Fact Sheet

DUPONT®

Teflon®

Nonstick & Industrial Coatings

Teflon® ETFE Coatings

Primers: 699-123 Water-Based, Black
532-6006 Powder, Blue

High-Build Topcoat Powders: 532-6110 Clear
532-6114 Green
532-6118 Sparkling Beige

Ultrasmooth Topcoat Powder: 532-6210 Clear

Description

Ethylene tetrafluoroethylene (ETFE) is a thermoplastic copolymer derived from the polymerization of ethylene and tetrafluoroethylene (*Teflon*®) monomers. This resin is an extremely tough and abrasion-resistant material having excellent chemical resistance and continuous operating temperatures up to 150°C (300°F). ETFE is also an excellent electrical insulator and has good nonstick and low-friction properties.

The *Teflon*® ETFE coatings listed above represent an expanded family of products based on new, improved formulations of ETFE resins—*some of which are now suitable for food contact end uses.* Refer to **Table 1** for physical property information. Using appropriate product combinations, coating systems are now available for use in a wide variety of applications ranging from thin-film systems (75–250 µm [3–10 mil]) for service involving abrasion resistance or mild chemical service, to thick-film systems (up to 1300 µm [50 mil]) for linings where the ultimate chemical protection is required.

Thick-film *Teflon*® ETFE coatings have been improved for application in thicker films per coat and for better sag resistance when approaching the final thickness. The application technique involves a spray-and-bake procedure whereby multiple coats, sprayed and baked individually, are used to achieve the desired final film thickness. The resulting finish is tough, seamless, and without pinholes—perfect for applications in harsh chemical environments.

The relative chemical inertness of *Teflon*® ETFE also makes it ideal for applications where maintaining product purity is critical. Some of these thick-film coatings are also suitable for food contact applications.

Table 1
Physical Properties

	Topcoats	
Product Code	**532-6110 Clear 532-6114 Green 532-6118 Sparkling Beige**	**532-6210 Clear**
Type	High-Build Topcoats	Ultrasmooth Topcoat
Specific Gravity	1.71	1.71
Coverage,* ft^2/lb m^2/kg	110 22	110 22
Average Particle Size, µm	80	80
Melting Range, °C (°F)	255–280 (491–536)	255–280 (491–536)

	Primers	
Product Code	**699-123 Black**	**532-6006 Blue**
Type	Liquid	Powder
Weight Solids, %	23.1	100
Volume Solids, %	18.0	100
Coverage,* ft^2/gal m^2/liter	287 7.0	109 (ft^2/lb) 22.4 (m^2/kg)
Density (lb/gal) (kg/liter)	8.9 1.0	1.76 (g/cc)
Viscosity, cps	200–500	NA

*At 25 µm (1.0 mil) assuming 100% spray efficiency.

FDA Status

Teflon® ETFE coating systems consisting of 699-123 Primer and 532-6110, 532-6118, and 532-6210 Topcoats, when used up to 1300 µm (50 mil), comply with FDA regulations governing components of coatings for direct food contact.

CAUTION: 532-6006 Blue Primer and 532-6114 Green Topcoat do not comply with FDA regulations. A coating system containing either of these products, even if over-coated with a compliant topcoat, is still a noncompliant coating system.

Medical

Do not use DuPont materials in medical applications involving permanent implantation in the human body or permanent contact with body fluids or tissues.

Typical Product Combination Examples

Thin-Film Systems

75–130 µm (3–5 mil)	699-123 Primer 532-6210 Topcoat applied "dry on wet" Black, one-bake, smooth, FDA-conforming, tough, abrasion-resistant, mild chemical service
130–250 µm (5–10 mil)	532-6006 Primer 532-6210 Topcoat (2 coats) Blue, smooth, tough, abrasion-resistant, mild chemical service

Intermediate Systems

250–650 µm (10–25 mil)	699-123 Primer 532-6210 Topcoat or 532-6110 Topcoat (multiple coats) Smooth, black, FDA-conforming (Use 532-6210 as a final topcoat for very smooth finish)
	532-6006 Primer 532-6210 Topcoat or 532-6110 Topcoat (multiple coats) Smooth, blue, chemical service (Use 532-6210 as a final topcoat for very smooth finish)
	699-123 (for FDA conforming uses) 532-6006 (for non-FDA conforming uses) 532-6118 Topcoat (multiple coats) Sparkling beige, permeation-resistant

High-Build Systems

650–1300 µm (25–50 mil)	699-123 Primer 532-6110 Topcoat (multiple coats) Black, FDA-conforming (Use 532-6210 as final topcoat for very smooth finish)
	699-123 Primer 532-6114 Green Topcoat (multiple coats) 532-6110 Clear Topcoat Green, chemical service
	699-123 Primer 532-6118 As Intermediate (multiple coats) 532-6210 Topcoat Clear Sparkling beige, permeation-resistant, FDA-conforming

Metal Surface Preparation

Best adhesion is obtained by thoroughly cleaning and then roughening the substrate.

Cleaning is preferably done using a commercially available hot alkaline solution. Commercial solvent degreasing is an acceptable alternative, as long as appropriate health and safety precautions are taken. Solvent cleaning by hand is not recommended. It is also the general consensus in the industry that a high-temperature burn-off prior to grit blasting provides improved performance of the final coating system.

Roughening is preferably done by grit blasting with aluminum oxide. New grit will give the best profile because it creates sharper peaks and valleys than can be obtained with old, rounded grit. The blast profile (surface roughness depth) should be at least 75–125 µm (3–5 mil) for intended coating thicknesses above 750 µm (30 mil). This profile can generally be achieved with coarse grit (10–20 mesh) using 620–690 kPa (90–100 psi) air pressure but surface properties of the part to be coated and design of the blasting equipment may require variations for optimal performance.

Primer Application

Teflon® ETFE has inherently superior adhesion to most other fluoropolymers and has been used without a primer in a variety of applications. However, a *Teflon*® primer will approximately double the adhesive strength of the bond. Both powder and liquid primers are available.

Liquid

The 699-123 Liquid Primer is recommended for all coating systems where the intended final film build is greater than 635 µm (25 mil). It is formulated with adhesive resins having outstanding resistance to high temperatures and can withstand the thermal abuse from multiple bakes during topcoat application.

Apply the 699-123 Black Primer in a thin layer such that it *just barely* hides the blasted substrate when wet. (A blast profile of 75 µm [3 mil] will provide a primer thickness of approximately 14 µm [0.5 mil]). The actual thickness will (and should) vary depending on the depth of blast profile. Avoid excessive thickness, which can lead to intercoat adhesion failure. After air drying, the primer should visually appear to be slightly rough with a dull, mottled look. Small white specs (ETFE particles) may be visible, which is normal.

Carbon steel substrates are sensitive to rusting; the 699-123 Liquid Primer is formulated with antiflash-rust additives. Preheating to 50°C (120°F) will minimize this problem, especially during humid weather or cool, damp, early morning start-ups.

The first powder topcoat can be applied directly over the wet, air-dried, or force-dried (66°C [150°F]) primer. *Do not fully pre-bake the primer.*

Powder

The 532-6006 Powder (Blue) Primer can be used reliably for all applications up to 635 µm (25 mil). This limitation is predicated on total oven bake time, which depends on the mass of the part and the film build per coat (thus the *number* of bakes). Primer failure is evident initially by severe discoloration (greenish-brown), followed by blistering.

Apply a heavy coat (50–75 µm [2–3 mil]) electrostatically and bake 15 min at 290°C (550°F). If preferred, 532-6006 Powder Primer also can be applied to a preheated part at the recommended bake temperature for ETFE topcoats resulting in a much thicker layer of primer coat.

Application

Teflon® ETFE Powder can be applied using any commercially available powder coating equipment. The powder is given an electrostatic charge, which results in an attraction to the grounded metal part. Use the maximum charging voltage that provides a good electrostatic attraction without repulsion. This voltage is usually in the 20–30 kV range, but varies with the specific equipment used. (Commercial equipment may operate at significantly higher voltages—60 kV has been observed.) Adjust delivery air pressure to produce a *cloud* of powder that does not excessively blow past the part.

After the first coat is applied, the part becomes electrically insulated and subsequent coats are poorly attracted, leading to thin films per coat. Thus, after the first coat, the hot flocking method is combined with the electrostatic application

(applying the powder to a hot part, immediately after it is removed from the baking oven). The resulting film builds will vary, depending on the temperature of the part and its mass (ability to hold heat). Spraying a hot part will always yield thicker films per coat than spraying a cold part. It may be necessary to decrease the application voltage after the first coat to avoid the formation of pits on the coating surface. These pits are caused when powder particles strike the uncured powder already on the part with sufficient force to knock some of the dry powder off. Reducing the application voltage reduces the energy of the incoming powder particles.

CAUTION: Hot flocking procedures may result in overexposure to decomposition fumes. Adequate ventilation is an absolute necessity.

Another alternative is to use triboelectric spray equipment. These devices create an electrostatic charge (negative) by virtue of motion through tubes made of nylon or other material. The powder particles are only weakly charged, but sufficiently to adhere to a previously coated part more effectively than powder sprayed from standard electrostatic equipment.

Topcoat Application

Thin Films

Use 532-6210 Clear Topcoat for all thin-film applications. This product has a high melt flow value and will provide smoother films. Electrostatic application of a second coat on a thin-metal part is difficult. The first coat electrically insulates the part and the thin metal will not hold heat long enough to melt-fuse a second coat. Triboelectric spray equipment will provide better results.

High Build Films

Use 532-6110 Clear, 532-6114 Green, or 532-6118 Sparkling Beige Topcoat for all high-build applications where the intended final film thickness exceeds 635 µm (25 mil). These coatings resist sagging and pulling away from sharp edges. The 532-6118 Sparkling Beige is specially formulated to provide maximum resistance to permeation, but it can only be used reliably up to 750 µm (30 mil) without risk of blistering. The 532-6114 Green is preferred as the intermediate coat because the chrome oxide pigment retards permeation and helps compensate for polymer shrinkage stresses. When using this topcoat, finish the part with a final coating of 532-6110 Clear. A smoother final finish can be obtained by using 532-6210 Clear for the final coat. To enhance the smoothness of the final surface without having to use a final coat of 532-6210, avoid excessively thick intermediate coats.

When using 699-123 Liquid Primer, apply the first powder topcoat electrostatically to the cold part and then place in the oven. After baking, subsequent coats can be applied by means of hot flocking.

When using 532-6006 Powder Primer, the first coat of topcoat may be hot flocked.

The film build per coat during hot flocking application is typically 75–250 µm (6–10 mil). However, this is only a guideline. Hot flocking can yield highly variable builds per coat depending on the mass and size of the parts coated.

Baking

Teflon® ETFE can be cured within a range of bake temperatures (metal temperatures), shown in **Table 2**.

Table 2
Teflon® ETFE Bake Temperatures

	Metal Temperature*	Time at Metal Temperature
Recommended (1st coat)	290°C (550°F)	15 minutes
Recommended (subsequent coats)	315°C (600°F)	15 minutes
Minimum	305°C (580°F)	30 minutes
Maximum	330°C (625°F)	10 minutes

*Oven temperatures may need to be slightly higher.

If the film thickness of the coating is in the 250–380 µm (10–15 mil) range but fails a Continuity Test (Spark Test) at 2,000 volts, the probability is that it was underbaked. Rebaking the part will eliminate the pinholes. Adjust the bake schedule accordingly.

Adherence to the recommended bake schedules is crucial to final performance for the high-build systems. These coatings have outstanding resistance to heat and are specially formulated to resist sagging in thick films, which is achieved by modifying the flowability of the molten material over time. The molten ETFE flows well initially, but the rate of flow decreases with increasing time. Insufficient dwell time in the molten state, therefore, can result in a film with pinholes. If encountered, this condition can be corrected by rebaking the part. Adjust the process time and/or temperature accordingly for subsequent parts.

Prolonged exposure at or above the maximum bake temperature can cause brown discoloration, polymer sagging, and blistering.

Safety

Follow normal industry safety procedures for handling and applying *Teflon*® products. Industrial experience has clearly shown that *Teflon*® ETFE coatings can be processed and used at elevated temperatures without hazard to personnel providing adequate ventilation is used. Oven ventilation should be available at baking temperatures of 275°C (525°F) and above. Spray booth ventilation should be sufficient to capture all the overspray from powders or liquids.

CAUTION: Hot flocking procedures may result in overexposure to decomposition fumes. Adequate ventilation is an absolute necessity.

When handling powders, care should be taken to avoid powder inhalation. Facemasks capable of excluding 0.3 µm (0.001-in.) particles are recommended, such as the Custom-Cumfo (Mine Safety Appliance Co.) #10-86430 with a Type Ultra-Filter #76876 cartridge. Care should be exercised to avoid contamination of cigarettes and other forms of smoking tobacco. This is especially important when handling powders. Wash hands before smoking or eating.

Before using *Teflon*® ETFE, read the Material Safety Data Sheet (MSDS) and the detailed information in the "Guide to the Safe Handling of Fluoropolymer Resins," latest edition, published by the Fluoropolymers Division of The Society of the Plastics Industry.

Storage

Teflon® ETFE powder coatings should be stored in their original plastic bags to avoid moisture pickup or contamination. These powders are stable indefinitely and are not sensitive to typical room temperature variations.

Teflon® ETFE liquid coatings are stable for 18 months from the date of manufacture when stored at normal room temperatures of 16–38°C (60–100°F). Do not allow to freeze.

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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.

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