

DuPont™ Tyvek® Users Manual



**Legendary Strength + Distinctive Appearance
= Outstanding Results.**



This handbook shows you how.



The miracles of science™

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DuPont™ Tyvek® A Graphic Improvement.

Do more. Do it better. Do it for less.

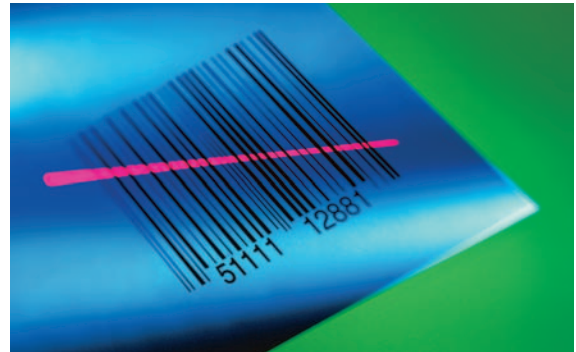
That's what happens when you make DuPont™ Tyvek® the substrate of choice for all your printing that calls for memorable graphics, unique strength, a distinctive texture—and an affordable way to achieve them.

DuPont™ Tyvek® is a spunbonded olefin family of tough, durable products that are stronger than paper and more cost-effective and versatile than fabrics. Made from high-density polyethylene fibers, it 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 creating very fine 0.5-10 micron fibers. (For comparison, a human hair is about 75 microns in cross section.) These non-directional fibers are first spun and then bonded together by heat and pressure, without binders.

Both Tyvek® and Tyvek® Brillion® are strong, lightweight, flexible, smooth, low-linting, opaque and resistant to water, chemicals, abrasion and aging. Their unique combination of properties makes the Tyvek® brands of protective materials ideal for a broad range of applications.

DuPont™ Tyvek® Brillion® is also a spunbonded olefin, in this case flash spun from high-density polyethylene. That creates small-diameter fibers which are then thermally calendered by heat and pressure for a tough, durable sheet structure with excellent tensile and tear strength. This unique manufacturing process results in a substrate with a high degree of whiteness, superior smoothness, and excellent bar code readability.



Known for its high degree of whiteness and ultra-smooth surface, Tyvek® Brillion® affords excellent bar code readability.

You name it, there's a DuPont™ Tyvek® designed to do it.

DuPont™ Tyvek® is very fine polyethylene fibers (seven times finer, in fact, than human hair) bonded by heat and pressure to create a printing substrate that isn't paper, fabric, or film, but combines the best properties of all three.

It is produced in "hard" and "soft" structure types. Products beginning with a 10 are "hard" structure products. For instance, Tyvek® 1056D is a hard structure. These products are considered "hard," as they are smooth, stiff, non-directional paper-like substrates with good printability. These products are available in various basis weights or calibers.

Type 10 Paper-like Hard Structure Smooth Pattern Stiff	Type 14 Fabric-like Soft Structure Embossed Pattern Flexible
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Tyvek® styles beginning with a 14 are "soft" structures. An example of a soft structure product is Tyvek® 1443R. These are lightly bonded products with an embossed pattern, providing a softer fabric-like flexible substrate with 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 materials using these styles. These styles can be printed, but are more demanding than hard structures.

Soft structure styles beginning with a 14, or Type 14, 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.

CORONA AND ANTISTATIC TREATMENTS IMPROVE ADHESION, PRINTABILITY AND HANDLING

Tyvek® products used in printing are corona treated to improve ink and coating adhesion. This electronic charging of the sheet oxidizes the surface and increases the wettability to inks, coatings and adhesives. Unlike other products, which require additional corona treatments, our treatment lasts more than 20 years.

To reduce the buildup of static electricity during sheet and roll handling operations, some styles are coated with a proprietary antistatic agent. Tyvek® used in sterile medical device packaging and in direct food contact applications are neither corona nor antistatic treated. These products end in the letter B, such as Tyvek® 1059B.



DuPont™ Tyvek® is extremely popular for tags and labels. It makes them stronger so they last longer, easier to see, more comfortable to wear and better able to stand up to the elements.

What's so special about DuPont™ Tyvek®?

DuPont™ Tyvek® gives a more distinctive look to anything you print than common paper ever could. It feels more natural and has far better flat, precision folding qualities than synthetic films. And although it isn't a fabric, it can easily function as one.

In fact, the physical properties common to both types of DuPont™ Tyvek® make them ideal substrates for most of your printing and converting applications.

OUTSTANDING CHEMICAL RESISTANCE

Tyvek® products are inert to most acids, bases and salts. Prolonged exposure to oxidizing substances, such as concentrated nitric acid or sodium per sulfate, will cause some loss of strength. Resistance to various compounds are summarized in the tables on pages 30-34.

GOOD DIMENSIONAL STABILITY

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

MEETS FDA REQUIREMENTS

Tyvek® 1059B meets 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).

UNIQUE FLAMMABILITY

The flammability characteristics of Tyvek® are similar to those of most synthetic fibers. When exposed to a flame, Tyvek® shrinks away rapidly. It will melt at 275°F (135°C), and its auto-ignition temperature is 750°F (400°C). Please refer to the MSDS (Material Safety Data Sheet) for additional information on the characteristics of Tyvek® brand of protective materials.

Hard structure products are rated class "A" when tested in accordance with ASTM E-84-89a, a test for flame and smoke development.

Soft structure products are rated "Class 1—Normal Flammability" by the Federal Flammable Fabrics Act for Clothing Textiles (16 CFR-1610).

Tyvek® with flame-retardant coatings are available through distributors.

REMARKABLE FLEXIBILITY

Tyvek® brand of protective materials has outstanding flexibility and does exceed 20,000 folding cycles when tested on an MIT flex tester (TAPPI method T-423) without pre-scoring.

LOW-LINTING

Tyvek® is composed of continuous fibers, hence it does not generate a significant amount of lint particles. This makes Tyvek® an excellent choice for cleanroom applications.

LIGHTWEIGHT AND STRONG

Tyvek® hard structure products are strong and tear resistant yet weigh only half as much as paper. For this reason, they are very popular in packaging and mail applications.

SUPERIOR MOISTURE RESISTANCE

The physical properties of Tyvek® withstand the effects of water. It is equally strong wet or dry.

Tyvek® meets the saltwater immersion test for British Standard 5609.

WITHSTANDS DEFORMATION

Under normal conditions, Tyvek® remains neutral. Elevated temperatures in excess of 220°F (104 C) will cause width loss and deformation.

HIGH OPACITY

Tyvek® has one of the highest opacity ratings in the printing industry.

WHITENESS

Tyvek® and Tyvek® Brillion® are among the whitest materials available for printing with a TAPPI Standard Test Method rating of 94.1. The Hunterlab Model D-25 color difference meter measures brightness, color components and whiteness. The following values are typical for hard structure:

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.

ROT AND MILDEW RESISTANCE

Tyvek® is mold and mildew resistant. It shows no degradation after being buried in soil for an extended period like paper products or coated synthetics.

SOILING RESISTANCE

Tyvek® resists soiling and absorption of oils and greases. Tyvek® can be washed with a mild detergent. Heated drying is not recommended.

NEUTRAL PH

Tyvek® "B" grade has a neutral pH of 7 which makes it excellent for archival quality because it does not have antistat or corona treatments. Tyvek® is also lignin free.

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



STATIC CONSIDERATIONS

In some processing steps, Tyvek® may generate static electricity unless treated with antistatic agents, referred to as antistat. These agents, while suppressing static generation and increasing wet ability, have no effect on sheet strength. Most types and styles of Tyvek®, supplied by DuPont are treated with antistatic agents. All treated styles of Type 14 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).

Antistat is water soluble and not intended as a “safety” feature. For this reason, it’s recommended that garments made of Tyvek® not be used in flammable or explosive environments.

Tyvek® styles that are antistat coated are excellent for both RFID and Smart Tag applications.

Tyvek® styles with a “B” suffix (1059B) do not contain an antistatic agent. These styles can build a static charge and should not be handled in areas where the potential for explosive vapor/air mixtures exists.

TEMPERATURE IMPACT

Toughness and flexibility are retained down to -100°F (-73°C). When exposed to heat, Tyvek® begins to shrink at approximately 220°F (104°C) and melts at 275°F (135°C). Under web offset processing conditions the web temperature should not exceed 175°F (79°C).



Few substrates stand up to outdoor exposure like Tyvek®. It isn't just rip-, tear-, puncture- and water-resistant, it's virtually impervious to extreme cold and heat—even UV.

UV RESISTANCE

Tyvek® is UV resistant, depending on style, from six months to over one year. Some physical properties will be reduced if exposed to UV for over one year. UV resistance can be improved with opaque coatings or with UV inhibitors. Styles of Tyvek® containing UV inhibitors are available for applications requiring higher UV resistance.

SOLVENT RESISTANCE

Tyvek® is highly resistant to most solvents. 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 32. The swelling effect of a solvent is usually reversible after evaporation. 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 over 5% volatile solvent will cause severe distortion of spunbonded Tyvek® for up to 20 minutes after printing.

Although rare, swelling can be caused by some plasticizers, aliphatic hydrocarbon resins used in inks, tackifiers and low-molecular weight adhesives sometimes seen in offset printing. The swelling caused by these materials is always permanent and, in some cases, is not apparent until several days or weeks after application.

SOLVENT AND ADHESIVE 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 Tyvek® after weeks or even months of storage. This is particularly true of some solvent-based, pressure-sensitive adhesives that are transfer-coated from a silicone-coated release sheet.

To determine whether an adhesive is compatible with Tyvek®, 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 Tyvek® 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 Tyvek® 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 up to 150°F (65°C), the pressure-sensitive adhesive is judged to be compatible. If, however, swelling or wrinkling occurs, it indicates the presence of low-molecular weight materials that function as swelling agents.

As an example, low-molecular-weight polybutylacrylate used in some pressure-sensitive adhesives will cause wrinkling and distortion 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 Tyvek® 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.

TOXICITY

Unaltered Tyvek® has been tested for toxicity for skin contact. No reports of toxic reactions have been received. Please refer to Material Safety Data Sheet (MSDS) information.

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 1-800-558-9329 and ask for document number 611 or click on the following:

<http://www.tyvek.com/na/industrialpack/english/4products/msds.pdf>

Your printing has never looked so good.

You want what you print to stand out. Memorable color quality and a distinctive texture—they're part of what turns an ordinary print job into something special.

The lightweight, smooth surface, high dimensional stability and opacity, together with the toughness and durability of Tyvek®, make it a popular printing substrate. It can be printed using most commercial printing processes. Some digital press applications and most ink-jet printers require a special coating. Tyvek® Brillion® is recommended for bar code thermal transfer printing. It can be printed either sheet or web-fed. Tyvek® has a rough and a smooth side. Always print on the smooth side first.

DESIGN/PREPRESS TIPS

Designer and printer must understand the unique properties and characteristics of printing on Tyvek®.

Higher basis weight styles are recommended for two-sided printing. Two days should be allowed for two-sided printing due to the need for a 48-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 Tyvek®.

Pantone® Matching System (PMS) colors can be specified, but the ink must be matched on Tyvek®. 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 is highly recommended 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.



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

Gold and silver metallic inks can be printed on Tyvek®; 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 shadow line 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).

Tyvek® 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 Tyvek® and are not recommended. UV cured inks generally appear brighter and more glossy and are recommended. Film laminations on Tyvek® will provide a very glossy, abrasion-resistant surface.

If color is critical, a press proof using Tyvek® is the only sure way to check color. When doing four-color process printing, avoid using fine reverse lines, borders and type of less than 6-point. A two to three dot overlap trap is required.

Whenever very tight register is required 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.

Guidelines for Printing

Tyvek® is printed in much the same way as other synthetic papers. Before production you should conduct ink, material and printing evaluations.

CHARACTERISTICS OF TYVEK® THAT AFFECT PRINTABILITY

- Properties of Tyvek® are unaffected by water; however, solvents with high VOC's used in some commercial inks can cause swelling—either immediately or after sheets have been printed. Solvent distortion will cause misregistration and sheet swelling. For this reason, sheet-fed offset lithographic and letterpress inks must be formulated with less than 3% volatile solvents. See pages 32-34 for solvents that are recommended.
- Because Tyvek® is not as absorbent as paper, lithographic/letterpress inks take longer to dry. As with all synthetic papers, you must use inks that dry through oxidation, not absorption.
- 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 whenever 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 Tyvek® 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).
- Heat transfer and dye sublimation printing is not recommended because the temperatures used to transfer the dyes exceed the melting point.
- Tyvek® styles with a “D” suffix (e.g., 1073D) and Tyvek® 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.
- Tyvek® styles with a “B” suffix (e.g., 1059B) are untreated and are used primarily for medical applications where optimum barrier properties are required. If a printer is uncertain whether

Tyvek® 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 Tyvek® 1059B 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 of 1059B without leaving a wet “track.”

- Unlike polyethylene film and other synthetics, spunbonded olefin does not lose the effectiveness of corona treatment with time. Samples of corona-treated Tyvek® stored for 20 years were found to have the same level of ink adhesion as a newly treated sample.
- Tyvek® is two-sided. The hard structure 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. Tyvek® 1079 is embossed with a fine cambric pattern. As with the other hard structure styles, the smooth side is preferred for printing and coating. The soft structure 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.
- To reduce curl or improve the lay-flat after printing, observe the following for Tyvek® hard structure 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 print coverage on the smooth side, followed by die-cutting into small blanks (for example, in envelopes) can result in curling, therefore, follow the recommendations above.

- Tyvek® is nearly isotropic. Its physical properties are approximately equal in the machine and cross-machine direction. This attribute is unique to Tyvek®.

Tyvek® Can Be Printed by Various Processes

Tyvek® brings greater flexibility to what you print and to the methods you can choose to print them. You can successfully use Tyvek® with practically all of the most commonly employed printing processes.

OFFSET LITHOGRAPHY

Items requiring good quality color and appearance can be printed on Tyvek® spunbonded olefin by the offset lithographic process.

Tyvek® 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 using a four-color press. Four-color process printing on a single-color press is not recommended because misregistration can occur due to sheet swelling between colors. Special low-solvent-content inks are required for offset lithographic printing of Tyvek®. These are described in detail on page 15 under “Printing Inks for Tyvek® 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 the product. 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 Tyvek® 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.

If printing black colors, sometimes after printing 25 to 50 sheets, the printed image will appear dull or gray. This is due to a build up of dampening solution. Because Tyvek® does not absorb water as readily as paper, the amount of dampening solution must be reduced. It may be necessary to reduce the level several times. This will also prevent ink emulsification and shorten the ink's drying time.

Because of its extremely high surface area Tyvek® will require approximately 15% more ink to achieve the same color density as uncoated paper. Tyvek® will not take on the gloss of coated paper.

Tyvek® 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 versus paper of equivalent thickness to compensate. Excessive pressure will cause dot gain and result in misregistration. Printing on Tyvek® that has been deeply and sharply embossed should be avoided as 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 Tyvek® because they afford the best results with large, solid print areas and halftones. Compressible blankets are preferred for printing coated Tyvek® 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

Tyvek® 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 Tyvek® 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 Tyvek® 1443R 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 lightweight characteristics, 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 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 Tyvek® 1443R is not recommended.

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

Due to the lack of stiffness in Tyvek® 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 TYVEK®

Most Tyvek® 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, Tyvek® 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 the substrate 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. Dry-offset, letterpress or flexography processes can print Tyvek, with excessive wetting agents in the coating acceptably. 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." In this test, an intense violet color is indicative of wetting agent on the surface. An uncoated sheet of Tyvek® 1073D should be tested at the same time as a control.

ENVELOPE IMPRINTING

Tyvek® Envelopes can be imprinted using standard envelope printing equipment. 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 Tyvek® are recommended.

Because Tyvek® Envelopes 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 on Tyvek® 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

Tyvek® prints nicely using the heat-set web offset lithographic process. Since it is composed of continuous fiber, it is nearly lint-free and reduces the downtime required for blanket/plate wash-up. In addition, the high tear strength virtually eliminates web breaks.

Because of the heat and solvent sensitivity of Tyvek®, low-energy heat-set inks are required to print 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 Tyvek® 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 it from melting in the dryer.

Tyvek® 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 $\pm 1/32$ in. (± 0.8 mm) on a 239/16 in. (0.6 mm) sheet throughout production runs.

Both UV and electron beam ink-curing systems have been used successfully with Tyvek® 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 Tyvek®. Infrared drying is not recommended because of the heat generated.

FLEXOGRAPHY

Tyvek® is often printed using the flexographic process for a wide variety of applications, ranging from envelopes, tags and labels for commercial and industrial applications, and wristbands. 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 misregister 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 soft structure.

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 flexo printing on Tyvek® 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 (such as DuPont™ Cyrel®) with a 50 Durometer hardness (Shore A) mounted with closed-cell foam sticky back will produce the best overall print uniformity.

Flexo printing on Tyvek® is one of the most popular ways to produce everything from envelopes to tags and labels to wristbands.



GRAVURE

Tyvek® 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 Tyvek®.

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 misregistration.

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

INK-JET PRINTING

Tyvek® can be ink-jet 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 special settings.

When doing high-quality graphics, an ink-jet coated Tyvek® must be used.

SCREEN PROCESS

Tyvek® 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 shrinking and misregistration 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. Screen process inks for Tyvek® are discussed on page 17.

LASER PRINTING (NON-IMPACT)

Conventional laser printing is not recommended on Tyvek® because of the temperatures involved in the printing units. For the same reason, Tyvek® should not be used in electrostatic copiers. However, Tyvek® can be used with the newer cold lasers (which generally have a fusing temperature below 200°F [93°C]).

THERMAL TRANSFER

All hard structure styles of Tyvek® are compatible with thermal transfer printing. Tyvek® Brillion® is recommended for bar code printing. All three types of ribbons can be used; however, under harsh conditions or in outdoor applications a wax/resin ribbon is recommended.

DIRECT THERMAL PRINTING

Currently, we do not have a product that will work with a direct thermal printer. A product for this application is under development.

DOT MATRIX PRINTING

A fade-resistant-non-bleeding ribbon is required for printing. This will allow the image to withstand a harsh environment. This is recommended as 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.

DIGITAL (ON-DEMAND) PRINTING

The Printing Applications Laboratory at the Rochester Institute of Technology (RIT) has certified DuPont™ Tyvek® Graphics styles for use with the Indigo Omnium® WebStream™, a web-fed digital color press.

Indigo presses represent a fast and cost-effective way to produce short-run work and incorporate variable information. As on-demand printing grows and printers continue to incorporate new digital technologies into their operations, DuPont™ Tyvek® provides the Indigo printer with a solution to a wide range of strength and durability issues.

This certification applies to the following Tyvek® styles: 1056D, 8740D, 1073D, 1079, 1085D and 4173D. Other “D” styles of Tyvek® within the thickness range of 6 to 10 mils also are compatible with the Omnium® WebStream™. In addition, these styles are corona and antistat treated, therefore no coating is required.

Tyvek® meets the following application requirements:

- Superior strength-to-weight ratio and soft hand (race numbers, wrist tickets)
- Exposure to frequent liquid or chemical spills (drum labels, licenses)
- Protection of critical information for instruction sheets and directions (poison charts, safety guidelines, trail guides, manuals)
- Excessive handling or folding (menus, brochures, maps)
- Outdoor exposure to extreme temperatures, inclement weather, heavy wind (signage, tags)
- A unique design element or texture (invitations, announcements)

Printing Inks for Tyvek® Spunbonded Olefin

There are many inks that are compatible for use with Tyvek®.

OFFSET LITHOGRAPHIC INKS

Tyvek® 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 Tyvek® swells, buckles or puckers within 20 minutes after printing, the ink probably contains a residual solvent that is incompatible with it.

The typical offset lithographic ink for use with Tyvek® 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 also compatible. High-boiling, “quick-dry” petroleum solvents should not be used in sheet-fed offset-litho ink formulations. 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. Opaque ink will also reduce the appearance of the fiber-swirl pattern.

Offset/letterpress inks dry more slowly than conventional paper inks. To minimize offsetting, pile height should not exceed 20 in. (0.5 meter). Winding is recommended after 6, 12 and 18 hours for sheets with heavy ink coverage. To shorten the drying time of inks, contact the ink supplier for the amount of ink drier that can be added. Excessive ink drier can hinder drying and may cause distortion. Offset powders are seldom needed. When excessive ink drying time is required, it is usually caused by too much ink and excessive dampening solution, resulting in ink emulsification. Fountain stimulators used to increase the rate of drying are only marginally beneficial, but can be used if desired.

Most commercial dampening systems work well with Tyvek[®], but only enough dampening solution should be used to prevent dry-up in non-image areas. Because Tyvek[®] 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.

Litho inks with more than 3% volatile solvent can cause swelling, puckering, curling and misregistration. 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 should 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 use with Tyvek[®].

METALLIC LITHOGRAPHIC INKS

It is difficult to print metallic inks on Tyvek[®] because they tend to pile on the plate and/or blanket (as with paper). Aluminum (silver) looks best because the fiber swirl enhances the metallic look.

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 Tyvek[®]. In some cases, aluminum overprinted with yellow will produce an attractive "gold" color. Wet trapping of metallic inks should be avoided when possible. An alternative would be either dry trap or reverse out the metallic color.

If Tyvek[®] 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.

UV-CURE INKS

UV-cure inks work well with Tyvek[®] and can be used for offset, flexo, ink-jet, and screenprinting. These inks are 100% solid systems that are instantly cured, eliminating 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 Tyvek®, a cooling system to reduce heat buildup is recommended because of its thermoplastic nature. It is difficult to achieve a high level of ink gloss and a reduction in fiber swirl on uncoated Tyvek® without first putting down a heavy base coating. However, a reasonably high level of gloss has been achieved on uncoated Tyvek® 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 Tyvek®. 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 Tyvek® 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 dryer can cause it to shrink.



For colors that stand up to the elements as well as the Tyvek® banners and signs they're printed on, use screen inks with fade-resistant pigments.

SCREEN PROCESS INKS

A variety of screen process inks are available for printing Tyvek®. 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 Tyvek® because they minimize sheet distortion, even with heavy ink-film thicknesses. If Tyvek® 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 Tyvek® 1443R for apparel requires an ink with optimum adhesion, flexibility and wet rub resistance. 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 34 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.

FLEXOGRAPHIC INKS

For flexographic printing, volatile solvent inks and aqueous inks are available for use with Tyvek®. Polyamide/alcohol inks are preferred 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.

Microcrystalline wax is usually added to inks for medical packaging applications to reduce offsetting. Because Tyvek® 1059B is not corona-treated, ink adhesion will not be as good and precautions must be taken to avoid offsetting and blocking. When used on medical packaging styles, inks must have adequate thermal resistance so they do not block when heat-sealed.

GRAVURE INKS

Flexographic inks are very similar to gravure inks. Type C nitrocellulose gravure inks are the most widely used for printing Tyvek® and they are often modified by the addition of an alkyd resin to improve ink hardness and adhesion.

GLOSS AND COLOR MATCHING

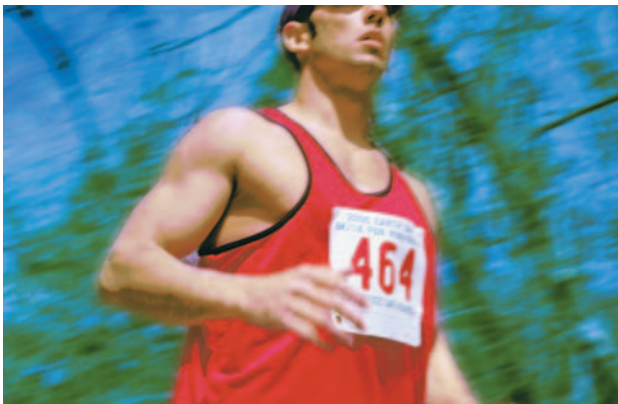
Ink gloss and color are important factors in the final appearance of printed Tyvek®. High gloss and darker colors accentuate the unique swirl pattern of uncoated Tyvek®. Conversely, the lower the gloss and the lighter the ink color, the less noticeable the swirl pattern. Ink gloss on uncoated Tyvek® is difficult to achieve. UV-cure inks and electron-beam cure inks and coatings improve ink gloss. Top coating and film lamination can be used to achieve a high gloss effect.

In-line aqueous coating, performed on the last unit of an offset litho press, does not add gloss to the image. This is due to the light scattering caused by the high surface area of Tyvek®.

Inks should be formulated using a target color swatch. Colors specified by Pantone® Matching System (PMS) colors should be formulated and matched on the specific Tyvek® style to be used. Inks made with the strongest color pigments will minimize ink film thickness and provide the best color results.

When color matching, the printer should specify which side of Tyvek® is being printed. If more than one side is printed, each color should be matched on the correct surface. Wet-ink densitometry measurements are needed to get the closest color match when both sides must be matched.

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



Printing on Tyvek® has a character and a look all its own—rich, soft, highly distinctive. And because it's Tyvek®, it wears like nothing else.

COLOR STABILITY

Tyvek® should not affect the stability of printing ink pigments. However, certain pigments in offset lithographic inks can shift in color or “burn out” after printing. These pigments include Rubine Red #52, Red Lake 2C and Alkali Blue. These pigments are not recommended for use on Tyvek® without preliminary testing, particularly when these pigments are used to make tints. The “burnout” phenomenon occurs very infrequently and is not predictable. High humidity and heat can add to this effect. A test for these 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 then 48 hours.
- If no color shift is observed, the ink/pigment compatibility should be acceptable.

LITHO INK TEST

To determine whether a sheet-fed offset lithographic ink is acceptable for use with Tyvek®, 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 solvents should give acceptable performance. Many quick-drying offset lithographic inks contain as much as 27% volatile solvents. These inks can cause gross misregistration 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, please visit our website. Undoubtedly, there are other suppliers capable of producing satisfactory inks for use with Tyvek®. The list we provide is intended only as a guide and is not a recommendation of any specific company

Your applications have never been in better shape.

DuPont™ Tyvek® can easily be used in place of other materials for converting. Whether you produce tags and labels, or maps and banners, or documents and envelopes, Tyvek® adds strength, durability and long life to virtually every application.

And while Tyvek® 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 worked with Tyvek® conduct a pilot run to fully test each conversion operation before beginning full-scale production. Here are a few tips to keep in mind:

Whether you're hiking, biking or RVing miles from civilization, or evading capture in hostile territory—like USAF Capt. Scott O'Grady in Bosnia—a durable map of DuPont™ Tyvek® can be a lifesaver.



- Tyvek® cannot be crush-cut as easily as paper. Its filaments are very strong and each must be completely severed; “hangers” will not break off.
- Tyvek® 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.
- Tyvek® is a thermoplastic material and it melts sharply at 275°F (135°C).
- When coating or laminating Tyvek®, the web temperature in the oven should not exceed 175°F (79°C).
- Because of its inherent “memory,” Tyvek® may occasionally curl when sheeted. Conventional decurler (breaker bar) equipment can be used at minimum tension.
- Before binding Tyvek® with printed paper, check compatibility because it may buckle or distort. Many publications contain residual solvents that can also cause distortion. When bound along the spine, paper will respond to changes in humidity. Tyvek® won't. This usually produces a buckled appearance along the spine of the publication.
- Type 10 styles with a “D” suffix (e.g., 1073D) and Tyvek® 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) are treated in a like manner. Tyvek® styles with a “B” suffix (1059B) do not contain an antistatic agent. These styles can build a static charge and should not be handled in areas where the potential for explosive vapor/air mixtures exists.
- Die-cutting lubricants should be avoided because some contain low molecular weight hydrocarbons that can cause swelling and distortion.

SLITTING, SHEETING AND CUTTING

Tyvek® hard structure (Type 10) styles can be slit and cut into sheets on most commercial equipment using conventional paper-cutting techniques. However, the inherent strength of the material 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 and is preferred for the lightweight styles (less than 2.2 oz/yd² [76.3 g/m²]).

In sheeting operations, best results are obtained by using styles with a "D" suffix. These are treated with an antistatic agent to reduce static during sheeting. When it is necessary to sheet non-antistatic styles, the use of conductive "tinsel" or ionized air produced by an electrostatic generator or a radiation bar, will usually reduce the build up of static. Antistatic agents or aerosol sprays should not be used on Tyvek® 1059B that will then be used for packaging sterile medical products and direct food label applications.

Type 14 soft structure styles can be cut much like fabric with conventional straight-knife machines. However, if the knife blade gets 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.



The microfiber technology of DuPont™ Tyvek® used for graphics applications offers high-strength, durability and opacity resulting in the best characteristics of paper, film and fabric in one substrate. (Shown 200 times.)

DIE-CUTTING

Sheets of Tyvek® can be die-cut using either steel rule (sharp edge) or male/female dies. Because of the inherent toughness of the material, male/female dies should be manufactured to close tolerances; steel rule dies are preferred. Tyvek® fibers must be completely cut which requires dies to 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 Tyvek® might require the 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.

When die-cutting Tyvek® materials, keep the lift heights below 3 in. (7.6 cm). This avoids oversizing the top blanks resulting from edge compression as the die is lowered. Use of a center-die pressure cylinder can help de-aerate and compact the lift, as well as minimize slippage.

CONVERTING TYVEK® FOR CONTINUOUS APPLICATIONS

Tyvek® is often used in continuous printing when the application requires strength and durability. But, because of its toughness, Tyvek® is more difficult to perforate and punch than paper. It can be successfully punched on tag, letterpress and rotary line-hole equipment. The higher tensile strength styles (i.e., 1085D, 1073D and 1079) are recommended for tags and labels.

Tyvek® 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 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 should be done with male/female dies made from hardened tool steel or tungsten carbide. Because of the close tolerances required to punch Tyvek®, soft steel dies dull quickly and increase downtime. Most manufacturers can provide the correct rotary dies for use with Tyvek®.

PUNCHING

Tyvek® 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 misregistration in web operations. If drilling, avoid excessive clamp pressure that can leave an impression on the sheet.



Punched and spiral bound, the pages of this fishing guide are water-, tear-, puncture- and rip-resistant because they're Tyvek®.

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. To ensure tear initiation, position a cut at the edge of the sheet.

LAMINATING/COATING

Tyvek® can be extrusion-, adhesive-, flame-, ultrasonic- and thermal-laminated. Laminates are used for protective covers, automotive parts protection, medical packaging and worker protection garments. Tyvek® 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 and/or to eliminate the appearance of fiber swirl, the best approach is to apply a coating. Tyvek® is routinely 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. 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®. For this reason, Type 14 soft structure styles are usually printed using the flexographic or gravure process combined with either solvent or water-based inks. Dye sublimation printing is not recommended because of the high temperatures used.

HEAT-SEALING / DIELECTRIC SEALING /ULTRASONIC SEALING

Although it is possible to fuse Tyvek® to itself using only heat, it is difficult to obtain strong seals. Melting the material destroys its fiber structure, thus reducing both flexibility and tear strength in the seal area. If, however, it is required, non-corona-treated and non-antistat styles are preferred for heat-sealing Tyvek® to itself.

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

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

Ultrasonic sealing can be used to create fiber tearing seals with most styles without the puckering that is often associated with heat seals. This process also forms strong seals to a variety of plastic films and nonwovens.

GLUING

A number of adhesives can be used to glue Tyvek®, either to itself or to other substrates. In general, water-based adhesives that provide quick tack and fast drying are preferred. The first step in choosing an adhesive is to determine how it will react with Tyvek®. Laboratory testing is the best way to make this determination. Table V on page 34 contains a list of solvents that are preferred in adhesives.

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 Tyvek® to paperboard.

Water-based synthetic adhesives bond Tyvek® to itself and to a variety of substrates. Ethylene/vinyl acetate adhesives and the acrylic pressure-sensitive adhesives work well with Tyvek®. The

synthetic adhesives that contain low-molecular weight materials 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 Tyvek® to itself and to a variety of substrates.

Hot-melt adhesive technology has been demonstrated in a number of applications using Tyvek®, including the construction of envelopes, tags and medical packaging. Care must be exercised in adhesive selection and consultation with the adhesive manufacturer is recommended.

EMBOSSING AND FOIL STAMPING

Tyvek® can be embossed with either high-or low-pressure equipment. Done properly, cold embossing does not significantly reduce the strength; however, it does reduce opacity in the embossed area. Embossing cylinders used with Tyvek® 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. Material 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 of Tyvek® is recommended when it is used with type or small designs, such as corporate logos. Solid areas greater than 2 sq. in. 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 temperatures 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 Tyvek® when exposed to heat and tension, super calendering is not recommended.

Foil stamping is easily accomplished on Tyvek® due to its thermoplastic nature. A variety of foils are available from suppliers for label and book cover applications. A foil should be chosen that transfers cleanly and adheres with a temperature/dwell time that is compatible with the melting point of 275°F (135°C).

SEWING

Uncoated or non-laminated Tyvek® 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 Tyvek®, use 5 or less 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.

SEWING HARD STRUCTURE

Tyvek® Soft Structure doesn't just feel like fabric, it can be printed on then sewn into many items typically made from fabric. Plus it has the durability and resistance to liquids that fabrics typically don't.

STYLES, TYPE 10

- 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.
- When sewing banners, avoid stitches at or near the edge to reduce the chance for edge-tear. Pressure-sensitive adhesive tabs of Tyvek® or Mylar® polyester film wrapped around a sewn seam at each edge will further reduce the possibility of edge tear.

SEWING SOFT STRUCTURE STYLES, TYPE 14

- Use up to 12 stitches/in (4.7 stitches/cm); however, 6 to 8 stitches/in (2.4 to 3.1 stitches/cm) provides 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 (57g).
- 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 AND ANTISTATIC TREATMENT

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

The critical surface tension of Tyvek® (high density polyethylene) is 30 dynes/cm². Corona treatment increases the surface tension to 40 to 42 dynes/cm². As a comparison, distilled water is 73 dynes/cm².

DuPont™ Tyvek®. Compared to paper, there's just no comparison.

Just how much better is DuPont™ Tyvek® than paper? These points sum it all up:

- For the same application, lighter weights of Tyvek® are normally used.
- Tyvek®, like other synthetics, is more elastic. It should be handled under the lowest tension practical to avoid distortion and misregistration. Tyvek® will elongate 15% to 25% before breaking, making deep embossing possible without fracturing.
- The physical properties of Tyvek® are the same, wet or dry. Although unaffected by water and many chemicals, Tyvek® may swell on contact with certain organic solvents used in some inks, coatings and adhesives. See pages 32-33 for details. It is also recommended that you conduct your own tests before use.
- Tyvek® absorbs little or no moisture; therefore, longer drying times are required for most inks, coatings and adhesives.
- Tyvek® is a thermoplastic. It maintains its toughness and flexibility down to -100°F (-73°C). An unrestrained sheet of Tyvek® is dimensionally stable up to 170°F (77°C) and will not shrink. Temperatures above 175°F (79°C) should be avoided when processing under tension.
- Tyvek® 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. Specialty dies may be required to process Tyvek®.
- Tyvek® has lower surface friction, which may facilitate handling in some operations.
- Tyvek® is slippery and should not be used in any application where it will be walked on without the application of a slip-resistant coating.



The physical properties of Tyvek® are unaffected by water and many chemicals.

Less space, less weight, more convenience.

Maintaining an adequate supply of DuPont™ Tyvek® is simple.

Rolls of Tyvek® 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 by turning or rocking it on its end. Clamp trucks can crush cores and distort Tyvek®. Clamp pressure should be set to a maximum of 1,800-2,000 psi (12,400-13,800 Pa) gauge and core plugs should always be in place when handling rolls.

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

If rolls or sheets are to be stored for several months, they should be wrapped in Tyvek® or polyethylene film for protection. 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 to sunlight will usually cause this color to disappear. If Tyvek® 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.

Good for what you do. Good for where you do it.

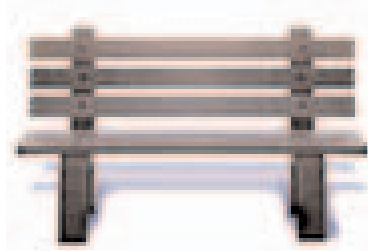
Anything printed on DuPont™ Tyvek® makes an impact on those who see it, not on the environment.

SOURCE REDUCTION AND MATERIAL MINIMIZATION

Perhaps the most important benefit of Tyvek® is its strength and durability relative to its light weight. For example, envelopes of Tyvek® typically weigh half as much as those made of other materials. In addition, the durability of products made of Tyvek® 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 Tyvek® from manufacturing processes for more than 25 years. In addition,



Tyvek® can be recycled at facilities throughout the world that recycle flexible HDPE products. For assistance in locating the one nearest you, contact DuPont at 1-800-448-9835.

DuPont provides support for customers, recyclers and trade associations to facilitate collection and recycling. Tyvek® is included in the ASTM 5203 standard for HDPE from post-consumer uses.



Recycled Tyvek® material is used for making plastic lumber for decking, lawn furniture, picnic tables and landscape timbers.

WASTE-TO-ENERGY INCINERATION

Tyvek® can be safely incinerated. Under optimal conditions, it yields water and carbon dioxide, and leaves essentially no residue for disposal. In fact, Tyvek® 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.

LANDFILLING

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

DuPont manages recycling programs worldwide. Examples of what they recover include used Tyvek® Envelopes in the United States and used Tyvek® Banners in Malaysia.

Problems? Solutions.

Customer satisfaction with DuPont™ Tyvek® has been consistently high. However, if you ever feel the quality of the DuPont™ Tyvek® material you receive is outside the written specifications, simply contact your supplier or a DuPont Customer Service Representative **1-800-224-3464**. When you do, please remember the following:

ROLL DEFECTS

If a roll of Tyvek® is found to contain defects or will not process acceptably, a 10 yd (9-m) full-width sample may need to be returned to DuPont, along with the package number. Some defects may require that a full roll of material be returned. Please do not destroy the material in question.

WRINKLES OR CREASES

If a roll 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. Request a return authorization from your DuPont Customer Service Representative or Distributor. The package number must be included.

CANCELING A JOB

Before canceling a sheet-fed printing job for print quality, please print 15 consecutive sheets of the job on offset paper and hold this with the rejected Tyvek® to help us evaluate the problem. Again, if a complaint is initiated, it is very important that the package numbers be identified.

Right where you want it.

Chances are your current substrate supplier can also provide you with DuPont™ Tyvek®.

Tyvek® material is available in multiple forms and through many distribution channels throughout the world.

Tyvek® Type 10 is available from distributors and select paper merchants in full rolls, slit rolls or sheets. Lists of distributors that sell rolls or sheets of uncoated, as well as coated, colored or pressure-sensitive coated Tyvek®, may be obtained by contacting DuPont at **1-800-448-9835** or at **www.graphics.dupont.com**.

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

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

Tyvek® 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 Type 14 products are also available on 3 in (7.6 cm) I.D. cores, with roll diameters of 21.5 in (0.54 m), 28 in, or 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 Tyvek® 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.

Technical guidelines

TABLE I

Resistance of DuPont™ Tyvek® to Salt Solutions¹

The breaking strength of Types 10 and 14² is unaffected after 1,000 hours exposure at 70°F (21°C) to the saturated salt solutions listed below:

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

¹ In the case of limited use/disposable protective apparel, the user should visit the website at <http://personalprotection.Dupont.com>.

² Tests actually performed on Tyvek® 1073D.

³ Sample yellowed after exposure.

TABLE II

Resistance of DuPont™ Tyvek® to Oxidizing and Reducing Agents¹

Exposure Conditions

Effect on Breaking Strength⁶

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 <http://personalprotection.dupont.com>.

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 Tyvek® 1073D.

TABLE III**Resistance of DuPont™ Tyvek® to Organic Solvents²**

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

Organic Chemical	Effect on Breaking Strength ³
Acetamide ⁴	None
Acetic acid	None
Acetone	None
Acrylonitrile	None/Slight
n-Amyl acetate	None
n-Amyl alcohol	None ⁵
Aniline	None
Benzaldehyde	None
Benzene	None
Benzyl alcohol	None
Benzyl chloride	None
n-Butyl alcohol	None
Carbon disulfide	None
Carbon tetrachloride	None
Chlorobenzene, mono-	None
Chloroform	None
Chlorohydrin	None
Ferric sulfate	None
Cottonseed oil	None
m-Cresol	None/Slight
Cyclohexanone	Slight/None
p-Dichlorobenzene ⁶	None
Dimethyl acetamide	None
Dimethyl formamide	None
Dimethyl sulfoxide	None

Organic Chemical	Effect on Breaking Strength ³
Dioxane, 1-4	None/Slight
Ether	Not Tested/Slight
Ethyl acetate	None
Ethyl alcohol	None
Ethylene glycol	None
Formaldehyde ⁷	None
Formic acid ⁸	Not Tested/Slight
Gasoline (leaded)	None/Slight
Glycerol	None
Kerosene	None/Slight
Linseed oil	None/Slight
Methyl alcohol	Slight/None
Methylene chloride	Slight/None
Methyl ethyl ketone	None
Mineral oil	None
Nitrobenzene	Slight/None
Oleic acid	Slight
Perchloroethylene	None
Phenol ⁴	None
Pine oil	None
Pyridine	None
Tetrachloroethane	None
Trichloroethylene	None
Triethylamine	None
Trifluoroacetic acid	None
Turpentine	None

1 Test actually performed on Tyvek® 1073D.

2 In the case of limited use/disposable protective apparel, the user should visit the website at <http://personal.protection.dupont.com>.

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 H₂O.8 Test performed with 91% concentration in H₂O.

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	1000	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 <http://personalprotection.dupont.com>.

2 Tests actually performed on Tyvek® 1073D.

3 Slight discoloration.

TABLE V

Order of Resistance to 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 made from Tyvek® brand of protective materials. For information on solvent permeation, the user should visit the website at <http://personalprotection.dupont.com>.

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 of protective material, please contact a DuPont representative:

DuPont Nonwovens–Tyvek®
Customer Information Center
4417 Lancaster Pike
Wilmington, DE 19805
1-800-448-9835

For more information about Tyvek®, visit these websites:

tyvek.com
personalprotection.dupont.com
envelopes.tyvek.com
graphics.dupont.com
discpackaging.tyvek.com
medicalfabrics.dupont.com
covers.tyvek.com
buildinginnovations.dupont.com
industrialpackaging.dupont.com
filtration.dupont.com
medicalpackaging.dupont.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 practical limits. We strongly recommend that processors seek and adhere to manufacturer's or supplier's current instructions for handling each chemical they use.

DuPont™
Tyvek®

