



Teflon®

Nonstick & Industrial Coatings

Applying Teflon® Coatings

Applying *Teflon*® coatings is a relatively easy process, using normal coating equipment and techniques. This Fact Sheet provides general guidelines for proper application; where special application techniques are required, the specific product Fact Sheet will indicate what deviations from normal procedures are necessary.

Normal industrial health and safety practices should be followed when applying *Teflon*® coatings. Ventilation and filtration systems should be maintained; cleanliness and good housekeeping practices are essential to prevent damage to the finish and for the safety of workers. Parts must have no unvented cavities which would cause rupture when heated to the cure temperatures of these coatings.

Particular items covered in detail in the specific product Fact Sheets are:

- How to mix, particularly if the product is shear sensitive.
- Whether the product needs to be diluted or thinned prior to use, and what solvent to use.
- Any special application equipment recommended.
- Cure temperatures, and whether it is necessary to force dry prior to curing.
- What primer to use with a particular top coat.

Surface Preparation

The best adhesion and final film performance are achieved by thoroughly cleaning the surface to remove all surface contaminants (rust, oil, grease, etc.). To assure all organic surface contamination has been removed, prebaking the piece at (or

slightly above) the final cure temperature will prevent any oil or remaining surface contamination from volatilizing during the cure step and forming blisters or discoloring.

Most *Teflon*® coatings require the substrate surface be grit blasted or roughened to assure adhesion. In a few situations, such as when the piece is completely encapsulated or there will be minor abrasion, the grit-blast step can be eliminated if using resin-bonded *Teflon*® S. Zinc phosphating is commonly used to improve rust resistance.

The blast medium must be free of contaminants. Aluminum oxide is recommended.

Getting Ready to Spray

All liquid products must be rolled, shaken, or stirred to ensure that all settled solids are reincorporated. Some products are shear sensitive, and cannot be stirred using high-speed mixing equipment. This information is contained in the Fact Sheet for each product.

Most products are supplied ready to spray, at normal spray viscosity. If the product must be thinned before spraying, check the Fact Sheet for the correct material to use.

Application

Many types of application equipment can be used for *Teflon*® coatings. The most widely used are listed below. Certain types are better for different coatings. Where one is particularly suitable, or not recommended, the product Fact Sheet will guide

your choice. *Teflon*[®] coatings are generally applied by commercial spray techniques. This must be done in a hood or well-ventilated area to prevent fluoropolymer or solvent fumes from affecting the breathing air of employees. See the Safe Handling Fact Sheet for respirator recommendations.

Separate spray guns should be used for water-based and solvent-based products.

Once a part has been coated and allowed to dry, do not allow overspray from other areas to fall on the part. Overspray will not melt back into the finish and, therefore, will leave rough areas on the finish.

Many coatings are shear sensitive, and the action of the needle moving in the fluid tip of the gun can cause coagulation. This shear-induced coagulation can be minimized by keeping the fluid delivery open and altering the fluid delivery by regulating the pressure on the pressure pot.

Manual Spray

In most cases, compressed air and standard spray equipment are the most suitable for *Teflon*[®] coatings. The spray guns should be held perpendicular to the piece using a flat, rectangular motion of the spray gun. “Whipping” the gun in an arc tends to make the wet film bubble and will cause excessive beading on the edges of the part.

Suction, gravity, or pressure-type spray equipment are all suitable for spraying *Teflon*[®] coatings. All spray equipment should be made from aluminum or stainless steel, or coated with *Teflon*[®] S. Transfer lines should be chemically inert and solvent resistant (e.g., tubing coated with *Teflon*[®], polyethylene, stainless steel). Air lines must be trapped to prevent oil or water from contaminating the compressed air or the product.

Normal distance from the gun to the part is 4–12 in. (10–30 cm). If the gun is too close, the finish will look rippled. If it is too far, the spray will be dry and rough. Reducing the atomizing pressure will help resolve both problems, too.

Automatic Spray

Automatic spray guns are generally used in large volume, conveyORIZED systems, where the parts to be coated are uniform in shape. While the setup requires experience and careful adjustment, films can be applied more uniformly and at a faster rate.

The finishes are fed to the guns through pressure pots with fluid pressures in the range of 5–8 psi (0.5–0.6 kg/cm²).

Where flat items are carried on a flatbed conveyor, the spray guns may reciprocate transversely and spray continuously.

Electrostatic Spray

Electrostatic guns or discs are suitable for the application of many *Teflon*[®] coatings. The advantages of electrostatic application include better film uniformity and 10–15% savings in material, due to the reduction in overspray. High volume production is usually required to justify the expense of automatic electrostatic systems, but relatively low-priced hand units are available.

Many *Teflon*[®] coatings are water-based with low resistivity (high conductivity). For these finishes, electrically isolate all the coating equipment, including pressure pots and transfer lines. Consult the equipment supplier for proper grounding techniques. Electrostatic potentials of 80,000 to 90,000 volts are commonly used for *Teflon*[®] coatings.

Certain *Teflon*[®] S products must be adjusted with nonpolar solvents before being sprayed electrostatically.

Airless Spray

This technique uses high pressures to atomize and direct the coating material. Because the opening of the gun tip is generally smaller in diameter than in conventional compressed air spray, shear conditions during spray may be too high for aqueous *Teflon*[®] products. Airless spray is generally used when coatings must be applied in deep recesses.

Powder Coating

Teflon[®] powder coatings are free-flowing powders that are applied with conventional electrostatic powder equipment, with either spray guns or fluidized bed. The application voltage and technique depends on the particular equipment, although the highly attractive nature of the powder permits a wide range of application voltages.

After one or two coats, the part may become too insulated for subsequent coats of *Teflon*[®] powder to be applied electrostatically. In this case, the part may be sprayed hot (hot flocked) as it comes out of the oven from curing the previous coat. This requires adequate ventilation. Even the small amounts of decomposition products of fluoropolymers which occur at bake temperatures may cause discomfort to people in the area if the fumes are not vented to the outdoors and allowed to be diluted by the outside air.

Other Application Techniques

Dip and flow coating techniques have been successfully used to apply *Teflon*[®] S coatings.

Roller coating has been used with some *Teflon*[®] S resin-bonded coatings. The aqueous *Teflon*[®] coatings are generally too shear sensitive to use in this manner.

Brushing on *Teflon*[®] or *Teflon*[®] S coatings is only practical for making small repairs. Brush techniques cannot normally apply uniform films thin enough to prevent cracking and popping during baking.

Multiple Coats

Many *Teflon*[®] coatings can be applied in multiple coats. This process requires careful attention to bakes of intermediate coats to prevent deterioration of underlying coats. Ability to apply multiple coats also depends on the wettability of the intermediate coats. This property varies considerably depending on the product. Consult the Fact Sheet for the product you are using to see if it can be applied in multiple coats.

Cure

Reaching and maintaining proper cure temperatures for a sufficient period of time to sinter, melt flow, or set the film is one of the most important factors in achieving a finish that will perform at its optimum. All temperatures mentioned in the Fact Sheets refer to metal temperatures, meaning that the part must be placed in an oven set at a high enough temperature and for a long enough time to allow the part itself to reach the recommended cure temperature. Ovens should be calibrated at least twice per year, and thermocouples should be used on the parts.

For coatings that are primarily PTFE, PFA, and FEP fluoropolymers, no film formation will take place below certain minimum temperatures. This means there is a limited, but practical, baking range for PTFE, FEP, and PFA products mentioned in the Fact Sheet for the product.

Teflon[®] S coatings contain organic binders in addition to the fluoropolymer resins. Cure time and temperature are important considerations for these coatings also, but there usually is a greater range of possible cure temperatures, resulting in varying film properties. Excessive bakes (time and/or temperature) will degrade the auxiliary organic binder, causing discoloration, film embrittlement, and loss of adhesion.

Teflon[®] S coatings stratify during the cure process, so that the fluoropolymer is more concentrated at the surface. The result of underbaking (or baking at the lower end of the specified temperature range) will be limited stratification, as well as reduced adhesion, hardness, corrosion resistance, and abrasion resistance.

Ovens

All commonly used types of industrial ovens are used for curing *Teflon*[®] coatings. *Teflon*[®] coatings are not affected by the combustion products of coal gas or natural gas, so direct-fired gas ovens may be used. Both batch ovens and high-production conveyorized ovens are used. Conveyorized ovens must be carefully designed to give accurate and uniform temperature control because maximum conveyor speed and minimum oven length are important economic factors that operate to reduce dwell time.

Ovens should be calibrated at least twice per year, and thermocouples used on the parts themselves or in the oven at several locations, recognizing that air temperatures are of little value except when based on experience with a given oven and oven load over a period of time.

Factors that affect total bake time (including warm up):

- Time in oven
- Heat capacity of oven
- Mass and thermal conductivity of the substrate
- Air circulation
- Oven air temperature and/or radiant energy

- Percent of substrate covered by *Teflon*[®] (insulator)
- Load of work in the oven
- Weight to surface area ratio

Convection Ovens

May be gas fired, direct or indirect, or heated by electrical resistance coils. Good circulation is required for uniform heating. Convection ovens require more time to warm up than infrared ovens, and conveyorized systems require greater floor space for equivalent line speeds.

Gas and Electric Infrared Ovens

Offer the advantages of rapid transfer of radiant energy, ability to control speed of warmup by placement of the radiant elements, and reduced dwell time. It is less effective where coated parts are complex in shape, because infrared energy travels in a straight line and the intensity of heat is inversely related to the distance (squared) from the source, so inner crevices and angles will not cure at the same rate as outer surfaces facing the source. High-velocity air may be used to make the air temperature more uniform.

Ventilation of ovens is very important for the safety of workers. Ventilation is usually provided via an outdoor stack. Negative pressure should be maintained at all times with an inward draft at both the entrance and exit of the oven. Even the small amounts of decomposition products of fluoropolymers that occur at bake temperatures may cause discomfort to people in the area if the fumes are not vented to the outdoors and allowed to be diluted by the outside air.

Repair

Repairing damaged *Teflon*[®] finishes is not always possible because once these coatings are fully cured it is difficult to wet the surface with additional coating material. The exceptions to this rule are the *Teflon*[®] P coatings. In general, the aqueous *Teflon*[®] coatings can be more easily repaired than the *Teflon*[®] S products.

Testing Cured Films

Measure the *film thickness* with a gauge for ferrous or nonferrous substrates, depending on which part. For parts with irregular surfaces, place a piece of foil in areas of the part that would be difficult to measure with the gauge. After curing the part, remove the foil and measure the film on the foil with a micrometer. An alternate method is to spray a flat panel at the same time the part is being coated to approximate the film thickness on the part.

The *surface* can be checked with a 10X magnification. Look for smoothness, color, gloss, blistering, pinholes, or mudcracking.

Film integrity (lack of pinholes) can be tested using a spark test if the substrate is conductive (and the coating is nonconductive!).

Adhesion tests are usually destructive.

- Post-boiling water fingernail test: Submerge the part in boiling water for 15 minutes. Remove, cool to room temperature, and dry thoroughly. Using a sharp knife, put a straight line scratch in the surface. Try to chip or peel the coating away from the knife scratch. It should not be possible to peel the film more than 0.2 mil (6 microns) from the knife scratch.
- Crosshatch test: Boil, cool, and dry piece as in fingernail test. Using a new single-edge razor blade, make eleven (11) parallel cuts in the film approximately 2.4 mm apart. Repeat at right angles to form 100 small squares. Press a strip of 2.5 cm-wide transparent tape over this area and rub firmly with a fingernail to get maximum contact. Pull the tape off firmly and rapidly without jerking. After removing this piece of tape, put another piece on at right angles, and repeat. Film with good adhesion will not show any squares removed (although some corners or edges may be lifted). If 20% or more of the squares are removed, the piece has failed the test.
- Tests that indicate adequate adhesion also indicate complete cure. For *Teflon*[®] S, rub cured film 50 times (back and forth) with a soft cloth saturated in MEK. Only surface pigments should show up on the cloth. The film should not be soft or tacky, otherwise the film was not completely cured.

Disposal

Disposal depends on the type of waste: cured film, dry but not cured material, and liquid product (within this category are flammable, acidic and heavy metal considerations). All require different handling. Both state and federal (EPA) regulations govern disposal of *Teflon*[®] materials. If you have any doubt about these regulations, contact your

state environmental office and the EPA to determine how to dispose of *Teflon*[®].

Waste minimization as a policy will help reduce the cost and paperwork involved in disposal.

Also see Safe Handling Practices, and the product MSDS and Fact Sheet.

For more information on Teflon® coatings

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