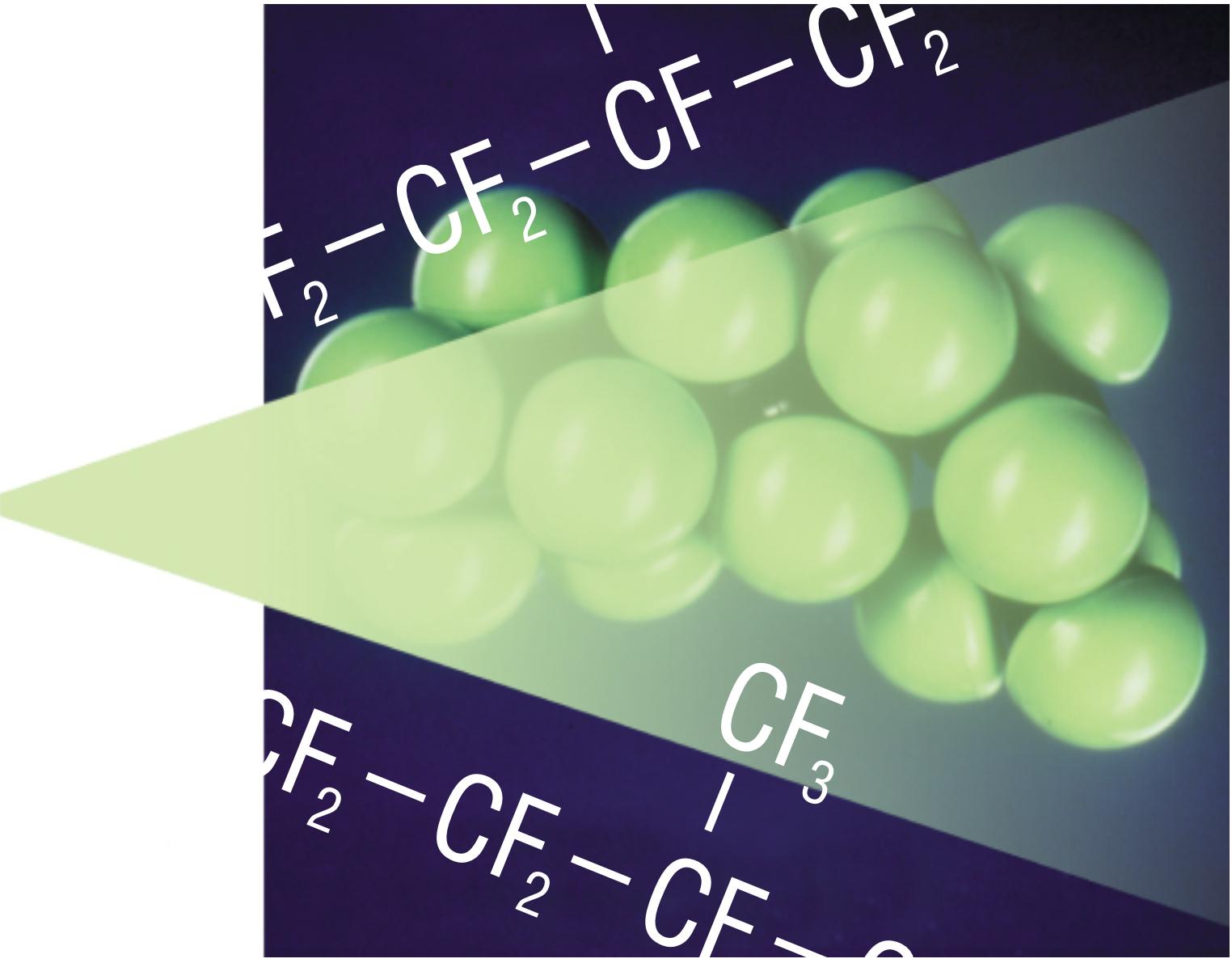
DuPont™ Teflon®



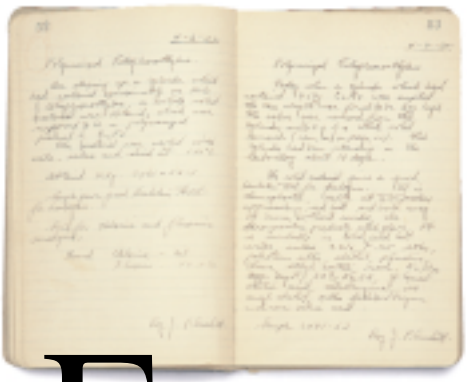
DuPont™ Teflon® industrial coatings

DUPONT®

The miracles of science™

DuPont™ Teflon®

Versatility unmatched by any other engineering material.



Since DuPont chemist Roy Plunkett first documented his discovery of Teflon® PTFE fluoropolymer resin in 1938, DuPont has continued to make fluoropolymer history. By expanding this basic technology to uniquely tailored fluoroproducts, Teflon® Industrial coatings continue to enhance the functional qualities of today's high-tech applications.

Ever since their discovery and subsequent introduction under the Teflon® trademark, fluoropolymers have demonstrated a versatility unmatched by any other engineering material. With a unique combination of properties, Teflon® Industrial coatings have gained acceptance in a wide range of applications.

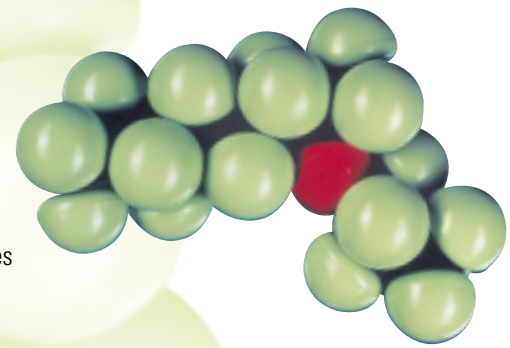
Teflon® Industrial coatings spray on like paint and bake to a tough, inert finish. Over the years, DuPont technology has extended the family of Teflon® coatings to ensure a finish with the ideal combination of properties to meet most design needs.

By combining heat resistance with almost total chemical inertness, excellent dielectric stability and a low coefficient of friction, Teflon® Industrial coatings offer a balance of properties unbeatable by any other material. It's the original non-stick finish. And DuPont, the originator of Teflon®, has the worldwide resources to help you solve your coating problems.

We've assembled examples of advantages using Teflon® Industrial coatings. Overall, it's a rather remarkable story whose applications you may be able to relate to your products and the way they are produced. It could save you money, enhance your product or give you the inspiration to develop a new product.

Let us share our experiences with you and help you explore profitable ideas with the beneficial help of these coatings. We invite you to contact us directly for further innovative applications with Teflon®.

Teflon® Industrial coatings can take your business to a new level of success.



Teflon® Industrial coatings are available in both powder and liquid forms. The versatility of these coatings allow almost unlimited application to a wide variety of part sizes and configurations—always adding value that goes far beyond the inherent non-stick qualities.

The 6 Basic Types of

1 Teflon® PTFE ▼

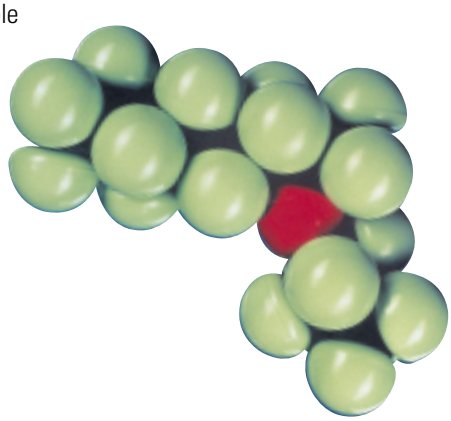
PTFE (Polytetrafluoroethylene) non-stick coatings are two-coat (primer/topcoat) systems. These products have the highest operating temperature of any fluoropolymer (290°C/550°F), an extremely low coefficient of friction, good abrasion resistance and good chemical resistance. PTFE is available only in water-based liquid form.

2 Teflon® FEP ▲

FEP (Fluorinated Ethylene Propylene copolymer) non-stick coatings melt and flow during baking to provide non-porous films. These coatings provide excellent chemical resistance.
In addition to low friction, FEP coatings have excellent non-stick properties. Maximum use temperature is 205°C/400°F. FEP is available in water-based liquid and powder forms.

3 Teflon® PFA ▼

Like FEP, PFA (Perfluoroalkoxy) nonstick coatings melt and flow during baking to provide non-porous films. PFA offers the additional benefits of higher continuous use temperature (260°C/500°F), film thicknesses up to 1,000 micrometers (40 mils) and greater toughness than PTFE or FEP. This combination of properties makes PFA an excellent choice for a wide variety of uses, especially those involving chemical resistance. PFA is available in both water-based liquid and powder forms.



DuPont™ Teflon® Industrial coatings can be used on carbon steel, aluminum, stainless steel, steel alloys, brass and magnesium, as well as non-metallics such as glass, fiberglass, some rubber and plastics. Optimum adhesion is obtained by roughening the surface prior to application of the coating. Except where specifically mentioned, most Teflon® Industrial coatings require a primer coat.

DuPont™ Teflon® Coatings

4 Teflon® ETFE ▲

ETFE is a copolymer of Ethylene and Tetrafluoroethylene, and is also sold under the Tefzel® trademark. Although not fully fluorinated, ETFE has excellent chemical resistance and can operate continuously at 150°C/300°F. This resin is the toughest of the fluoropolymers and can be applied at film builds up to 1,000 micrometers (40 mils) to provide a highly durable finish. ETFE is available in powder form.

5 Teflon®-S One Coat

These solvent-based liquid coatings are formulated with special blends of fluoropolymers and other high-performance resins to improve toughness and abrasion resistance. Because the film components stratify during baking, most of the fluoropolymer properties (such as low friction and non-stick character) are retained. The resins provide adhesion and abrasion resistance. These products can sometimes be applied to smooth, clean metal. Bake requirements vary, depending on the specific coating, from 165°C/325°F to 315°C/600°F.

6 Teflon®-S Dry Lubricant

Dry lubricant coatings are special versions of Teflon®-S technology designed to provide lubrication under high Pressure/Velocity (PV) conditions. These are solvent-based, one-coat systems which are usually cured between 260°C/500°F and 370°C/700°F.

Teflon® Industrial coating contains the dangerous glass shards of a broken light bulb. While maintaining its toughness at high temperatures, the coating exhibits remarkable optical clarity that doesn't diminish light output.

Outstanding Properties

Non-stick

Very few solid substances will permanently adhere to a Teflon® finish. And while tacky materials may show some adhesion, almost all substances release easily.

Low coefficient of friction

The coefficient of friction of Teflon® is generally in the range of 0.05 to 0.20, depending on the load, sliding speed and particular Teflon® coating used.

Nonwetting

Since surfaces coated with Teflon® are both oleophobic and hydrophobic, they are not readily wet. Cleanup is easier and more thorough—in many cases, surfaces are self-cleaning.

Heat resistance

Teflon® Industrial coatings can operate continuously at temperatures up to 290°C/550°F and can be used for intermittent service up to 315°C/600°F with adequate ventilation.

Unique electrical properties

Over a wide range of frequencies, Teflon® has high dielectric strength, low dissipation factor and very high surface resistivity. By special techniques, it can even be made electroconductive enough to be used as an anti-static coating.

Cryogenic stability

Many Teflon® Industrial coatings withstand severe temperature extremes without loss of physical properties. Teflon® industrial may be considered for use at temperatures as low as -270°C/-454°F.

Chemical resistance

Teflon® is normally unaffected by chemical environments. The only chemicals known to affect all Teflon® Industrial coatings are molten alkali metals and highly reactive fluorinating agents.

Thanks to a variety of coating types, the unique properties of Teflon® Industrial coatings can become an integral surface component of any kind of part—from clutches which engage easier and valves that resist wear to coil springs that become silent. And with proper equipment, Teflon® Industrial coatings can even be applied to specific areas of complex geometric parts, such as the internal threads of a nut.

How to Evaluate and

The high technology performance of Teflon® Industrial coatings makes them the natural choice in many industries. DuPont offers the design engineer in aerospace, as in automotive, a sufficient range of Teflon® Industrial coatings to choose from, to ensure the ideal combination of properties for the specific application.

GENERAL PRODUCT SELECTION GUIDE*

Required Property	Good	Better	Best
Chemical Resistance	Teflon®-S	ETFE or FEP	PFA
Corrosion Resistance	FEP	Teflon®-S	Teflon®-S over Phosphate Pre-Treatment
Abrasion Resistance	PTFE or FEP	Teflon®-S	ETFE or PFA or Dry Lubricant
Heat Resistance	Teflon®-S	FEP	PTFE or PFA
Non-stick	Teflon®-S	PFA	PTFE or FEP

*Use this table for general guidance only. All Teflon® fluoropolymers have all of these properties. The table listings show which coating systems excel in the desired property, but other application requirements such as substrate type, film build, bake and use temperatures, food contact, etc., may necessitate the selection of another choice. However, severe compromises are seldom necessary since a Teflon® coating system offering the desired balance of properties is usually available.

A variety of specific products are available in each of the fluoropolymer categories above. Consult the *Product Fact Sheets* for individual listings and details.

Typical properties tested in accordance with ASTM methods are shown on the next pages.

Specify

When choosing a protective coating, consider the following important elements:

Substrate

- Ability to withstand grit-blasting or etching
- Ability to withstand high temperature bake

Service Requirements

- Maximum continuous and intermittent operating temperature
- Priority of properties needed—non-stick, chemical resistance, mechanical toughness, heat resistance or low friction
- Film thickness

Food Contact

Some Teflon® Industrial coatings are formulated for food contact uses. From time to time, however, regulations in various countries change. Contact a DuPont Sales Office for information regarding conformance of specific coatings to the appropriate regulations in the countries where your products will be sold and used.

Molds coated with Teflon® are used for manufacturing today's highly popular sports shoes. Providing a permanent release surface, Teflon® industrial coatings eliminate aerosol sprays which contaminate the workplace and cause unwanted rejects.

Medical Uses

DuPont does not evaluate Teflon® Industrial coatings for medical applications involving permanent or temporary implantation and/or internal contact with fluids and tissues in the human body. Except in a few special circumstances, we maintain a strict policy prohibiting such uses. Please consult the *DuPont Policy Fact Sheet** for details.

Health and Safety

Teflon® Industrial coatings have been used safely for 50 years, and it is DuPont policy to maintain this excellent safety record. For specific details please consult the *Safe Handling Practices Fact Sheet** and the *Guide to the Safe Handling of Fluoropolymer Resins** booklets published by the Society of Plastics Industry, Inc.

**Available upon request from your DuPont representative or sales office.*

Typical Properties

MECHANICAL PROPERTIES						
Property	**ASTM Standard**	**Unit**	**Teflon® PTFE**	**Teflon® FEP**	**Teflon® PFA**	**Teflon® ETFE**
Specific Gravity	D792		2.15	2.15	2.15	1.76
Tensile Strength	D1457, D1708, D638	MPa psi	21-35 3,000-5,000	23 3,400	25 3,600	40-47 5,800-6,700
Elongation	D1457, D1708, D638	%	300-500	325	300	150-300
Flexural Modulus	D790	MPa psi	500 72,000	600 85,000	600 85,000	1,200 170,000
Folding Endurance	D2176	(MIT) cycles	$>10^6$	5-80 x 10^3	10-500 x 10^3	10-27 x 10^3
Impact Strength	D256	J/m ft·lb/in	189 3.5	No break	No break	No break
Hardness	D2240	Shore D pencil	50-65 HB	56 HB	60	72
Abrasion Resistance • Bell Abrasion (1) • Sliding Arm (2) • Tabor Abrasion (3)		 g/µm mg mg	 85 7.9-9.7 12	 11.1-15.2 14.8	 	 13.4
Scratch Resistance scratch master • initial (4) • complete (5)		 kg kg	 5.7-7.0 7.3-10.7	 5.1-11.4 8.5-13.2	 	
Coefficient of Friction • static • dynamic	D1894	 	 0.12-0.15 0.05-0.10	 0.12-0.20 0.08-0.3	 0.2 	 0.24-0.50 0.3-0.4
Contact Angle • water		 degree	 104°-111°	 95°-105°	 104°-111°	 90°-100°

Notes:

1. Bell Abrasion Tester: grams abrasive/micrometers
2. Sliding Arm Test: 1,000 cycles, 500 gr load, 400 Emery paper, 35.5 sq. cm surface
3. Tabor Abrasion: Cs 17 wheel, 1 kg load, 1,000 cycles, weight loss in mg
4. Scratch Master: initial = first sign of substrate
5. Scratch Master: complete = total removal of film
6. Salt Spray Resistance: 5% NaCl @ 35°C/95°F, hours to failure
7. Detergent Resistance: hours to failure
8. Dielectric Strength: 100 micrometers film

The values shown in this table represent average experiences from numerous testing sources and are not intended to be specifications. These values will vary depending upon the individual compositions of the primers and topcoats and the systems used. For further information on the properties of these coating systems, and examples of how they have led to the development of new products, increased production rates and resultant cost savings, you should consult DuPont or a Licensed Industrial Applicator.

THERMAL PROPERTIES

Property	ASTM Standard	Unit	Teflon® PTFE	Teflon® FEP	Teflon® PFA	Teflon® ETFE
Melting Point	D3418	°C °F	327 621	260 500	305 582	267 512
Cure Temperature		°C °F	380-430 715-805	360-390 680-735	380-400 715-750	300-325 575-615
Max. Use Temperature						
• Continuous		°C °F	290 550	205 400	260 500	150 300
• Intermittent		°C °F	315 600	230 450	290 550	200 390
Flame Rating**	UL94		V0	V0	V0	V0
Limiting Oxygen Index	D2863	%	>95	>95	>95	30-36
Heat of Combustion	D240	MJ/kg Btu/lb	5.1 2,200	5.1 2,200	5.3 2,300	13.7 5,900
Thermal Conductivity		Btu·in/h·ft²·°F W/m·k	1.7 0.25	1.4 0.20	1.3 0.19	1.65 0.24

CHEMICAL PROPERTIES

Property	ASTM Standard	Unit	Teflon® PTFE	Teflon® FEP	Teflon® PFA	Teflon® ETFE
Chemical/Solvent Resistance	D543		Excellent	Excellent	Excellent	Excellent
Water Absorption, 24 h	D570	%	<0.01	<0.01	<0.03	<0.03
Salt Spray Resistance (6)	B-117					
• on aluminum		Hours	744+	744+	1000	1000
• on steel		Hours	192			
Detergent Resistance (7)						
• on aluminum		Hours	264	744		
• on grit-blasted aluminum		Hours	624	600		
• on grit-blasted steel		Hours	24	480		
Weather Resistance	Florida Exposure	Years Unaffected	20	20	10	15

ELECTRICAL PROPERTIES

Property	ASTM Standard	Unit	Teflon® PTFE	Teflon® FEP	Teflon® PFA	Teflon® ETFE
Dielectric Constant	D150	1 MHz	2.1	2.1	2.1	2.6
Dielectric Strength (8)	D149	V/µm	18	53	80	79
Dissipation Factor	D150	1 MHz	<0.0001	0.0006	0.0001	0.007
Arc Resistance	D495	sec	>300	>300	>180	122
Volume Resistivity	D257	ohm·cm	$>10^{18}$	$>10^{18}$	10^{18}	$>10^{17}$
Surface Resistivity	D257	ohm/sq	$>10^{18}$	$>10^{16}$	$>10^{17}$	$>10^{15}$

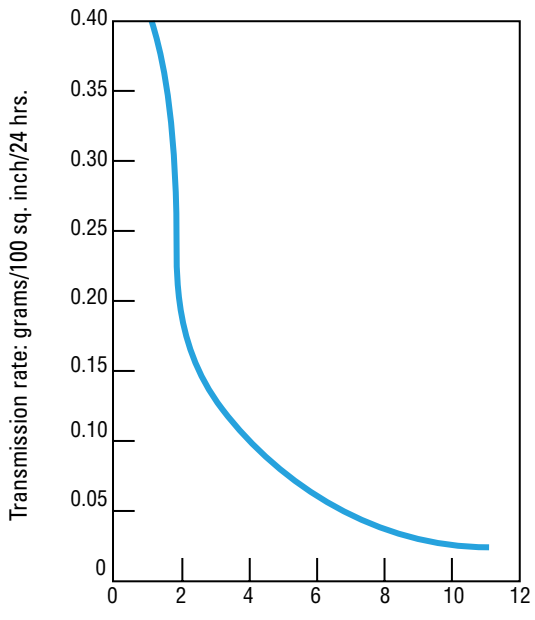
** Statements regarding behavior in a flame situation are not intended to reflect hazards presented by this or any other material when under actual fire conditions.

Typical Properties, *continued*

Water Vapor Transmission Rates of Teflon® FEP Film, 25 micrometers (1 mil) thickness/per ASTM E-96 (modified)
Values measured on thicker specimens and converted to 25µ (1 mil)

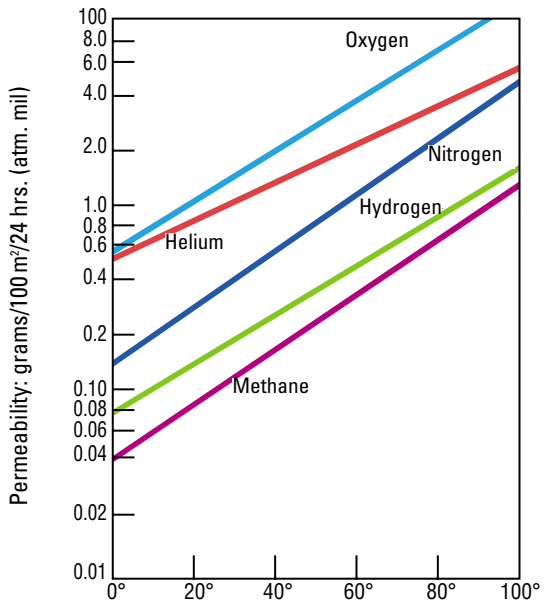
Vapor	Temperature °C	g/100 sq. inch or g/645 sq. cm (24 hours)
Acetic Acid	35°	.41
Acetone	35°	.95
Acetophenone	25°	.50
Benzene	35°	.64
Carbon Tetrachloride	35°	.31
Ethyl Acetate	35°	.76
Hexane	35°	.56
Hydrochloric Acid, 20%	25°	<.01
Piperidine	25°	.04
Red Fuming Nitric Acid	25°	7.5-1.4
Sodium Hydroxide, 50%	25°	<.01
Sulfuric Acid, 98%	25°	.00001
Water	39.5°	.40

Water Vapor Transmission Rate of Teflon® FEP film at 40°C/104°F per ASTM E-96 (modified)



Note: values are averages only and not for specification purpose

Permeability of Teflon® FEP film to gases at various temperatures



Note: values are averages only and not for specification purpose

DuPont™ Teflon®

Since the discovery of this truly unique material over 50 years ago, Teflon® has been used on everything from fry pans to components for the space program. Teflon® comes in a broad range of coating types based on different kinds of fluoropolymers, and is available in both powders and liquids. This breadth of technology virtually assures a proper surface modification for your application.

Fluoropolymer technology is one of the fundamental core competencies of DuPont, giving us the ability to not only customize coating formulations, but to customize the polymers themselves. The Teflon® brand carries with it the assurance of high-quality products, from the polymerization kettle to the final coating on your special device. And it doesn't stop there. DuPont also offers worldwide sales and marketing services as well as product availability anywhere in the world.

DuPont has developed a distinctive logo for Teflon® Industrial coatings designed to reflect the integrity and identity of the brand. Used on products, packaging, labels, advertising and other promotional materials, it provides assurance that the products it identifies are of the highest quality and contain only genuine DuPont fluoropolymers. Like the Teflon® trademark, the logo is owned exclusively by DuPont and may only be used under license from DuPont.

For more information on obtaining a license to use this mark, please contact your DuPont representative, or call 302-999-2591.

For more information about Teflon® Industrial coatings, please contact your DuPont representative or call the appropriate sales office on the back cover.

Licensed Applicator Program

DuPont™ Teflon® industrial coatings

DuPont Licensed Industrial Applicator

Teflon® is a registered trademark of DuPont.

DuPont has a network of licensed applicators located throughout the world. Although DuPont sells coatings to any legitimate user, a Licensed Industrial Applicator (LIA) is a company selected for its extensive knowledge and experience in recommending and applying Teflon® Industrial coatings, as well as for the quality of its workmanship. LIAs are also kept abreast of new technologies from DuPont.

Licensed Industrial Applicators are valuable resources for companies that are not equipped to apply Teflon® Industrial coatings. Their capabilities range from coating only one part to handling full-scale production. These Applicators maintain inventories of a broad range of Teflon® coatings, which are especially useful for evaluating and selecting the coating system for your prototype parts. We highly recommend you contact them to discuss your coating needs.

Industrial Applicators meeting DuPont criteria are entitled to identify themselves through the use of the emblem above. Contact your local DuPont office for a worldwide listing of DuPont Licensed Industrial Applicators.

DuPont™ Teflon® is sold in forms other than formulated liquid and powder coatings. For more information on Teflon® industrial coatings, resins, fibers, films or linings, please contact:

UNITED STATES

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Chestnut Run Plaza
P.O. Box 80702
Wilmington, DE 19880-0702
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Fax: 302-366-8602

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A. Spinoystraat 6
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