Product Handbook for DuPont™ Tyvek®

DUPONT®
Tyvek®
WHAT DO YOU NEED TO PROTECT?™

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WHAT DO YOU NEED TO PROTECT?™

INTRODUCTION

Tyvek® brand protective material is a family of tough, durable spunbonded olefin sheet products that are stronger than paper and more cost-effective and versatile than fabrics. Made from high density polyethylene fibers, Spunbonded Olefin is an extremely versatile material, offering a balance of physical characteristics that combine the best properties of paper, film and cloth.

Spunbonded Olefin is formed by a continuous process from very fine 0.5-10 μm fibers. (For purposes of comparison, a human hair is about 75 μm in cross section.) These nondirectional fibers (plexifilaments) are first spun and then bonded together by heat and pressure, without binders.

Spunbonded Olefin is strong, lightweight, flexible, smooth, low-linting, opaque and resistant to water, chemicals, abrasion and aging. Its unique combination of properties makes Spunbonded Olefin ideal for a broad range of applications.

A Choice of "Hard" or "Soft" Structure Types for a Wide Range of Applications

Spunbonded Olefin is produced in "hard" and "soft" structure types. Type 10, a "hard," area-bonded product, is a smooth, stiff nondirectional paper-like substrate with good printability in both sheet and roll form.

Type 10	Types 14 & 16
Paper-like	Fabric-like
Hard Structure	Soft Structure
Area-bonded	Point-bonded
Smooth Pattern	Embossed Pattern
Stiff	Flexible

Types 14 and 16 are "soft," point-bonded products with an embossed pattern, providing a fabric-like flexible substrate with good printability and tear resistance. Like Type 10, they have high opacity, excellent whiteness and good surface stability. Sewing, gluing, and, to a limited extent, ultrasonic seaming and heat sealing may be used in fabricating these styles.

The unique ability to resist air and water penetration, while allowing moisture vapor to pass through makes DuPont Tyvek® extremely popular for providing protection, comfort and energy efficiency when used in residential and commercial construction.

Type 14 styles are used where barrier, durability and breathability are required. They offer excellent splash and dry protection against particulate matter and provide an excellent bacterial barrier. The unique low-linting properties, combined with the barrier properties, make Type 14 an excellent material for cleanroom apparel in pharmaceutical manufacture and electronic device assembly.

Type 16 styles are pin perforated with 5-20 mil (0.13-0.51 mm) holes, giving them much higher air and moisture permeability, additional softness, and greater flexibility and drape than Type 14 styles, but at the expense of lower tear strength and barrier properties. Type 16 styles, when fabricated into garments, have higher air permeability at the expense of barrier properties. Typically, Type 16 styles are used in disposable, general-purpose industrial garments, bags and packaging.

Corona and Antistatic Treatments Improve Adhesion, Printability and Handling

Most Spunbonded Olefin that will be printed on is corona (discharge) treated to improve ink and coating adhesion. This treatment oxidizes the surface and increases the wettability of the surface to inks, coatings and adhesives. This treatment lasts more than 20 years.

To reduce the buildup of static electricity during sheet and roll handling operations, some styles are also coated with an antistatic agent. Spunbonded Olefin destined for use in the packaging of sterile medical devices is not corona treated nor antistated.

PRODUCT PROPERTIES

A Unique Combination of Properties

The physical properties common to all three types of Tyvek® brand spunbonded olefin combine to make them ideal substrates for many printing and converting applications.

OUTSTANDING CHEMICAL RESISTANCE

Spunbonded Olefin is inert to most acids, bases and salts. Prolonged exposure to oxidizing substances, such as concentrated nitric acid or sodium persulfate, will cause some loss of strength. Resistance to various acids and bases; oxidizing and reducing agents; salt solutions; and organic solvents is summarized on pages 22-25.

WITHSTANDS DEFORMATION

Elevated temperatures increase the sensitivity to tension-caused width loss and deformation. For example, Style 1073D can withstand 1.5 lb/lineal in. width (2.6 N/cm) tension at room temperature, but at 225˚F (107˚C), tension in excess of 0.6 lb/lineal in. width (1.1 N/cm) will cause permanent deformation.

GOOD DIMENSIONAL STABILITY

Sheet dimensions change less than 0.01% between 0 and 100% relative humidity at constant temperature.

FDA REQUIREMENTS

Styles 1059B and 1073B meet the requirements of Title 21 of the United States Code of Federal Regulations (21 CFR 177.1520) for direct food contact applications (such as food packaging; desiccant, de-oxidizing agent or other "active packaging;" and direct contact labels) where the temperatures do not exceed 212˚F (100˚C).

Envelopes made of DuPont Tyvek® resist punctures, tears, and moisture better than any other envelope available.

FLAMMABILITY

The flammability characteristics of Spunbonded Olefin, a synthetic nonwoven material, are similar to those of most synthetic fibers.

When exposed to a flame, Spunbonded Olefin shrinks away rapidly. If the flame is made to follow the shrinking sheet, Spunbonded Olefin will melt at 275˚F (135˚C), and if its auto-ignition temperature of 750˚F (400˚C) is reached, it will burn.

Type 10 Spunbonded Olefin is rated class "A" when tested in accordance with ASTM E-84-89a.

Types 14 and 16 are rated "Class 1—Normal Flammability" by the Federal Flammable Fabrics Act for Clothing Textiles (16 CFR-1610). Spunbonded Olefin does not pass DOC FF3-71, Children's Sleepwear Test.*

Spunbonded Olefin and laminates of Spunbonded Olefin are not intended for use in fire-retardant garments. The user should ensure that Spunbonded Olefin meets all flammability standards for the application.

REMARKABLE FLEXIBILITY

Spunbonded Olefin has outstanding flexural strength and will easily exceed 20,000 cycles when tested on an MIT flex tester (TAPPI method T-423).

LOW-LINTING

Because Spunbonded Olefin is composed of essentially continuous fibers, it does not generate a significant amount of lint particles under conditions of ordinary use.

LIGHT WEIGHT

Type 10 has a density of approximately 0.38 g/cc, which is only half as much as paper.

SUPERIOR MOISTURE RESISTANCE

The physical properties of Spunbonded Olefin are not affected by water; Spunbonded Olefin is equally strong wet or dry under ordinary conditions and ambient temperature.

GOOD LIQUID BARRIER PROTECTION

Spunbonded Olefin with neither corona treatment nor antistatic agent (e.g., Style 1073B) has a hydrostatic head in excess of 50 in. (127 cm). If antistat is applied, the hydrostatic head will drop to 40-50 in. (102-127 cm). Corona treated and antistated Spunbonded Olefin (e.g., Style 1073D) has a hydrostatic head that is less than 15 in. (38 cm).

* Spunbonded Olefin does *not* meet the requirements under the Federal Flammable Fabrics Act for Children's Sleepwear, FF3-71 and FF5-74.

HIGH OPACITY

The high opacity of Spunbonded Olefin is the result of multiple light refractions among the very fine polyethylene fibers and air within the densely packed sheet structure.

WHITENESS

Spunbonded Olefin is one of the whitest materials available for printing. The GE Brightness of Spunbonded Olefin (using the TAPPI Standard Test Method/ Technidyne Instrument) is 94.1. For purposes of comparison, a pure titanium dioxide pellet measures 93.8. Color value, or whiteness, is also defined by L,a,b values. The Hunterlab Model D-25 color difference meter measures the brightness, color components and whiteness. The following values are typical for Type 10:

L = 97.8 brightness (100 for perfect white)
a = 0.3 green component
b = 0.1 yellow component
w = 96.5 overall color acceptance

POROSITY

Compared with most textile fabrics, the air permeability of Types 10 and 14 is low. Moisture-vapor transmission is much higher than that of plastic films and similar to that of coated papers.

EXCELLENT ROT & MILDEW RESISTANCE

Although mold and mildew can grow on Spunbonded Olefin, it shows no degradation after being buried in soil for an extended period. Clean Spunbonded Olefin will not promote the formation of mildew.

SOILING

Resistance is high to soiling by waterborne soils, but is low to absorption of oils and greases. Types 14 and 16 can be laundered. For more information, contact DuPont at 1-800-448-9835.

NEUTRAL pH

Spunbonded Olefin has a neutral pH = 7. Therefore, it is neither acidic nor basic. The styles that are corona treated and antistatic treated also have a pH = 7.

STATIC

In some processing steps, Spunbonded Olefin may generate static electricity unless treated with antistatic agents. These agents, while suppressing static generation and increasing wettability, have no effect on sheet strength. Most types and styles of Spunbonded Olefin as supplied by DuPont are treated with antistatic agents. All treated styles of Types 14 and 16 have a static decay of <0.1 second when tested according to method 4046 of Federal Test Method Standard 101 C after 25 hours conditioning at 70˚F (21˚C) and 50% relative humidity (RH).

This topical antistat is water soluble and is not intended as a "safety" feature. For this reason, it is recommended that garments of Spunbonded Olefin *not* be used in flammable or explosive environments.

Styles with a B suffix do *not* contain an antistatic agent. Styles like these with no antistatic agent can build a static charge during roll or sheet handling and should not be handled in areas where the potential for explosive vapor/air mixtures exists.

TEMPERATURE RANGE

Toughness and flexibility are retained down to -100˚F (-73˚C). When exposed to heat, Spunbonded Olefin begins to shrink at approximately 270˚F (132˚C) and melts at 275˚F (135˚C). Under actual processing conditions, where tension is required to handle the web, the web temperature should not exceed 175˚F (79˚C).

UV RESISTANCE

Physical properties of Spunbonded Olefin are degraded with extended exposure to direct sunlight (ultraviolet rays), although at least one to three months of useful outdoor life can be expected in many applications. UV resistance can be improved with opaque coatings. Styles of Spunbonded Olefin containing UV inhibitors are available for applications requiring higher UV resistance.

SOLVENT RESISTANCE

Water and highly polar solvents have very little effect on the properties of Tyvek® brand spunbonded olefin. However, certain solvents used in some inks, paints, adhesives and coatings can cause swelling. A list of the preferred solvents and those to be avoided is found on page 25. The swelling effect of a solvent is usually reversible after it evaporates from Spunbonded Olefin. However, if a vehicle or binder is present in the solvent, the distortion caused by the solvent is likely to be permanent.

Solvent distortion can be minimized by rapid evaporation or drying in an oven. As an example, a sheet-fed offset lithographic ink containing 25% volatile solvent will cause severe distortion of Spunbonded Olefin 20 minutes after printing. The same ink printed on a heat-set web offset press and dried in an oven at 200˚F (93˚C) will be distortion free.

Swelling of Spunbonded Olefin can also be caused by some plasticizers, aliphatic hydrocarbon resins used in inks, tackifiers and low-molecular weight adhesives. The swelling caused by these materials is always permanent and, in some cases, is not apparent until several days or weeks after application.

TOXICITY

Spunbonded Olefin, as supplied by DuPont, has been tested for toxicity by skin contact tests on animals and humans. No reports of toxic reactions have been received.

Spunbonded Olefin is not radioactive, is stable in all recommended use environments and requires no special spill procedures.

MSDS

Spunbonded Olefin is considered an "article" under provisions of the Toxic Substance Control Act (TSCA) and is considered nonhazardous under provisions of the Hazard Communication Standard. No Material Safety Data Sheet (MSDS) is required for Spunbonded Olefin, although one is available as a service to customers. To obtain a copy, contact DuPont at 1-800-448-9835.

Solvent Compatibility Testing

The compatibility of solvents in inks, coatings and adhesives can be determined by placing two to three drops on a sheet of the style being used. If severe distortion occurs within 20 minutes, the material should be avoided, if possible, or used sparingly. Some adhesive ingredients can cause delayed distortion of Spunbonded Olefin after weeks or even months of storage. This is particularly true of some solvent-based, pressure-sensitive adhesives that are transfer-coated to Spunbonded Olefin from a silicone-coated release sheet.

To determine whether an adhesive is compatible with Spunbonded Olefin, it should be coated onto a release sheet and then transferred to an aluminum plate. Alternatively, the adhesive may be coated directly onto an aluminum plate with a doctor blade that will deposit about 1 mil (0.025 mm) of dry adhesive. The plate should be dried in an oven at 300˚F (150˚C) for 10 minutes to remove all the volatile solvent from the adhesive. After cooling, a sheet of Spunbonded Olefin is rolled onto the adhesive-coated plate. An aluminum plate is preferred for this test to eliminate dimensional changes that occur with coated release sheets. After contact with the adhesive for 24 hours, the Spunbonded Olefin and plate are placed in an oven at room temperature and the temperature is raised at the rate of 20˚F/hr (10˚C/hr). If no distortion occurs to the Spunbonded Olefin up to 150˚F (65˚C), the pressure-sensitive adhesive is judged to be compatible with Spunbonded Olefin. If, however, swelling or wrinkling occurs, it indicates the presence of low-molecular-weight materials that function as swelling agents for Spunbonded Olefin.

As an example, low-molecular-weight polybutylacrylate used in some pressure-sensitive adhesives will cause wrinkling and distortion of Spunbonded Olefin 24 to 48 hours after processing if the rolls are stored in a location where the temperatures are above 90˚F (32˚C). However, high-molecular-weight polybutylacrylate is compatible with Spunbonded Olefin up to 212˚F (100˚C). Of course, it may be necessary to screen each of the individual components by this procedure when testing a new formulation. This procedure has proved to be suitable for screening solvent-base, water-base and hot-melt, pressure-sensitive adhesives for Spunbonded Olefin.

Tyvek® Brand Spunbonded Olefin Is Different...Compared to Paper Substrates

• For the same application, lighter weights of Spunbonded Olefin are normally used.

• Spunbonded Olefin is more elastic. It should be handled under the lowest tension practical to avoid distortion and mis-registration. Spunbonded Olefin will elongate 15% to 25% before breaking, making deep embossing possible without fracturing.

• The physical properties of Spunbonded Olefin are the same, wet or dry. Although unaffected by water and many chemicals, Spunbonded Olefin may swell on contact with certain organic solvents used in some inks, coatings and adhesives. See page 6 for details. It is also recommended that you conduct your own tests before use.

• Spunbonded Olefin absorbs little or no moisture; therefore, longer drying times are required for most inks, coatings and adhesives.

• Spunbonded Olefin is thermoplastic. It maintains its toughness and flexibility down to -100˚F (-73˚C); however, an unrestrained sheet of Spunbonded Olefin is dimensionally stable up to 270˚F (132˚C) and will not shrink. Temperatures above 175˚F (79˚C) should be avoided when processing under tension.

• Spunbonded Olefin is tough; web breaks rarely occur. When sheeting, slitting and die-cutting, each filament must be completely cut; "hangers" will not break off as they do with paper.

• Spunbonded Olefin has lower surface friction, which may facilitate handling in some operations.

• Spunbonded Olefin is slippery and should not be used in any application where it will be walked on without the application of a slip-resistant coating. Garments made of Spunbonded Olefin should have slip-resistant or anti-slip materials on the outer surface of boots, shoe covers or other garment surfaces in conditions where slipping could occur.

Incredibly strong, yet incredibly light, car covers of DuPont Tyvek® can protect your car from whatever Mother Nature has in store. Tyvek® brand spunbonded olefin keeps cars cool by reflecting heat, and blocks 99.8% of the sun's UV rays that cause paint and interior colors to fade. It can withstand high water pressure, helping to protect your car's finish from acid rain and other pollutants. Tyvek® is also a shield against dust particles as small as two microns, and stains from the falling debris of trees, birds and insects. Yet the unique breathable spunbonded structure of Tyvek® allows condensation to pass through so trapped water evaporates away.

PRINTING ON TYVEK®

The lightweight, smooth surface, high dimensional stability and opacity, together with the toughness and durability of Tyvek® brand spunbonded olefin, make it well-suited as a printing substrate. It can be printed by offset lithography, letterpress, flexography, gravure, screen process, dot matrix, thermal transfer, ion deposition, digital press applicatopns and ink-jet processes, using standard commercial printing equipment. Spunbonded Olefin can be printed either sheet- or web-fed. Types 14 and 16 are usually web-fed because of their inherent softness. Four-color process printing can be done on all types, but is most commonly done on Type 10.

DuPont Tyvek® is an ideal choice for packaging today's ubiquitous CDs and DVDs.

Design / Prepress Tips

Most artwork can be printed on Spunbonded Olefin by offset lithography if it is designed for this substrate and the preferred printing/converting equipment is used. To ensure acceptable printing, the designer and printer must understand the unique properties and characteristics of Spunbonded Olefin.

First, the customer or the agency must specify a style. Styles 8740D and 1085D are recommended for two-sided printing because of their higher opacity. Styles 1058D and 1073D are recommended only for single-sided printing. In the timeline, three days should be allowed for two-sided printing due to the need for a 24-hour dry time before printing the second side.

It is important to identify critical colors in the planning and design stage. Color matching of ink must be done because a color shift will occur when going from paper to Spunbonded Olefin.

PANTONE® Matching System (PMS) colors can be specified, but the ink must be matched on Spunbonded Olefin. Always refer to PMS colors printed on uncoated paper (U) in the PANTONE® Color Formula Guide when selecting colors.

When a special color, such as a corporate logo color, is to be printed in a four-color process piece, it may be advisable to print the special colors as a fifth or sixth non-process (PMS) color on a six-color press. This will allow more freedom to correctly color match the four-color subject without shifting the corporate logo colors.

The extra pressure or squeeze required on press when litho printing Spunbonded Olefin necessitates some different steps in making the color separations for process printing compared to paper:

- The gray scale should be manipulated so that there is no more than 35% to 40% (vs. the usual 50%). The 97% tones should be reduced to 90% to 95%. The net result is a flatter highlight area and a more accentuated shadow and midtone in the separations. This translates to a "normal" picture on press because maximum dot gain takes place in the midtones due to the maximum perimeter of the dots, and in the shadows due to the additional squeeze required on press.

- All colors must be over-corrected. Red colors are made up of yellow and magenta with cyan and/or black adding detail and shape. In this case, the cyan and black must be reduced to minimum dot size and dropped out or eliminated entirely whenever possible. Similarly, the cyan must be drastically reduced in the magenta and yellow. Continuing this process, the magenta must be reduced in yellows and the yellow in magentas. In greens, the magenta should be over-corrected and in blues, the yellow should be lightened as much as possible.

- All colors should be as light as possible in the highlights.

- These changes to the separation can be partially accomplished in the actual scanning, but for practical purposes are more easily done in the Adobe® Photoshop® program on a computer. The best chance for success is to have an experienced color separation person make these changes or supervise the procedure.

- To achieve best results, a press proof should be scheduled on your first attempts.

Gold and silver metallic inks can be printed on Spunbonded Olefin; however, due to the light scattering effect of the fiber pattern, a bright, shiny metallic effect is not achieved. Foil stamping is a better alternative.

When printing white on white, specify that the white be as white as possible. Alternately, a shadowline or border may be added to enhance the separation. Spunbonded Olefin has an inherent fiber-swirl pattern that cannot be covered up by laying down more ink. Dark solids accentuate the appearance of fiber swirl; whereas, small, busy patterns using light colors and screens minimize the appearance of fiber swirl. Fiber swirl can sometimes be minimized in large areas of light colors by using opaque colors (e.g., ocean blue on a map).

Spunbonded Olefin is not coated paper and does not provide a glossy print surface. Increasing the ink film thickness will not achieve higher gloss, but will cause ink distortion and increased ink drying time. Press varnish does not noticeably improve gloss or ink rub resistance; however, it does accentuate the appearance of fiber swirl. Because of its very bright blue-white surface, most press varnishes appear slightly yellow on Spunbonded Olefin and are not recommended. Ultraviolet- (UV-) cured inks generally appear brighter and more glossy on Spunbonded Olefin, and are recommended. Film lamination of Spunbonded Olefin will provide a very glossy, abrasion-resistant surface.

If color is critical, a press proof is the only sure way to check color. When doing four-color process printing, avoid using fine (approximately $^{1}/_{16}$ in.) reverse lines, borders and type, particularly near the outer edges of the press sheet. This is especially important when printing will be done on the lighter weights of Spunbonded Olefin. A dark solid with a one- to two-dot overlap is preferred.

Whenever very tight register is required, such as on large maps using more than four colors, the color with the least amount of ink coverage should be printed on the first unit, followed by increasing amounts of ink coverage on subsequent units.

Before printing Spunbonded Olefin for the first time, the printer should understand the characteristics of Spunbonded Olefin that affect printability.

Guidelines for Printing

Spunbonded Olefin can be printed acceptably by all the commercial printing processes. Although Spunbonded Olefin is printed in much the same way as paper, and on the same equipment, some of its physical properties require special attention for optimum results. For this reason, *we strongly recommend that those who have never before worked with Spunbonded Olefin conduct ink, material and printing evaluations before beginning a full-scale print run*.

Characteristics of Spunbonded Olefin that Affect Printability

- The properties of Spunbonded Olefin are unaffected by water; however, hydrocarbon solvents in the kerosene range used in some commercial inks can cause swelling—either immediately or after sheets have been printed. Solvent distortion will cause mis-register and sheet swelling. For this reason, sheet-fed offset lithographic and letterpress inks must be formulated with less than 3% volatile solvents.

- Because Spunbonded Olefin is not as absorbent as paper, lithographic/letterpress inks take longer to dry.

- Uncoated Spunbonded Olefin has a unique fiber-swirl pattern that will show through most inks. The appearance of fiber swirl can be minimized by using light colors and a "busy" multi-color pattern. Opaque inks should be used when possible. Coated Spunbonded Olefin is recommended when the end-use application calls for optimum ink "hold-out;" high-gloss, high-fidelity printing; or increased surface abrasion resistance.

- The melting point of Spunbonded Olefin is 275°F (135°C). During web handling operations, the web tension should not exceed 0.75 lb/in. (1.4 N/cm) width and the sheet temperature should not exceed 175°F (79°C).

- Sublistatic printing (heat transfer printing) is not recommended because the temperatures used to transfer the dyes exceed the melting point of Spunbonded Olefin.

• Type 10 Styles with a "D" suffix (e.g., 1073D) and Style 1079 are treated with an antistatic agent to reduce static during sheet handling operations. Antistatic agents function best at a relative humidity of 50% or more. Below 20% relative humidity, antistatic agents lose their effectiveness and sheet feeding will become noticeably difficult. The above-mentioned styles have also been treated by corona discharge to improve adhesion of inks, coatings and adhesives. Type 14 Styles with an "R" suffix (e.g., 1443R) and Type 16 Styles with an "E" or "R" suffix (e.g., 1622E) are treated in a like manner.

• Type 10 Styles with a "B" suffix (e.g., 1073B) are untreated and are used primarily for medical applications where optimum barrier properties are required. Type 14 Styles followed by an "A" suffix contain an antistatic agent, but are not corona treated. Because these untreated "B" and "A" Styles have only marginally acceptable ink adhesion, precautions must be taken during handling to avoid ink rub-off. If a printer is uncertain whether Spunbonded Olefin is corona treated, a simple "Water Drop" test can be performed as follows. Place a drop of water on the unknown sample and on known samples of 1073B and 1073D. Tilt each sheet until the drop rolls off and observe whether wetting has occurred. Water will wet out the treated style (1073D); whereas the drop of water will remain as a ball and roll off the untreated sheet (1073B) without leaving a wet "track."

• Unlike polyethylene film, Spunbonded Olefin does not lose the effectiveness of corona treatment with time. Samples of corona-treated Spunbonded Olefin stored for 20 years were found to have the same level of ink adhesion as a newly treated sample.

• Spunbonded Olefin is two-sided. The Type 10 Styles have a rough or "wire" side, and a smooth side. The difference is minor, but can usually be felt, and can be seen easily under a low-power magnifying glass. Where print clarity is most important, the smooth side should be used. Style 1079 is embossed with a fine cambric pattern. As with the other Type 10 Styles, the smooth side is preferred for printing and coating. The Type 14 Styles have a linen and rib side. The linen side is preferred for printing because of better ink hold-out and better surface fiber stability. The linen side is also smoother than the rib side. However, garment fabrication may dictate that the rib side be printed with some sacrifice in print quality.

• Where curl or lay-flat after printing must be minimized, observe the following for Type 10 Styles:
— For one-sided printing, print the rough or "wire" side.
— For two-sided printing, print minor coverage on the smooth side first, followed by major coverage on the rough side.
— Allow at least 0.5 in. (13 mm) unprinted border.

NOTE: Heavy edge-to-edge coverage on the smooth side of Type 10 products, followed by die-cutting into small blanks (for example, in envelopes) can result in curling.

• Spunbonded Olefin is nearly isotropic. Its physical properties are approximately equal in the machine and cross-machine direction.

Tyvek® Brand Spunbonded Olefin Can Be Printed by Various Printing Processes

OFFSET LITHOGRAPHY

Items requiring good quality color and appearance can be printed on Spunbonded Olefin by the offset lithographic process.

Spunbonded Olefin is dimensionally stable and handles well on both large and small, single- and multi-color offset lithographic presses.

Four-color process work should be done on Spunbonded Olefin using a four-color press. Four-color process printing on a single color press is not recommended because misregister can occur due to sheet swelling between colors. Special low-solvent-content inks are required for offset lithographic printing of Spunbonded Olefin. These are described in detail on pages 12-15 under "Printing Inks for Spunbonded Olefin." UV-cure inks are being run routinely on Spunbonded Olefin by the sheet-fed litho process. These inks cure instantly and do not distort Spunbonded Olefin. Wet and dry rub resistance is at least equivalent to conventional oil-based ink.

To further minimize sheet distortion caused by ink, the ink film thickness should be kept to a minimum by using extra strong colors. Tints should be made using opaque white rather than extender, whenever possible.

When printing four or more colors that completely cover a large sheet, the color sequence should be chosen so that the color with the least coverage is laid down first and the color with the greatest amount of coverage is laid down last.

Spunbonded Olefin has a pH of 7 (neutral) and does not affect the chemistry of the lithographic dampening system. *Because Spunbonded Olefin absorbs little water, the dampening solution should be maintained at a minimum level to avoid a pastel or washed-out appearance of the printing; i.e., only enough dampening solution should be added to prevent dry-up in the non-image areas*.

Sometimes after printing 25 to 50 sheets, the printed image will appear dull or gray (if black is being printed). This is due to a buildup of dampening solution. Because Spunbonded Olefin does not absorb water as readily as paper, the amount of dampening solution must be reduced. In fact, it may be necessary to reduce the level several times. This will also prevent ink emulsification and shorten ink drying time.

Because of the extremely high surface area of Spunbonded Olefin, it will require approximately 15% more ink to achieve the same color density as uncoated paper. Type 10 Spunbonded Olefin will not take on the gloss of coated paper, no matter how much ink is used.

Spunbonded Olefin is more compressible than either film or paper. It is necessary to add 3 to 4 mil (0.08 to 0.10 mm) of additional squeeze between the blanket and back cylinder vs. paper of equivalent thickness to compensate for the thickness variation of Spunbonded Olefin. However, as with any material being printed, no more pressure than is necessary should be used because excessive pressure will cause dot gain and result in mis-registration. Printing on Spunbonded Olefin that has been deeply and sharply embossed should be avoided because it is difficult to obtain adequate ink fill without excessive pressures, which may result in sheet distortion.

Conventional offset blankets of medium hardness are recommended for lithographic printing of uncoated Spunbonded Olefin because they afford the best results with large, solid printed areas and halftones. Compressible blankets are preferred for printing coated Spunbonded Olefin because they improve print uniformity in large halftone-screen areas, particularly when trapping screens with solids.

FOUR-COLOR PROCESS PRINTING OF STYLE 1443R BY SHEET-FED OFFSET LITHOGRAPHY

Style 1443R Spunbonded Olefin is used for fabricating promotional apparel. Superior graphics can be obtained using four-color process sheet-fed offset lithography. The advantage that Spunbonded Olefin offers over other materials is that four or more colors can be printed on the linen (smooth) side while maintaining precise register, high-fidelity print quality (150 lines/in. [60 lines/cm]) screens and good ink hold-out.

The challenge to the printer who chooses to do this on a sheet-fed press is formidable, but it is being done routinely.

Lightweight, fabric-like Style 1443R Spunbonded Olefin is difficult to sheet-feed and requires a considerable amount of patience and feeder adjustment by the press operator. Style 1443R should be sheet-fed with the rib pattern parallel to the direction of sheet travel to obtain optimum register. Because of its light weight, the air used to separate the sheets must be reduced.

Sheets up to 28 in. x 40 in. (70 cm x 100 cm) are much easier to feed and deliver than larger sheets. Printing is done on the linen (smooth) side to optimize ink hold-out and surface fiber stability. Because soft structures of Spunbonded Olefin (Types 14 and 16) do not jog well, four-side trimming should be done near the press. Load the sheets into the feeder with as little handling as possible to avoid the need for jogging. Because of the difficulty in jogging sheets after delivery, multi-pass printing of Style 1443R is not recommended.

Low-solvent-content litho inks are recommended for sheet-fed printing of Style 1443R. These should be made at as low a tack as possible, generally 14.

Due to the lack of stiffness in Style 1443R, small folds or creases will occur in some of the sheets during printing. These creases will appear as narrow white streaks in the finished press sheets. Smaller sheets are less likely to crease than larger sheets.

OFFSET LITHOGRAPHIC PRINTING OF PRESSURE-SENSITIVE COATED TYVEK® BRAND SPUNBONDED OLEFIN

Most Spunbonded Olefin that is coated with water-based, pressure-sensitive adhesives for label stock can be printed by any of the commercial printing processes. Occasionally, Spunbonded Olefin will be coated with a water-based adhesive that contains an excessive amount of wetting agent. This wetting agent can migrate to the opposite side of Spunbonded Olefin and disrupt the ink/water balance of the offset lithographic press, producing a washed-out appearance in the printing. The effect is most noticeable in the thin areas of the sheet, but may appear over the entire sheet. Sometimes it is mistaken for insufficient impression. Stock with this coating defect can be printed acceptably by the dry-offset, letterpress or flexographic processes. If the wetting agent has migrated through to the side to be printed, it can usually be detected by using the "Special Blue R Dye Test." An intense violet color is indicative of wetting agent on the surface. An uncoated sheet of Style 1073D should be tested at the same time as a control.

The unique structure of DuPont Tyvek® delivers an optimum balance of bacteria penetration resistance, tear strength, puncture resistance and clean peel, as well as compatibility with all sterilization methods—making it the industry choice for sterile medical packaging.

ENVELOPE/IMPRINTING

Envelopes of Spunbonded Olefin can be imprinted using standard envelope printing presses. For light ink coverage, such as "corner cards," standard paper inks can be used. For heavy ink coverage, such as logos, offset inks compatible with Spunbonded Olefin are recommended.

Because envelopes made of Spunbonded Olefin are less rigid than paper envelopes, a "wedge" should be placed under the center of the feed stack to maintain a level feed with horizontal feeders. Printing quality may be enhanced by using a "patch" blanket with offset presses. The patch blanket allows greater squeeze without interference from the flap ends.

HEAT-SET WEB OFFSET

Spunbonded Olefin is well-suited for printing by the heat-set web offset lithographic process. Because Spunbonded Olefin is composed of continuous fiber, it is nearly lint-free and reduces the downtime required for blanket/plate washup. In addition, the high tear strength virtually eliminates web breaks.

Because of the heat and solvent sensitivity of Spunbonded Olefin, *low-energy* heat-set inks are required to print Spunbonded Olefin by this process. These inks contain low-boiling hydrocarbon solvents that flash-off at web temperatures of 175°F to 200°F (79°C to 93°C) and press speeds of 22,000 impressions/ hour. Although the drying oven may operate at a temperature higher than 175°F (79°C), the temperature Spunbonded Olefin reaches should not exceed 175°F to 200°F (79°C to 93°C). It is a good practice to measure the web temperature with a surface pyrometer. In the case of sudden press shutdowns, provisions must be made to prevent Spunbonded Olefin from melting in the drier.

Spunbonded Olefin has been run successfully on web offset presses roll/roll, roll/sheet and roll/folded signature. Adjustment of the sheeter is crucial and requires a sharp blade set to a close tolerance. To avoid sheet size variation, web tension going into the sheeter must be at a minimum. Sheet cutoff has been maintained at ±1/32 in. (±0.8 mm) on a 23 9/16 in. (0.6 mm) sheet throughout production runs.

Both UV and electron beam ink-curing systems have been used successfully with Spunbonded Olefin on web offset presses. Because the inks used are 100% solids and cure almost instantly, higher color density and gloss can be achieved. UV-cured inks do not distort Spunbonded Olefin. Infrared drying is not recommended because of the heat generated.

FLEXOGRAPHY

Spunbonded Olefin is printed by the flexographic process for a wide variety of applications, ranging from sterile packaging and labels to industrial and medical apparel. Equipment used for single- or multi-color web printing of flexible packaging materials is best suited to Spunbonded Olefin because it permits processing at low temperatures and tensions.

Web temperature should be kept below 175°F (79°C) and tensions kept below 0.75 lb/lineal in. (1.4 N/cm) of width, to prevent sheet distortion and print mis-register in multi-color work.

Generally speaking, a floppy web should enter and exit from the printing nip. High-velocity, low-temperature drying air should be thoroughly mixed by the diffusers to avoid oven hot spots. Gas-fired driers should be carefully controlled because of the very high burner outlet temperatures. Powered rollers and short, unsupported web spans will help maintain the recommended low-unwind and processing tensions. Bowed rolls ahead of printing and windup stations are very effective in eliminating wrinkles and are required for printing Types 14 and 16.

A chill roll prior to windup is helpful in reducing sheet temperature, thus helping to prevent ink blocking and minimizing sheet distortion. Chill rolls are essential for flexographic printing of Spunbonded Olefin used for medical packaging, which is often coated with a heat seal coating on the back side. If this coating is softened, it will block and cause ink pickoff.

Resiliency is needed in flexographic plates to help offset the inherent thickness variations of Spunbonded Olefin. Photopolymer plates (Cyrel®) with a 50 Durometer hardness (Shore A) mounted with 15 to 20 mil (0.38 to 0.51 mm) of sticky-back, closed-cell foam produce the best overall print uniformity on Spunbonded Olefin, and have been used successfully to print 4-point type and medium-density bar codes. Soft natural rubber plates with a 30 Durometer hardness (Shore A) are recommended for fine-line reverses greater than 13 mil (0.33 mm). Rubber plates should also be backed up with 15 to 20 mil (0.38 to 0.51 mm) of sticky-back, closed-cell foam for optimum print uniformity.

The new, thin (<0.067 in. [1.7 mm]) photopolymer plates also print well on Spunbonded Olefin and are preferred for four-color process flexography.

Experimentation will reveal the right amount of pressure necessary to obtain adequate ink fill in the thin spots without print "smash" in adjacent thick areas. Both sides of Type 10 Spunbonded Olefin can be printed, although the smooth side is preferred. On Types 14 and 16, the linen side is preferred.

For flexographic process printing on Type 10 Styles of Spunbonded Olefin, a 65-line/in. (26-line/cm) screen is recommended to avoid dot gain in the thick areas of Spunbonded Olefin. For process printing on Type 1443R, an 85-line/in. (33-line/cm) screen should be used.

GRAVURE

Spunbonded Olefin can be printed by the gravure process on equipment used for single- and/or multi-color printing of paper and films. Materials designed for use in packaging, book covering and apparel are currently being printed by this method. Gravure cylinders with 100 lines/in. (40 lines/cm) or more are preferred for printing both the uncoated and coated styles of Spunbonded Olefin. The smooth side of Type 10 and the linen side of Types 14 and 16 are preferred gravure surfaces when printing uncoated styles. As in flexography, the web temperature should be maintained below 175°F (79°C), with tensions below 0.75 lb/lineal in. (1.4 N/cm) to avoid web neck-down and mis-registration.

The same precautions for web handling described for flexography apply to gravure printing.

INKJET PRINTING

Spunbonded Olefin can be inkjet printed for addressing and bar coding. For optimum performance, solvent-, oil- and wax-based inks are recommended.

Selected, pigmented water-based inks can provide satisfactory performance by using one or more of the following: draft-mode printing; longer feed intervals; supplemental driers; and longer exit conveyors.

For high-quality graphics using inkjet printing, coated Spunbonded Olefin should be used.

For information about emerging digital technologies or for inkjet ink recommendations, call DuPont at 1-800-448-9835.

SCREEN PROCESS

Spunbonded Olefin can be printed on hand, automatic and rotary screen presses in sheet and web form for signs, banners and other decorative uses.

When conveyor ovens are used instead of room-temperature drying, high velocity air will aid drying and carry away the solvents. Sheet temperature should be kept below 175°F (79°C), with tensions below 0.75 lb/lineal in. (1.4 N/cm) to avoid sheet neck-down and mis-registration in multi-color web printing. When using UV-cured screen inks, cooling is required to prevent sheet distortion or shrinking due to the heat generated within the ink when curing heavy coverage of dark solids. Screen process inks for Spunbonded Olefin are discussed on page 13.

LASER PRINTING (NON-IMPACT)

Today, laser-based electrophotography is being used more widely for high-speed black and white copiers. These copiers use lasers to activate (deactivate) the charged drums. The laser beam does not contact Tyvek® brand spunbonded olefin during the printing operation. *However, conventional laser printing is not recommended because of the temperatures involved in the printing units, which will melt Spunbonded Olefin if a jam occurs. For the same reason, Spunbonded Olefin should not be used in electrostatic copiers. It is important to note, however, that the newer cold lasers (which generally have a temperature below 200°F [93°C] can be used with Spunbonded Olefin*.

DOT MATRIX PRINTING

Dot matrix printing is being used to imprint a variety of labels and business forms, especially those used for chemical drum labeling that require variable information, and in some cases, bar codes. A fade-resistant, non-bleeding ribbon is required for printing these labels of Spunbonded Olefin so that the image will survive the harsh environment to which these labels are sometimes subjected.

A clay-coated style of Spunbonded Olefin or Tyvek® Brillion® will yield the best results when using dot matrix printing.

Printing Inks for Spunbonded Olefin

Because Spunbonded Olefin is available in a variety of uncoated and coated forms, samples of the specific material to be printed should be submitted to an ink supplier for formulation of compatible inks for the required job. A list of ink suppliers for Spunbonded Olefin is available by contacting DuPont at 1-800-448-9835. Following are some recommendations to consider when selecting or formulating printing inks to achieve the best results with Spunbonded Olefin.

OFFSET LITHOGRAPHIC INKS

Spunbonded Olefin is largely unaffected by water or highly polar solvents (alcohols, glycols, esters). However, non-polar, volatile, kerosene-type hydrocarbon solvents used in some commercial inks will cause it to swell or pucker.

If Spunbonded Olefin swells, buckles or puckers within 20 minutes after printing, the ink probably contains a residual solvent that is incompatible with Spunbonded Olefin.

The typical offset lithographic ink for use with Spunbonded Olefin is formulated from rosin esters and long oil alkyds. These can be diluted with drying oils, such as tung (chinawood oil) or linseed oil. In addition, 100% solid soy-based resins are compatible with Spunbonded Olefin. High-boiling, "quick-dry" petroleum solvents should not be used in sheet-fed offset-litho ink formulations for Spunbonded Olefin. Likewise, aliphatic hydrocarbon resins should be avoided because they can also cause distortion and sheet swelling. "Dry pigment grinds" should be used to avoid the residual solvent in pigments made from flushes. Magie® oils should be avoided.

To minimize the tendency of Spunbonded Olefin to curl or pucker, the *least possible ink film thickness* should be applied, with a goal of 0.3 mil (0.0076 mm). In some cases, using a 60% screen will beneficially reduce ink coverage. When tints are used, the ink should be made with opaque white rather than transparent extender. This will minimize the swelling effect the extender might have on Spunbonded Olefin. Opaque ink will also reduce the appearance of the fiber-swirl pattern.

Offset/letterpress inks dry more slowly on Spunbonded Olefin than conventional paper inks. To minimize offsetting, pile height should not exceed 20 in. (0.5 m.) Winding is recommended after 6, 12 and 18 hours for sheets with heavy ink coverage. To shorten the drying time of very slow-drying inks, contact the ink supplier for the amount of drier that can be added. Excessive drier can hinder drying and may cause Spunbonded Olefin to distort.

When excessive ink drying time is required on Spunbonded Olefin, it is usually caused by printing with too much ink and excessive dampening solution, which can result in ink emulsification. Fountain stimulators used to increase the rate of drying are only marginally beneficial with inks on Spunbonded Olefin, but can be used if desired.

Most commercial dampening systems work well with Spunbonded Olefin, but only enough dampening solution should be used to prevent dry-up in non-image areas. Because Spunbonded Olefin absorbs less water than paper, it requires less dampening solution. *If the printed image is dull or has a washed-out appearance, the amount of dampening solution should be reduced.*

For optimum drying, the fountain solution should be maintained at a pH between 4 and 5. All uncoated styles of Spunbonded Olefin have a pH of 7.0.

Litho inks with more than 3% volatile solvent can cause swelling, puckering, curling and mis-registration. Solvent content of as-supplied resins should also be checked prior to use to ensure that the volatile solvent content of the finished ink remains below the recommended 3% maximum.

If it is necessary to reduce the tack of an ink, "000" varnish, tung oil or a reducer recommended by the ink supplier can be used. It is important that volatile materials, such as aliphatic hydrocarbon solvents, not be added indiscriminately to offset-litho inks. For this reason, it is strongly recommended that ink suppliers be consulted before any attempt is made to modify ink for Spunbonded Olefin.

METALLIC LITHOGRAPHIC INKS

It is difficult to print metallic inks on Spunbonded Olefin because they tend to pile on the plate and/or blanket (as with paper). Aluminum (silver) looks best on Spunbonded Olefin and the fiber swirl is shown to advantage here.

Gold is usually a two-component ink and should be mixed just before using. Two light passes will reduce the tendency to pile. Gold usually looks dull on Spunbonded Olefin. In some cases, aluminum overprinted with yellow will produce an attractive "gold" color. Wet trapping of metallic inks should be avoided on Spunbonded Olefin. As an alternative, either dry trap or reverse out the metallic color.

If Spunbonded Olefin is printed with a metallic ink and will later be glued (e.g., an envelope), the glue must be compatible with metallic inks, otherwise, the metallic effect will be lost and the color may shift. Adhesives containing acetic acid should not be used if metallic inks have been used.

Very attractive metallic surface effects can be obtained by vacuum metallizing Spunbonded Olefin. Contact DuPont at 1-800-448-9835 for sources of vacuum metallized Spunbonded Olefin.

UV-CURE INKS

UV-cure inks work well with Spunbonded Olefin and can be used for web-fed and sheet-fed offset lithographic printing. Because these inks are 100% solids systems that are instantly cured on Spunbonded Olefin, they eliminate the risk of solvent distortion and provide a means of getting high-density dark colors with improved gloss compared to conventional linseed/alkyd inks.

Although short exposure to UV radiation has no effect on the physical properties of Spunbonded Olefin, a cooling system to reduce heat buildup is recommended because of the thermoplastic nature of Spunbonded Olefin.

It is difficult to achieve a high level of ink gloss and a reduction in fiber swirl on uncoated Spunbonded Olefin without first putting down a heavy base coating. However, a reasonably high level of gloss has been achieved on uncoated Spunbonded Olefin via electron beam top coating. Heavy, clear top coatings can be applied in-line with printing and instantly cured via the electron beam process.

INFRARED-CURE INKS

Infrared (IR) drying is not recommended for sheet-fed litho printing of Spunbonded Olefin. IR-cure inks dry rapidly by flashing off solvent under an IR heat unit near the delivery end of the press. Because offset inks for Spunbonded Olefin are formulated with little or no solvent, they do not respond well to IR drying. Special high-solvent-content IR inks distort Spunbonded Olefin and, at slow running speeds, the heat generated by the IR drier can cause Spunbonded Olefin to shrink.

Trusted and reliable, protective garments of DuPont Tyvek® offer a superior combination of barrier, comfort and durability.

SCREEN PROCESS INKS

A variety of screen process inks are available for printing Spunbonded Olefin. Lacquer-type inks are preferred because they produce a minimum amount of distortion. Screen "poster inks," and enamels that contain a high percentage of mineral spirits, should be avoided. Water-based inks are compatible with Spunbonded Olefin because they minimize sheet distortion, even with heavy ink-film thicknesses. If Spunbonded Olefin is to be used outdoors, screen inks with fade-resistant pigments should be requested from the ink supplier to avoid loss of color.

Screen printing of Styles 1422R/1443R for apparel requires an ink with optimum adhesion, flexibility and wet rub resistance. The solvent-based urethane screen inks are preferred for this type of application. When selecting solvents to adjust the screen open or drying time, refer to Table V on page 25 and choose a solvent as close as possible to the *top* of the list to minimize swelling and puckering. Methyl and butyl Cellosolve® work well for adjusting screen open-time when compatible with the ink system.

UV-cure screen inks have been used successfully with Spunbonded Olefin, especially for four-color process work. Contact DuPont at 1-800-448-9835 for the latest information on these inks.

FLEXOGRAPHIC INKS

For flexographic printing, volatile solvent inks and aqueous inks are available for use with Tyvek® brand spunbonded olefin. Polyamide/alcohol inks are preferred for all styles of Spunbonded Olefin because of their optimum level of adhesion and rub resistance. Nitrocellulose can be added to produce a harder ink film, but with some sacrifice in adhesion. Water-based flexo inks print well on Spunbonded Olefin.

Microcrystalline wax is usually added to medical packaging inks for Spunbonded Olefin to reduce offsetting. Because Styles 1059B, 1073B and 4058B Spunbonded Olefin are not corona-treated, ink adhesion is only marginal, at best, and precautions must be taken to avoid offsetting and blocking. When used for medical packaging, inks for Spunbonded Olefin must have adequate thermal resistance so they do not block when heat-sealed.

GRAVURE INKS

Most of what has been said about flexographic inks is also true about gravure inks. Type C nitrocellulose gravure inks are most widely used for printing Spunbonded Olefin and they are often modified by the addition of an alkyd resin to improve ink hardness and adhesion.

Gloss and Color Matching

Ink gloss and color can be important factors in the appearance of printed Spunbonded Olefin. The higher the gloss or the darker the color of the ink, the more apparent the unique swirl pattern of uncoated Spunbonded Olefin. Conversely, the lower the gloss and the lighter the ink color, the less noticeable the swirl. Ink gloss on uncoated Spunbonded Olefin is difficult to achieve compared to the gloss on coated Spunbonded Olefin. UV-cure inks and electron-beam-cure inks and coatings improve ink gloss on uncoated Spunbonded Olefin. Top coating and film lamination also help.

In-line aqueous coating done on the last unit of an offset litho press does not add much gloss to the image because of light scattering caused by the high surface area of Spunbonded Olefin.

Inks should be formulated using a goal color swatch. Colors specified by PANTONE® Matching System (PMS) colors should be formulated and matched on the Spunbonded Olefin substrate. Inks made with the highest color density will minimize ink film thickness and provide the best color results.

When color matching, the printer should specify which side of Spunbonded Olefin is being printed with which color. Wet-ink densitometer measurements are needed to get the closest color match when both sides must be matched.

Because of the high surface area of Spunbonded Olefin, it will usually require approximately 15% more ink than uncoated paper to achieve the same color density.

With a complete line of products, Tyvek® Weatherization Systems enable the construction of more comfortable, energy-efficient buildings.

Color Stability

Spunbonded Olefin has a pH of 7.0 and, with its normal level of antistat, it has no effect on the stability of printing ink pigments. Certain pigments in offset lithographic inks have occasionally shifted in color or "burned out" on Spunbonded Olefin after printing. These pigments include Rubine Red #52, Red Lake 2C and Alkali Blue. These pigments are *not* recommended for use on Spunbonded Olefin without preliminary testing. This is especially true when these pigments are used to make tints. The "burnout" phenomenon occurs very infrequently and is not predictable. A test for "burnout" on *suspect* pigments can be made as follows:

- Print approximately 100 sheets with excessive fountain solution on the press and immediately seal them in plastic film.

- Compare these sheets with air-dried control sheets after 24 and 48 hours.

- If no color shift is observed, the ink/pigment compatibility with Spunbonded Olefin should be acceptable.

Litho Ink Test

To determine whether a sheet-fed offset lithographic ink is acceptable for use with Spunbonded Olefin, the volatile solvent content should be determined. This can be done as follows:

- Coat a 3 in. x 5 in. (7.6 cm x 12.7 cm) pre-weighed piece of aluminum foil with a thin film of ink—1 mil (0.025 mm) or less.

- Weigh the coated piece of foil immediately and then place it in an oven for two hours at 220°F (105°C).

- Remove from oven and allow to cool.

- Re-weigh and calculate the percentage weight loss.

Experience has shown that inks with 3% or less volatile solvent should give acceptable performance on Spunbonded Olefin. Many quick-drying offset lithographic inks contain as much as 27% volatile solvent. Use of such inks can cause gross mis-registration and sheet distortion or curl.

Ink Manufacturers

For a list of some of the companies that have formulated satisfactory inks for printing on Spunbonded Olefin, contact DuPont at 1-800-448-9835. Undoubtedly, there are other suppliers capable of producing satisfactory inks for use with Spunbonded Olefin. The list we provide is intended only as a guide and is not a recommendation of any specific company.

CONVERTING TYVEK®

Although Tyvek® brand spunbonded olefin is processed in much the same way as paper or plastic films and on the same equipment, it does require different handling techniques for optimum results. For this reason, we strongly recommend that those who have never before worked with Spunbonded Olefin conduct a pilot run to fully test each conversion operation before beginning full-scale production. Here's a few tips to keep in mind:

- Spunbonded Olefin cannot be crush-cut as easily as paper. Its filaments are very strong and each must be completely severed; "hangers" will not break off.

- Spunbonded Olefin elongates more than paper and will stretch up to 15% to 25% before breaking. To minimize distortion or neck-down, keep web tension as low as practical—0.75 lb/lineal in. (1.4 N/cm)—during processing.

- Spunbonded Olefin is a thermoplastic material and it melts sharply at 275°F (135°C).

- When coating or laminating Spunbonded Olefin, the web temperature in the oven should not exceed 175°F (79°C).

- Spunbonded Olefin, because of its inherent "memory," may occasionally curl when sheeted. Conventional decurler (breaker bar) equipment can be used at minimum tension.

- Before binding Spunbonded Olefin with printed paper, check compatibility because it may buckle or distort. Many publications contain residual solvents that can also distort Spunbonded Olefin. When bound along the spine, paper will respond to changes in humidity; whereas Spunbonded Olefin will not. This usually produces a buckled appearance along the spine of the publication.

- Type 10 Styles of Spunbonded Olefin with a "D" suffix (e.g., 1073D) and Style 1079 are treated with an antistatic agent to reduce static during sheet handling operations. Antistatic agents function best at a relative humidity of 50% or more. Below 20% relative humidity, antistatic agents lose their effectiveness and sheet feeding will become noticeably difficult. These styles have also been treated by corona discharge to improve adhesion of inks, coatings and adhesives. Type 14 Styles with an "R" suffix (e.g., 1443R) and Type 16 Styles with an "E" suffix (e.g., 1622E) are treated in a like manner. For more information about the type of treatment for each style, contact DuPont at 1-800-448-9835.

The microfiber technology of DuPont Tyvek® used for protective apparel offers increased airflow, softer feel, improved toughness and durability over uncomfortable film-based competitive garments.

(Shown 200x)

- Die cutting lubricants should be avoided because some contain low-molecular-weight hydrocarbons that can cause swelling and distortion.

Slitting, Sheeting & Cutting

Type 10 Spunbonded Olefin can be slit and cut into sheets on most commercial equipment using conventional paper-cutting techniques. However, the inherent toughness of Spunbonded Olefin requires that all cutting parts be kept clean and sharp, with true, well-supported, nick-free edges. A sharp, slightly rounded edge gives longer service than a pointed edge for crush cutting, but a sharp edge is preferred for other slitting methods.

Multiple roll sheeting (four to six rolls) works well with Spunbonded Olefin and is preferred for the lightweight styles (less than 2.2 oz/yd^2 [76.3 g/m^2]).

In sheeting operations, best results are obtained by using styles of Spunbonded Olefin with a "D" suffix. These are treated with an antistatic agent to reduce static during sheeting. When it is necessary to sheet non-antistated styles, the use of conductive "tinsel" or ionized air produced by an electrostatic generator or a radiation bar will usually reduce the buildup of static to an acceptable level. Antistatic agents or aerosol sprays should *not* be used on Styles 1059B and 1073B that will be used for packaging sterile medical products.

"Soft" structure Types 14 and 16 can be cut much like fabric with conventional straight-knife machines. However, if knife blades get too hot, these soft structure materials can melt and edge-fuse. To minimize cutting problems:

- Replace straight-edged blades with blades that have a wavy or serrated edge.

- Use blades coated with Teflon® TFE fluorocarbon or lubricated with a non-staining silicone spray.

- Reduce the cutting stroke from 1.5 in. (3.8 cm) down to 1 in. (2.5 cm).

- Operate at 1,800 rpm instead of 3,600 rpm.

Die-Cutting

Sheets of Spunbonded Olefin can be die-cut using either steel rule (sharp edge) or male/female dies. Because the inherent toughness of the material requires that male/female dies be manufactured to close tolerances, steel rule dies are usually preferred. Spunbonded Olefin fibers must be completely cut; dies must be kept in good condition, with sharp, true, nick-free, well-supported edges. Dull dies cause cut edges to curl. On steel rule or high dies, slight internal relief helps reduce heat buildup.

When working with closed dies, the strength of Spunbonded Olefin will probably require use of a side cutter or chisel edge to speed up release and prevent die and product damage. Dies should be hardened to Rockwell C 50 to 60 to extend their life.

Keep lift heights below 3 in. (7.6 cm) when die-cutting to avoid oversizing top blanks by edge compression as the die comes down. Use of a center-die pressure cylinder can help de-aerate and compact the lift, as well as minimize slippage.

Converting Spunbonded Olefin for Continuous Business Forms

Because of its toughness, Spunbonded Olefin is more difficult to perforate and punch than paper. However, business forms made from Spunbonded Olefin can be punched on tag, letterpress and rotary line-hole equipment. The higher tensile strength styles of Spunbonded Olefin (i.e., 1058D, 1073D and 1079) are recommended for business forms because they perforate and punch better.

Spunbonded Olefin is more elastic than paper and tends to stretch under tension, but recovers after perforating/punching. This creates the effect of shrinkage in the final printed form. It is necessary to convert Spunbonded Olefin at low tension and to hold the distance between sprocket holes within ± 0.02 in. (0.5 mm) in a 100-in. (2.5-m) length sheet.

Unlike paper, as the machine speed increases, the tension adjustment decreases. If the hole distance is short at a particular tension at 330 ft/min (100 m/min), it will be less short at 1,150 ft/min (350 m/min). Rotary sprocket punching of Spunbonded Olefin should be done with male/female dies made from hardened tool steel or tungsten carbide. Because of the close tolerances required to punch Spunbonded Olefin, soft steel dies dull quickly and increase downtime. Contact DuPont at 1-800-448-9835 for sources of the preferred types of rotary dies.

Punching

Spunbonded Olefin can be punched on tag, letterpress and rotary line-hole equipment. Best results are obtained from sharp, well-registered and closely fit punches. Punches may be either smooth or serrated, and will cut best if ground concave on the ends. Most manufacturers of punching equipment suggest use of longer punches or deeper punch penetration, or both, to ensure a cleaner hole. A soft, self-honing male punch in a hardened female die is recommended. Gear backlash should be kept to an absolute minimum. The lowest practical tension should be used to avoid stretch and mis-registration in web operations. If drilling, avoid excessive clamp pressure that can leave an impression on the sheet.

Perforating

To make clean-tearing perforations, use the maximum practical number of cuts with the smallest land (reserve) between them. An 8:1 ratio ($^1/_4$-in. [6.4-mm] cut with $^1/_{32}$-in. [0.8-mm] reserve) is suggested. Tear initiation can be ensured by positioning a cut at the edge of the sheet.

Laminating / Coating

Spunbonded Olefin can be extrusion-, adhesive-, flame-, ultrasonic- and thermal-laminated. Laminates are used for protective covers, automotive parts protection, military packaging and worker protection garments. Spunbonded Olefin can be air-knife- or gravure-coated with heat-seal coatings for medical packaging applications.

When there is a need to improve the fidelity of printing on Spunbonded Olefin and to eliminate the appearance of fiber swirl, the best approach is to apply a coating such as that used for book covering. Spunbonded Olefin is readily coated with a wide range of solvent and water-based materials applied with conventional equipment. Air-knife coating is preferred for aqueous coating systems because it deposits a uniform thickness of coating on Spunbonded Olefin. It also produces a very smooth surface that is ideal for offset lithographic printing. Gravure coating has been used successfully for solvent-based coating systems, particularly where deep coloration is required. Pyroxylin coating formulations containing a high concentration of isopropyl alcohol (25%) are preferred for obtaining deep coloration.

Dyeing

Conventional textile dyeing processes do not impart permanent color to Tyvek® brand spunbonded olefin. For this reason, Types 14 and 16 are usually printed by the flexographic or gravure process using either solvent- or water-based inks. Sublistatic printing is not recommended because of the high temperatures used.

Heat-Sealing / Dielectric Sealing / Ultrasonic Sealing

Although it is possible to fuse Spunbonded Olefin to itself using only heat, it is difficult to obtain strong seals this way because melting the material destroys its fiber structure, reducing both flexibility and tear strength in the seal area. Non-corona-treated, non-antistated styles of Spunbonded Olefin are preferred for heat-sealing Spunbonded Olefin to itself. The molecular film of oxide and antistat on the surface of corona-treated/ antistated Spunbonded Olefin causes a discontinuous melt to form, thus reducing the seal strength.

Trim seal dies designed with a spring-loaded restraining plate have been used successfully for heat sealing. However, the preferred method is to apply a coating with a melting point below that of Spunbonded Olefin, such as branched polyethylene. With such a coating, high seal strengths can be achieved using hot-bar or impulse techniques.

Spunbonded Olefin, like polyethylene film, cannot be dielectrically sealed by conventional methods. However, commercial proprietary processes have been developed that allow Spunbonded Olefin to be dielectrically sealed using conventional radio-frequency equipment.

Ultrasonic sealing can be used to create fiber tearing seals with most styles of Spunbonded Olefin, without the puckering that is often associated with heat seals. This process also forms strong seals to a variety of plastic films and nonwovens. For more information about sealing Spunbonded Olefin, contact DuPont at 1-800-448-9835.

Gluing

A number of adhesives can be used to glue Spunbonded Olefin, either to itself or to other substrates. In general, water-based adhesives that provide quick tack and fast drying are preferred. However, the first step in choosing an adhesive is to determine how it will react with Spunbonded Olefin. Laboratory testing is the best way to make this determination. Table V on page 25 contains a list of solvents that are preferred for use with Spunbonded Olefin.

Natural-product adhesives based on starch, dextrin, casein or animal by-products are preferred to synthetic-based adhesives. Hot animal glue is an excellent adhesive for adhering Spunbonded Olefin to paperboard.

Water-based synthetic lattices also bond Spunbonded Olefin to itself and to a variety of substrates. Ethylene/ vinyl acetate adhesives are especially useful, as are the acrylic pressure-sensitive adhesives. Synthetic adhesives often contain low-molecular-weight materials that can act as solvents at elevated temperatures, causing swelling and wrinkling. Polyurethane adhesives provide optimum adhesion (lap and shear), flexibility and water resistance for adhering Spunbonded Olefin to itself and to a variety of substrates.

Hot-melt adhesive technology has been amply demonstrated in a number of applications involving Spunbonded Olefin, including the construction of envelopes, tags and medical packaging. Care must be exercised in adhesive selection and consultation with the adhesive manufacturer is recommended. For a list of some of the companies that have formulated satisfactory adhesives for use with Spunbonded Olefin, contact DuPont at 1-800-448-9835. Undoubtedly, there are other suppliers capable of producing satisfactory adhesives for use with Spunbonded Olefin. This list is intended only as a guide and is not a recommendation of any specific company.

Embossing & Foil Stamping

Spunbonded Olefin can be embossed with either high- or low-pressure equipment. Done properly, cold embossing does not significantly reduce the strength of Spunbonded Olefin. However, it does reduce opacity in the embossed area. Embossing cylinders used for Spunbonded Olefin usually are very shallow, having a depth of only 5 to 25 mil (0.13 to 0.65 mm). A Shore "D" hardness of 70 to 80 for the rubber backup cylinder is preferred. Spunbonded Olefin that is going to be printed should never be deeply embossed because it is difficult to fill this deep embossing pattern with ink. Foil stamping works best on Spunbonded Olefin when it is used with type or small designs, such as corporate logos. Solid areas greater than 2 square inches will bubble and distort in the stamped area.

Embossing is not recommended if it is to be followed by film lamination. The depth of embossing should be adjusted so that there is only a 2 to 3 point loss in opacity. Embossing roll temperature should not exceed 175°F (79°C) and roll tension should be kept below 0.75 lb/lineal in. (1.4 N/cm). Due to the thermoplastic/elastic nature of Spunbonded Olefin when exposed to heat and tension, super calendering is not recommended.

Foil stamping is readily accomplished on Spunbonded Olefin due to its thermoplastic nature. A variety of foils is available from suppliers for label and bookcover applications. A foil should be chosen that will transfer cleanly and adhere to Spunbonded Olefin in a temperature/dwell time that is compatible with the melting point of Spunbonded Olefin at 275°F (135°C).

Sewing

Spunbonded Olefin can be sewn satisfactorily on any conventional sewing machine. Best results are obtained from machines equipped with puller- or drop-feeds. Smooth, rubber-covered rolls should be used rather than knurled metal rolls, which tend to leave impressions on the material.

When stitching Spunbonded Olefin, use the least number of stitches per inch and the smallest needle practical for maximum resistance to tearing. Both lock stitches and chain stitches work well, especially a 1-in. (2.5-cm) chain stitch, which can prevent raveling.

FOR TYPE 10 SPUNBONDED OLEFIN

- Use 3 to 5 stitches/in. (1.2 to 2 stitches/cm) at low tension to eliminate skipping.

- Use #036 (Union Special) or #14 (Singer) needle, or equivalent.

- Use a flat-tipped needle that cuts slit-like perforations. "Rock Point" (Union Special) or "Narrow Wedge" (Singer) will permit top-speed operation with the same thread used for round-point needles.

- The informal industry standard of 25/4 tex (24/4 cc) glacé thread of short staple cotton in #14 and #036 needles has given satisfactory performance in outdoor banners when coupled with 16.5/3 tex (36/6 cc) soft looper thread. If smaller diameter thread is required, 14.5/4 tex (40/4 cc) glacé thread of "Sak" quality should provide satisfactory results.

- Avoid stitches at or near the edge to reduce the chance for edge-tear on banners. Pressure-sensitive adhesive tabs of Spunbonded Olefin or Mylar® polyester film wrapped around a sewn seam at each edge will further reduce the possibility of edge-tear.

FOR TYPES 14 AND 16 SPUNBONDED OLEFIN

- Up to 12 stitches/in. (4.7 stitches/cm) can be used; however, 6 to 8 stitches/in. (2.4 to 3.1 stitches/cm) provide the highest seam strength (greatest resistance to postage stamp tear).

- Use a fine-tooth feed dog—12 to 21 teeth/in. (4.7 to 8.3 teeth/cm).

- Decrease presser-foot tension until the sheet just feeds through the machine without slipping. Approximately 10-lb (4.5-kg) force should be sufficient.

- Decrease bobbin tension until the bobbin just slips down the thread: 3 oz (85 g).

- Wind bobbin with thread tension set so that thread just slips through the disc: 2 oz (57 g).

- After setting bobbin tension, adjust needle tension to produce a balanced stitch.

- Conventional threads of cotton/synthetic or 100% synthetic threads of nylon or polyester can be used.

- Spun-filament polyester is stronger than cotton thread and is preferred for flame-resistant considerations.

Identification of Corona Treatment & Antistatic Treatment

All styles of Spunbonded Olefin with a "D", "R", or "E" suffix and 1079 are corona-treated and anti-stated on both sides (e.g., Styles 1073D and 1443R).

The critical surface tension of Spunbonded Olefin (high density polyethylene) is 30 dynes/cm^2. Corona treatment of Spunbonded Olefin increases the surface tension to 40 to 42 dynes/cm^2. For reference purposes, distilled water is 73 dynes/cm^2.

AVAILABILITY

Tyvek® brand spunbonded olefin is available in roll form in white only. Limited-use garment materials of Spunbonded Olefin are also available with protective coatings.

Availability and Shipping

Spunbonded Olefin is sold worldwide from plants in Richmond, Va., USA; Luxembourg; and Shenzhen, China.

Type 10 is also available from distributors and paper merchants in full rolls, slit rolls or sheets. Lists of firms that sell rolls or sheets of uncoated Spunbonded Olefin, as well as coated, colored or pressure-sensitive coated Spunbonded Olefin, may be obtained by contacting DuPont at 1-800-448-9835.

DuPont ships Spunbonded Olefin protected by stretch-wrap film. Narrow-width rolls are shipped with more than one roll per package. Some rolls may contain splices. Each splice is identified with a flag.

Like paper, Type 10 has different surface characteristics on each side and is wound with the smooth side out. This information is on the package label. Types 14 and 16 are wound with the linen side out.

Type 10 products are available in a variety of widths on nominal 28-in. (0.7-m) or 39-in. (1-m) O.D. rolls with 3-in. (7.6-cm) I.D. cores. Rolls of Types 14 and 16 products are also available on 3-in. (7.6-cm) I.D. cores, with roll diameters of 21.5 in. (0.54 m) to 39 in. (1 m) O.D.
No chuck notches are supplied in the 0.425-in. (1.1-cm) thick heavy paper cores. Not all widths and diameters are available in all styles.

Contents Labels

The package label for Spunbonded Olefin will be found on the outside of each package. A core label will be found on the inside of the core. We suggest that customers record package numbers and retain them throughout processing. Inquiries about specific rolls should always refer to the package number.

STORAGE & HANDLING

Rolls of Spunbonded Olefin should be stored vertically on their ends and in their shipping wrappers. Horizontal storage can cause flat spots that, in turn, can lead to processing difficulties. Rolls should be handled carefully with a dolly, stevedore truck or hand truck. Avoid drops or bumps that could cause deformation. Never move a roll of Spunbonded Olefin by turning or rocking it on its end. Clamp trucks can crush cores and distort Spunbonded Olefin. Clamp pressure should be set to a maximum of 1,800-2,000 psi (12,400-13,800 Pa) gauge. Core plugs should always be in place when handling rolls.

Because of the slippery nature of Spunbonded Olefin, care must be taken when moving loaded fork trucks over bumpy floors; up and down inclines; and around sharp turns. When trucking Spunbonded Olefin over any distance in sheeted form, the use of preformed corner angles, corner edge guides and flat pallet tops is recommended. A light tension on vertical and horizontal strapping can also prevent shifting and edge damage to the sheets.

If rolls or sheets of Spunbonded Olefin are to be stored for several months, they should be wrapped in Spunbonded Olefin or polyethylene film. Unbleached kraft paper should not be used because it may cause a yellowing of the edges and top sheets. Storage in areas where engine or space heater exhaust gases concentrate may also cause yellowing. Short exposure of yellowed Spunbonded Olefin to sunlight will usually cause the color to disappear. If Spunbonded Olefin is stored outdoors, it should be protected from direct exposure to sunlight because prolonged exposure to UV light will cause a deterioration of physical properties.

DuPont Tyvek® is an environmentally responsible material, with 25% of its composition (for envelopes only) coming from recycled milk and water containers.

DuPont manages a national recycling program that collects used Tyvek® Envelopes, which are then recycled into useful materials that provide alternatives to wood.

RESOURCE CONSERVATION

DuPont recognizes the universal concern about resource conservation and is focused on developing meaningful solutions to the issues. DuPont also advocates an integrated conservation and waste management system, including: source reduction/ material minimization, recycling, waste-to-energy incineration and safe landfilling.

SOURCE REDUCTION/MATERIAL MINIMIZATION

Perhaps the most important benefit of Spunbonded Olefin is its strength and durability relative to its light weight. For example, envelopes of Spunbonded Olefin typically weigh half as much as envelopes made of other materials. In addition, the durability of products made of Spunbonded Olefin offers the potential for reuse.

RECYCLING

DuPont strongly supports and practices the principle that the use of recycled products is a critical part of resource conservation. For example, DuPont and its direct customers have recycled pre-consumer scrap Spunbonded Olefin from manufacturing processes for more than 20 years. DuPont is also a customer for post-consumer recycled (PCR) high density polyethylene (HDPE) from such sources as milk or water jugs. Several styles of Spunbonded Olefin are made using 25% PCR material, and they are equal in quality, performance and aesthetics to Spunbonded Olefin products made of "virgin" HDPE.

In addition, Spunbonded Olefin can be recycled at more than 70 facilities in North America that recycle flexible HDPE products with the SPI symbol 2 HDPE. For assistance in locating the one nearest you, contact DuPont at 1-800-448-9835. Recycled Spunbonded Olefin is used for making such products as plastic lumber for decking, lawn furniture, picnic tables and landscape timbers.

DuPont provides support for customers, recyclers and trade associations to facilitate collection and recycling of Spunbonded Olefin products. Spunbonded Olefin is included in the ASTM 5203 standard for HDPE from post-consumer uses. For more information, call the Recycle Hotline at 1-800-448-9835.

WASTE-TO-ENERGY INCINERATION

Although incineration is not practiced as extensively in the United States as it is in Europe or Japan, Spunbonded Olefin can be safely incinerated. Under optimal conditions, it yields water and carbon dioxide, and leaves essentially no residue for disposal. In fact, Spunbonded Olefin is an excellent fuel for generating heat or electricity because it yields two or more times the energy value of coal and is equal to oil in BTU rating. For more information, contact DuPont at 1-800-448-9835.

LANDFILLING

Because Spunbonded Olefin is a high-value recyclable material, DuPont encourages pre- and post-consumer recycling. However, if landfilling is necessary, Spunbonded Olefin can be safely disposed of in a landfill at the end of its useful life. Spunbonded Olefin will not leach into groundwater because it is chemically inert and contains no binders.

CUSTOMER SERVICE

Occasionally, an order of Spunbonded Olefin may be judged unacceptable by the customer. If a customer believes the quality of Spunbonded Olefin is questionable, he should contact his supplier or DuPont Customer Service Representative. Here's a few suggestions to help you:

- If a roll of Spunbonded Olefin is found to contain defects or will not process acceptably, a 10-yd (9-m) full-width sample should be returned to the DuPont Customer Service Representative, along with the package number. Some defects may require that a full roll of material be returned.

- If a roll of Spunbonded Olefin has unacceptable wrinkles or creases that cannot be removed with a bowed roll or spreader bar within the first 500 yd (450 m), it should be rejected and set aside. A return authorization should be requested from the DuPont Customer Service Representative. The package number must be included.

- Before lifting a sheet-fed printing job for print quality, 15 consecutive sheets of offset paper should be printed and held along with the rejected Spunbonded Olefin to help us mutually evaluate the problem. If a complaint is initiated, it is very important that the package numbers be identified.

TABLE I

Resistance of DuPont Tyvek® to Salt Solutions[1]

The breaking strength of Types 10 and 14[2] is unaffected after 1,000 hours exposure at 70˚F (21˚C) to the saturated salt solutions listed below:

Aluminum Chloride	Cobaltous Sulfate	Ferrous Sulfate[3]	Sodium Chloride
Aluminum Sulfate	Copper Chloride	Magnesium Chloride	Sodium Fluoride
Ammonium Chloride	Copper Sulfate	Manganous Chloride	Sodium Nitrate
Ammonium Nitrate	Ferric Ammonium Sulfate[3]	Mercuric Chloride	Sodium Nitrite
Ammonium Sulfate	Ferric Chloride[3]	Nickel Chloride	Sodium Sulfate
Ammonium Thiocyanate	Ferric Citrate[3]	Potassium Chloride	Sodium Thiocyanate
Cadmium Chloride	Ferric Nitrate[3]	Potassium Thiocyanate	Stannic Chloride
Calcium Chloride	Ferric Oxalate[3]	Silver Nitrate	Stannous Bromide
Calcium Thiocyanate	Ferric Sulfate[3]	Sodium Bisulfate	Stannous Chloride
Chromic Sulfate	Ferric Potassium Sulfate[3]	Sodium Bromide	Zinc Chloride

[1] In the case of limited use/disposable protective apparel, the user should visit the website at www.TyvekProtectiveApprl.com or use the TyFax® Data Service at 1-800-55-TYFAX for permeation data.
[2] Tests actually performed on Styles 1073D and 1422A.
[3] Sample yellowed after exposure.

TABLE II

Resistance of DuPont Tyvek® to Oxidizing and Reducing Agents[1]

	Exposure Conditions				Effect on Breaking Strength[6]
Agent	**Concentration, %**	**Temperature, ˚F (˚C)**	**Time, Hr.**	**pH**	**Type 10/Type 14[7]**
Calcium hypochlorite	Sat. Solution	70 (21)	1	11.8	None
Chlorine water	Sat. Solution	70 (21)	10	1.3	Moderate/Slight
Hydrogen peroxide	90	70 (21)	10	—	Not Tested/Slight
Peracetic acid	2.0[2]	210 (99)	10	8.0	Not Tested/Slight
Potassium monopersulfate	1.0[3]	160 (71)	100	10.5	Moderate/Considerable
Sodium chlorite	0.6[4]	210 (99)	10	4.5	None/Slight
Sodium chlorite	0.6[3]	210 (99)	10	10.5	None/Slight
Sodium hypochlorite	0.3[4]	70 (21)	10	4.5	Not Tested/Moderate
Sodium hypochlorite	5.3	70 (21)	1	12.2	None
Sodium perborate	1.0[3]	160 (71)	100	10.5	None
Sodium bisulfite	3.0[4]	210 (99)	10	4.5	None
Sodium bisulfite	3.0[3]	160 (71)	10	9.0	None
Sodium hydrosulfite	3.0[5]	160 (71)	10	13.5	None
Sodium sulfite	3.0	210 (99)	10	10.1	None
Sodium thiosulfate	3.0	210 (99)	10	9.8	None

[1] In the case of limited use/disposable protective apparel, the user should visit the website at www.TyvekProtectiveApprl.com or use the TyFax® Data Service at 1-800-55-TYFAX for permeation data.
[2] Sodium carbonate and 1% "Calgon" as additives.
[3] Sodium carbonate as additive.
[4] Acetic acid as additive.
[5] Sodium hydroxide as additive.
[6] Change in breaking strength caused by exposure:
None = 90 through 100% of original strength retained
Slight = 80 through 89% of original strength retained
Moderate = 60 through 79% of original strength retained
Considerable = 20 through 59% of original strength retained
[7] Tests actually performed on Styles 1073D and 1422A.

TABLE III

Resistance of DuPont Tyvek® to Organic Solvents[2]

Tested at 100% Concentration at 70˚F (21˚C)
for 1,000 Hours, Except Where Noted

Organic Chemical	Effect on Breaking Strength[3]	Organic Chemical	Effect on Breaking Strength[3]
Acetamide[4]	None	Ether	Not Tested/Slight
Acetic acid	None	Ethyl acetate	None
Acetone	None	Ethyl alcohol	None
Acrylonitrile	None/Slight	Ethylene glycol	None
n-Amyl acetate	None	Formaldehyde[7]	None
n-Amyl alcohol	None[5]	Formic acid[8]	Not Tested/Slight
Aniline	None	Gasoline (leaded)	None/Slight
Benzaldehyde	None	Glycerol	None
Benzene	None	Kerosene	None/Slight
Benzyl alcohol	None	Linseed oil	None/Slight
Benzyl chloride	None	Methyl alcohol	Slight/None
n-Butyl alcohol	None	Methylene chloride	Slight/None
Carbon disulfide	None	Methyl ethyl ketone	None
Carbon tetrachloride	None	Mineral oil	None
Chlorobenzene, mono-	None	Nitrobenzene	Slight/None
Chloroform	None	Oleic acid	Slight
Chlorohydrin	None	Perchlorethylene	None
Coal tar	None	Phenol[4]	None
Cottonseed oil	None	Pine oil	None
m-Cresol	None/Slight	Pyridine	None
Cyclohexanone	Slight/None	Tetrachloroethane	None
p-Dichlorobenzene[6]	None	Trichloroethylene	None
Dimethyl acetamide	None	Triethylamine	None
Dimethyl formamide	None	Trifluoroacetic acid	None
Dimethyl sulfoxide	None	Turpentine	None
Dioxane, 1-4	None		

[1] Tests actually performed on Styles 1073D and 1422A.
[2] In the case of limited use/disposable protective apparel, the user should visit the website at www.TyvekProtectiveApprl.com or use the TyFax® Data Service at 1-800-55-TYFAX for permeation data.
[3] Change in breaking strength caused by exposure:
None = 90 through 100% of original strength retained
Slight = 80 through 89% of original strength retained
[4] Test performed at 200˚F (93˚C).
[5] Sample yellowed after exposure.
[6] Test performed with 100% concentration of powder.
[7] Test performed with 10% concentration in H_2O.
[8] Test performed with 91% concentration in H_2O.

TABLE IV

Resistance of DuPont Tyvek® to Inorganic Chemicals at 70˚F (21˚C)[1]

Agent	Concentration, %	Time, Hr.	Effect on Breaking Strength Type 10/Type 14[2]
Sulfuric acid	10	1,000	None
Sulfuric acid	96	1,000	None
Hydrochloric acid	37	1,000	None
Nitric acid	10	1,000	None
Nitric acid	70	10	None[3]
Phosphoric acid	10	10	None
Hydrofluoric acid	10	10	None
Ammonium hydroxide	28	1,000	None/Slight
Sodium hydroxide	40	1,000	None
Chlorine water	Sat. Solution	10	Moderate
Hydrogen peroxide	90	10	Slight
Sodium hypochloride	5.3	1	None
Aluminum chloride	Saturated	1,000	None
Ammonium nitrate	Saturated	1,000	None
Ammonium sulfate	Saturated	1,000	None
Calcium chloride	Saturated	1,000	None
Copper sulfate	Saturated	1,000	None
Ferric sulfate	Saturated	1,000	None
Silver nitrate	Saturated	1,000	None
Sodium bromide	Saturated	1,000	None
Sodium chloride	Saturated	1,000	None
Zinc chloride	Saturated	1,000	None

[1] In the case of limited use/disposable protective apparel, the user should visit the website at www.TyvekProtectiveApprl.com or use the TyFax® Data Service at 1-800-55-TYFAX for permeation data.
[2] Tests actually performed on Styles 1073D and 1422A.
[3] Slight discoloration.

TABLE V Order of Increasing Swelling Effect of Solvents on DuPont Tyvek®[1]

Preferred Solvents	Use Sparingly	Avoid If Possible
Glycerol	Dibutyl Phthalate	n-Butyl Acetate
Diethylene Glycol	iso-Butyl Alcohol	Sun Spirits
Propylene Glycol	Methyl Cellosolve® Acetate	Pine Oil
Triethylene Glycol	Propylene Glycol Methylether	"Lactol"[3] Spirits
Ethylene Glycol	Acetone	SDW Turpentine
Methyl Alcohol	Butyl Cellosolve®	Dichloromethane
Raw Linseed Oil	Cellosolve® Acetate	Tetrahydrofuran
Ethyl Alcohol	n-Butyl Alcohol	Mineral Spirits T
Diacetone Alcohol	n-Propyl Alcohol	Pentane
"Carbitol" [2]	n-Hexyl Alcohol	Petroleum Ether
"Carbitol" Acetate	n-Pentyl Alcohol	Pinene
Dipropylene Glycol	iso-Propyl Acetate	Rubber Solvent
Methyl Cellosolve®[2]	Butyl Cellosolve® Acetate	VM + P Naphtha
Dipropylene Glycol Methylether	2-Octyl Alcohol	Toluene
Methyl iso-Butyl Carbinol	Butyl "Carbitol" Acetate	Naphthol Spirits
Cellosolve®[2]	N-Decyl Alcohol	Xylene
iso-Propyl Alcohol	Ethyl Acetate	Kerosene
	iso-Butyl Acetate	Magie® Oil [4]
	Methyl Ethyl Ketone	
	n-Propyl Acetate	
	Methyl Isobutyl Ketone	
	Cyclohexanone	
	Diethyl Ketone	

[1] This information is provided as a guide for selecting solvents for inks and coatings. It bears no relationship to solvent permeation of garments of Spunbonded Olefin. For information on solvent permeation, the user should visit the website at www.TyvekProtectiveApprl.com or use the TyFax® Data Service at 1-800-55-TYFAX for permeation data.
[2] Union Carbide Chemicals & Plastics, New York, NY.
[3] Union Oil Co. of California, Amsco Div., Palatine, IL.
[4] Magie Bros. Oil Co., Franklin Park, IL.

For any questions about the ordering, shipping, storage, handling or disposal of Tyvek® brand protective material, please write or call a DuPont representative:

DuPont
P.O. Box 80728
Wilmington, DE 19880-0728
(800) 448-9835

DuPont Canada, Inc.
Box 2200 Streetsville
Mississauga, Ontario
Canada L5M 2H3
(416) 821-3300

For more information about Tyvek® brand protective material, please visit:

www.Tyvek.com

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Rapidly advancing knowledge of new, long-term toxic effects of many chemicals has emphasized the need to reduce human exposure to many chemicals to the lowest practicable limits. We strongly recommend that processors seek and adhere to manufacturer's or supplier's current instructions for handling each chemical they use.

The cover of this handbook is printed on Style 1085D Tyvek® brand protective material.

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2 HDPE
Spunbonded Olefin is recyclable

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WHAT DO YOU NEED TO PROTECT?™

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