Switzerland
(022) 7175111

Canada

DuPont Canada, Inc.
P.O. Box 2200, Streetsville
7070 Mississauga Road
Mississauga, Ontario, Canada
L5M 2H3
(905) 821-5193

Japan

DuPont Kabushiki Kaisha
Tedlar® PVF Film
4th Floor Chiyoda Honsha Bldg.
5-18, Sarugaku-cho 1-chome
Chiyoda-Ku, Tokyo 101 Japan
(011) 81-3-5281-3428

Asia Pacific

DuPont Asia Pacific Ltd.
TST P.O. Box 98851
1122 New World Office Bldg.
(East Wing)
Salisbury Road, TST
Kowloon, Hong Kong
(011) 852-3-734-5345

DuPont Singapore PTE Ltd.
1 Maritime Square #07-01
World Trade Center
Singapore 099253
65-273-2244

CAUTION: Do not use in medical applications involving permanent implantation in the human body. For other medical applications, see "DuPont Medical Caution Statement," H-50102.

Tedlar®
Only by DuPont

(12/95) 244322B Printed in U.S.A.
[Replaces: H-61637]
Reorder No.: H-61637-1