PLASTIC DIFFUSER SOLUTIONS FOR LED LIGHTING

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CURBELL PLASTICS

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In recent years, plastic sheet and film manufacturers have introduced new materials that are engineered to diffuse LED light, hide hot spots, and create even lighting surfaces.

The Challenges of Diffusing LED Light

LEDs offer a number of advantages over traditional fluorescent and incandescent lamps including longer life, improved energy efficiency, smaller lamp size, less generated heat, and lighter weight. However, one of the challenges of LED light sources is that they consist of an array of many small diodes that create intense points of light. These LED "hot spots" have poor aesthetic characteristics, which can detract from the appearance of architectural and commercial lighting fixtures, backlighted signs, transportation lighting, and lighted point-of-purchase displays.

LED lamps can be especially challenging for manufacturers of robotic machine vision systems. These systems rely on high resolution cameras being able to detect contrast between the parts being inspected and the surrounding background. Machine vision software records the position and orientation of each part on a conveyor or on an assembly line. Some systems can even determine if parts are within specified dimensional tolerances. LED front lighting and/or back lighting is used to illuminate the parts. In cases where the lighting is uneven, cameras may be unable to distinguish if parts are correctly positioned and within tolerances.

In recent years, plastic sheet and film manufacturers have introduced new materials that are engineered to diffuse LED light, hide hot spots, and create even lighting surfaces. In addition to hiding the pinpoints of light, the new diffuser materials exhibit high levels of light transmission compared with traditional plastic light diffusers. This results in brighter light from a given set of LED lamps.

This paper provides an overview of recently introduced plastic sheet and film materials that are engineered to function as high performance LED light diffusers. The first section compares the transparent base polymers that are formulated with additives to make LED light diffusers. The subsequent sections discuss the latest LED diffusing sheet and film materials made from polycarbonate and acrylic plastics.

Polycarbonate and Acrylic Diffusers

Translucent plastic light diffusers consist of a transparent base polymer, typically polycarbonate or acrylic, with light diffusing additives and sometimes embossed surfaces to increase light scattering. Polycarbonate and acrylic each have advantages and limitations so it is important to understand the behavior of these two polymers when selecting materials for light diffuser applications.

Figures 1 through 6 (shown on page 5) show some of the mechanical, thermal, and optical properties of polycarbonate and acrylic plastics. As shown in Figure 1 and Figure 2 on page 5, polycarbonate has higher impact strength and higher temperature capability (heat deflection temperature) compared with acrylic. That is why polycarbonate is often used for light diffuser applications where durability and/or performance at elevated temperatures are required. The toughness of polycarbonate also allows for its use as a thin film in lighting applications. Polycarbonate has superior flammability characteristics compared with acrylic and, unlike acrylic, polycarbonate can easily be die cut and cold formed.

Polycarbonate has outstanding impact resistance and it is often used for light diffusers in applications such as stair treads and detention centers where durability is required.

Acrylic is stronger and stiffer than polycarbonate as shown in Figure 3 (tensile strength) and Figure 4 (flexural modulus or stiffness). Figure 5 shows that acrylic also has higher light transmission than polycarbonate. Acrylic has the additional benefit of being inherently UV stable. However, acrylic is somewhat brittle in that it has low impact strength and low tensile elongation as shown in Figures 1 and 6. This is why acrylic light diffusers sometimes break during shipping and handling.

Acrylic sheet has outstanding aesthetic properties, including superior edge quality compared with polycarbonate. This has made it the material of choice for applications including lighted point-of-purchase displays and high-end light fixtures where visual appeal is essential.

Figure 1. Notched Izod Impact Strength of Polycarbonate and Acrylic

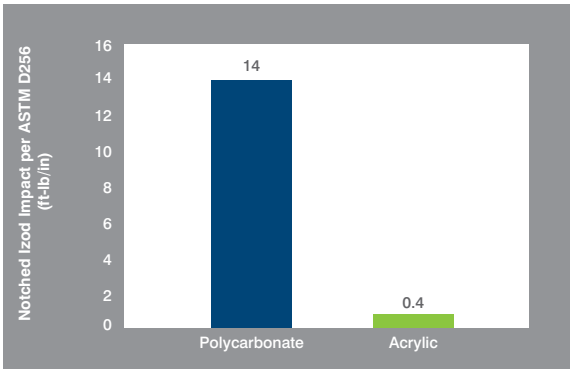


Figure 2. Heat Deflection Temperature of Polycarbonate and Acrylic

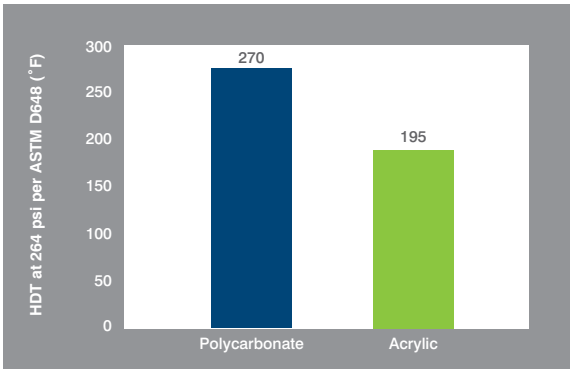


Figure 3. Tensile Strength of Polycarbonate and Acrylic

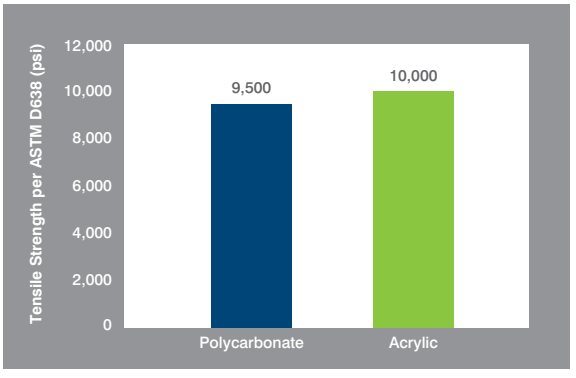


Figure 4. Flexural Modulus of Polycarbonate and Acrylic

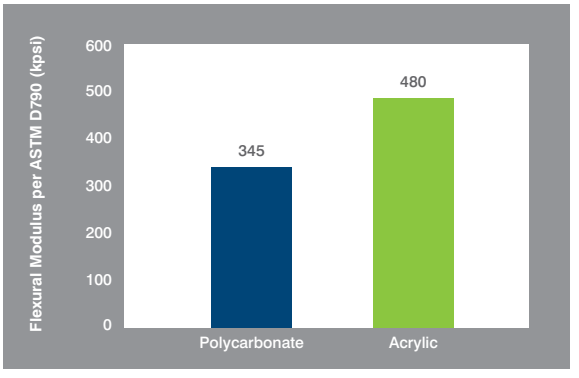


Figure 5. Light Transmission of Polycarbonate and Acrylic

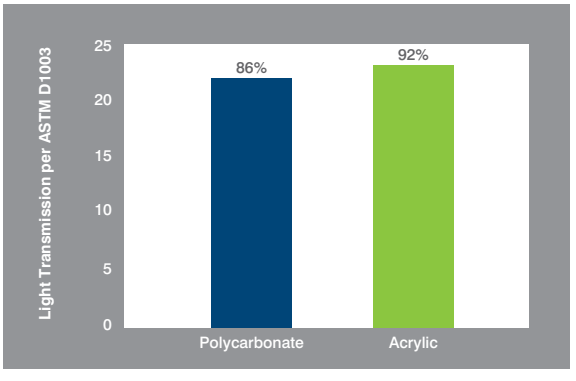
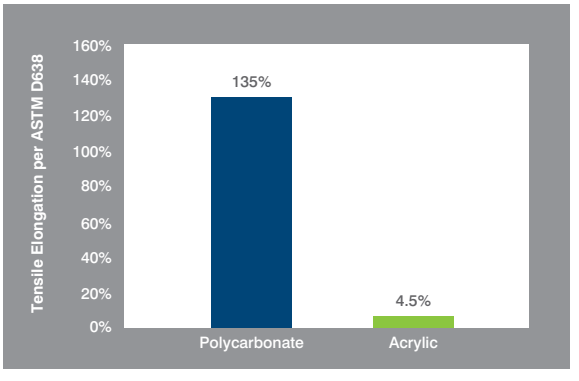
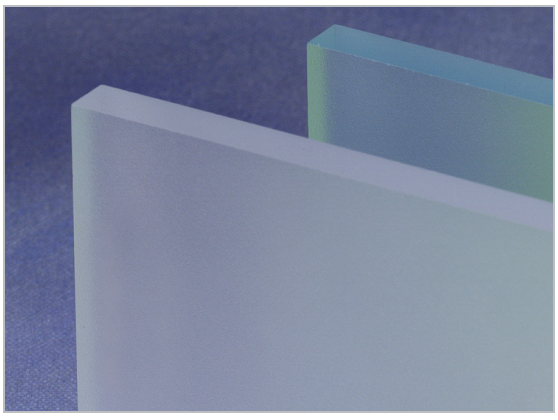


Figure 6. Tensile Elongation of Polycarbonate and Acrylic



The charts shown in Figures 1 through 6 compare the mechanical, thermal, and optical properties of polycarbonate and acrylic plastics. Additives and surface embossing can be used to give these materials enhanced light diffusing properties.



Acrylics have outstanding aesthetic properties, even when back-lighting is turned off. The edges of acrylic sheet can be polished to a high gloss.

In summary polycarbonate and acrylic each have certain properties that contribute to their mechanical, thermal, and optical performance. Due to recent advances in materials technology, both of these plastics are now available in formulations that greatly enhance their ability to transmit and diffuse LED light. The following sections describe the current state-of-the-art in commercially available polycarbonate and acrylic sheet and film materials that are engineered for use in LED light diffusing applications.

LED Light Diffusing Polycarbonate Sheet Materials

TUFFAK® LUMEN XT

TUFFAK® Lumen XT (formerly called Makrolon®) is a family of polycarbonate sheet materials that are offered with various levels of light transmission and light diffusion as well as different thicknesses and different shades of translucent white. TUFFAK® Lumen XT diffuses light by two mechanisms. First, it uses a bulk scattering agent, which consists of transparent particles with a different refractive index than the polycarbonate matrix. These particles are engineered to direct light forward rather than reflecting it back on the light source. The loading of the particles contributes to the diffusing power and light transmission properties of the different grades of TUFFAK® Lumen XT.

The second mechanism by which TUFFAK® Lumen XT scatters light is via a texture that is embossed on one side of the sheet. This texture creates surfaces that are not perpendicular to the incoming light, which results in additional light scattering. Figure 7 is a schematic that shows how light is scattered when it hits a diffuser particle in TUFFAK® Lumen XT, and how the textured surface that is embossed on one side of the sheet promotes scattering. Figure 8 is a micrograph of the embossed surface on one side of TUFFAK® Lumen XT sheet.

Figure 7. Schematic illustrating how light is scattered by the diffuser particles and the textured surface of TUFFAK® Lumen XT

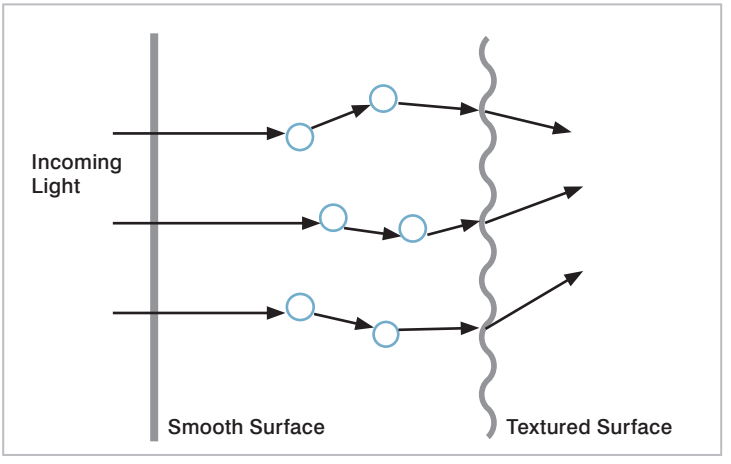
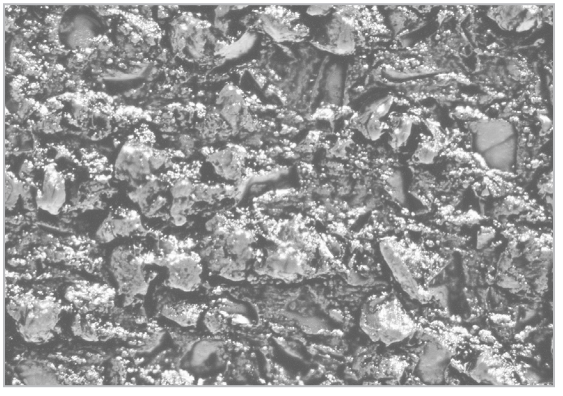


Figure 8. Micrograph of the textured surface of TUFFAK® Lumen XT sheet



TUFFAK® LUMEN XT - LIGHT TRANSMISSION AND DIFFUSION

The photographs below illustrate how different grades of TUFFAK® Lumen XT (formerly called Makrolon®) allow for different levels of light transmission and diffusion. The light box shown in Figure 9 contains an array of LEDs placed at various depths from the top surface of the box. Depths of 0.75" and 1.75" are indicated in the photograph. Figure 10 shows three different grades of TUFFAK® Lumen XT placed over the light box – a low diffusion/high transmission grade (left), a medium diffusion/medium transmission grade (middle), and a high diffusion/low transmission grade (right). When looking at the pictures, one notices that the low diffusion/high transmission grade (left) appears to be very bright and it obscures pinpoints from LEDs set at a depth of 1.75". However, it fails to obscure pinpoints from LEDs set at a shallower depth of 0.75".

In contrast, the high diffusion/low transmission grade (right) appears less bright, but it successfully obscures pinpoints for LEDs as close as 0.75" from the surface of the diffuser. This demonstrates how different grades of TUFFAK® Lumen XT may be appropriate depending on the depth of the light fixture and the desired levels of light transmission and light diffusion.

Figure 9. Light box with LEDs placed at various depths

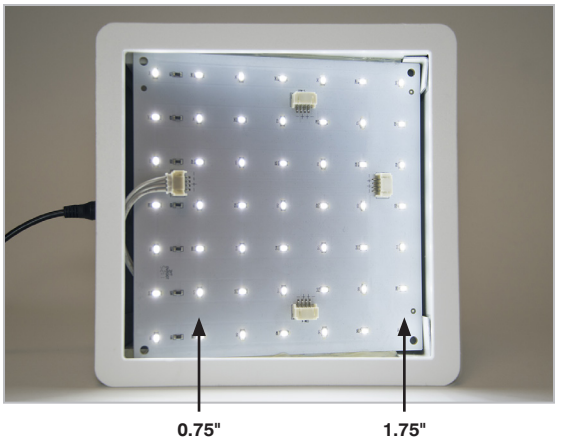
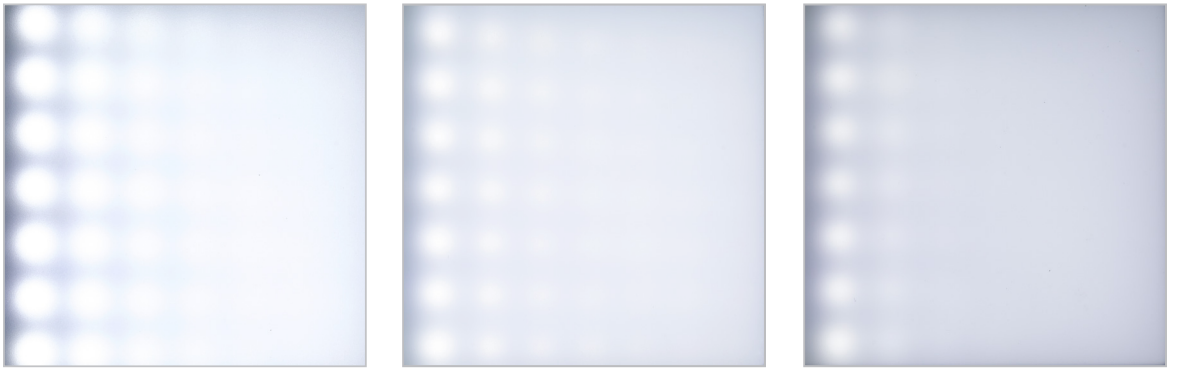


Figure 10. Different grades of TUFFAK® Lumen XT placed over a light box



LOW DIFFUSION
HIGH TRANSMISSION

MEDIUM DIFFUSION
MEDIUM TRANSMISSION

HIGH DIFFUSION
LOW TRANSMISSION

TUFFAK® LUMEN XT - WARM AND COOL COLORS

In addition to offering varying levels of light transmission and diffusion, TUFFAK® Lumen XT (formerly called Makrolon®) is available in both "warm" (designated LW) and "cool" (designated LC) tints of translucent white. The LW grades exhibit slightly higher light transmission than the LC grades. When the LEDs are turned off, the LW grades have a yellow tint. The LC grades have more of a gray tint when the LEDs are turned off. Either an LC grade or an LW grade may be appropriate depending on the aesthetic qualities that the fixture designer is trying to achieve.

TUFFAK® Lumen XT is available in "warm" (left) and "cool" (right) translucent white colors.

Figure 11 shows the levels of light transmission and light diffusion associated with various grades, thicknesses, and color tints (warm or cool) of TUFFAK® Lumen XT. Light transmission is measured as the percent of light transmitted through the diffuser. Light diffusion (FWHM angle) is measured in degrees, with a higher number indicating greater diffusion of the light. In the TUFFAK® Lumen XT series, the higher the number (e.g. LW9 or LC7), the greater the diffusion of the light, and the closer the designer can place the diffuser to the LED array. However, the higher numbered grades have lower levels of light transmission. The lower the TUFFAK® Lumen XT number (e.g. LC3 or LW3), the lower the diffusion power but the greater the light transmission.

Figure 11. Light Diffusion and Transmission of TUFFAK® Lumen XT

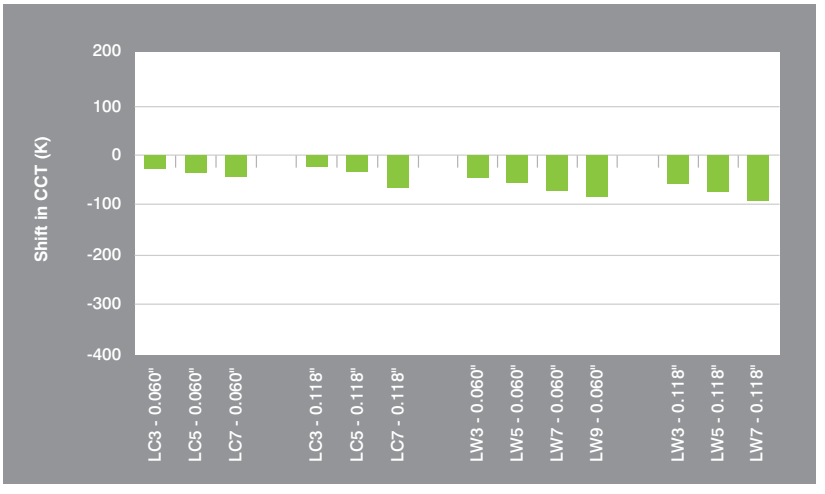
TUFFAK® Lumen XT Grade	DIFFUSION (FWHM, degrees)		% TRANSMISSION (ASTM D1003)	
	.060" thick	.118" thick	.060" thick	.118" thick
LC0	14	13	91	90
LC3	38	53	90	85
LC5	53	77	88	77
LC7	86	135	79	62
LW3	38	53	93	90
LW5	53	77	90	81
LW7	86	135	82	67
LW9	146	166	73	55

CORRELATED COLOR TEMPERATURE (CCT) SHIFT OF TUFFAK® LUMEN XT

Like all plastic materials, TUFFAK® Lumen XT (formerly called Makrolon®) will slightly shift the color of an LED light source once the light is transmitted through the diffuser. Lighting designers who wish to achieve tight color tolerances may wish to correct for this color shift by selecting LEDs with slightly warmer or cooler colors so that the finished (shifted) color meets their specification.

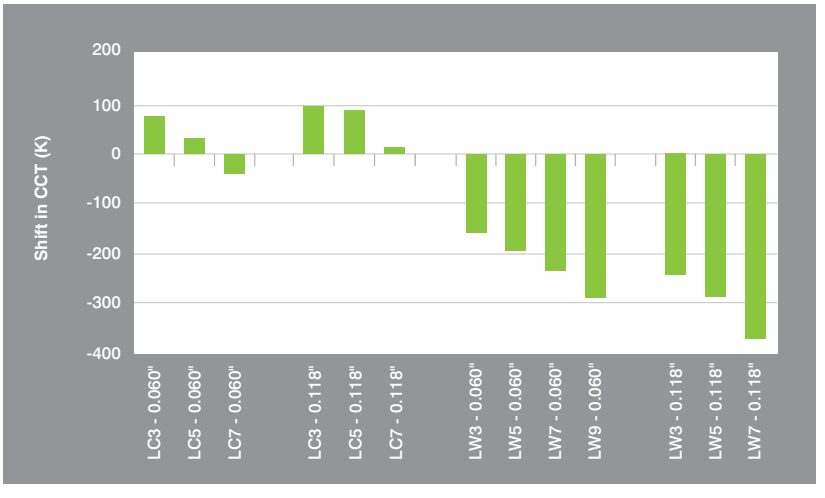
Correlated color temperature (CCT) is a measure of the color of the light emitted by a lamp expressed in Kelvin (K). Low color temperatures (2,700 K - 3,000 K) are generally referred to as “warm” colors (yellow or reddish tint). Higher color temperatures (over 5000 K) are considered to be “cool” colors (bluish tint). Figures 12 and 13 illustrate the slight shifts in color associated with using various grades and thicknesses of TUFFAK® Lumen XT with either a 3000 K (warm) or a 6000 K (cool) LED lamp.

Figure 12. Correlated Color Temperature Shift for a 3000 K LED



These graphs show shifts in Correlated Color Temperature (CCT) for various grades and thicknesses of TUFFAK® Lumen XT.

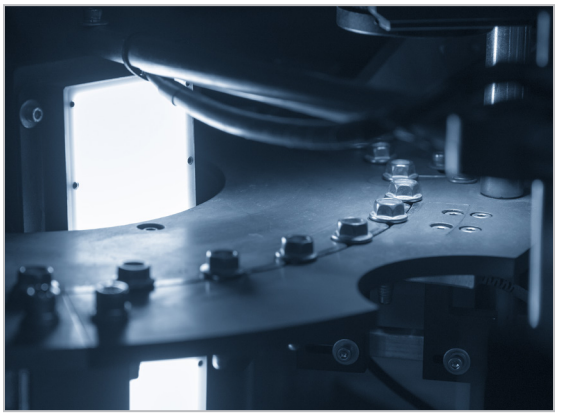
Figure 13. Correlated Color Temperature Shift for a 6000 K LED



Data for modeling TUFFAK® Lumen XT is available in a number of optical design software products including Photopia®, LightTools®, and Trace Pro®.

TUFFAK® LUMEN XT FOR MACHINE VISION SYSTEMS

TUFFAK® Lumen XT (formerly called Makrolon®) polycarbonates are outstanding LED light diffusers for machine vision systems because they are durable and available in grades with different light transmission and light diffusion values as well as warm and cool tints. This allows vision inspection system designers to select the grade of TUFFAK® Lumen XT that achieves the required contrast for a particular inspection application.



Even lighting is essential for proper functioning of the high resolution cameras on machine vision systems. TUFFAK® Lumen XT polycarbonate sheet materials are outstanding LED light diffusers for these applications

TUFFAK® LUMEN XT-V WITH ENHANCED FLAMMABILITY CHARACTERISTICS

TUFFAK® Lumen XT-V has enhanced flammability characteristics. 0.118" thick TUFFAK® Lumen XT-V passes UL 94 V0 and UL 94 5VA testing. This material is intended for lighting applications where the most stringent flammability performance is required. TUFFAK® Lumen XT-V is available with 3 different levels of light transmission and diffusion.

TUFFAK® DX-NR OUTDOOR GRADE LIGHT DIFFUSING POLYCARBONATE

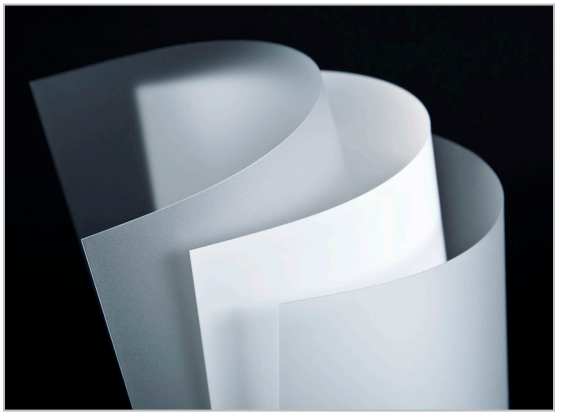
TUFFAK® Lumen XT is not UV stabilized and it is intended for indoor use only. However, the manufacturer has recently introduced a new grade of LED diffusing polycarbonate sheet, TUFFAK® DX-NR, which is engineered for use in outdoor light fixtures. TUFFAK® DX-NR uses advanced UV resistance technology to insure long lasting weathering performance.

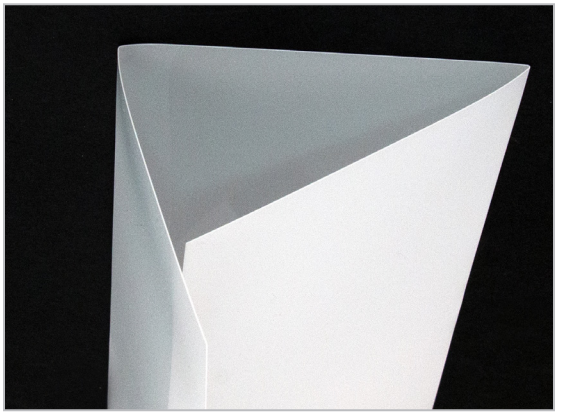
TUFFAK® DX-NR has outstanding weathering performance as well as LED light diffusion and light transmission characteristics. This makes it an excellent choice for outdoor light diffusers.

LED Light Diffusing Polycarbonate Films

MAKROFOL® LM (LIGHT MANAGEMENT) FILMS

Light diffusing polycarbonate films offer certain advantages over sheet materials including lighter weight and the ability to be easily die cut, cold bent, and wrapped into curved shapes. Additionally, since polycarbonate films are thin, they are often economical alternatives to thicker plastic sheet diffuser materials.





Makrofol® LM polycarbonate films can be cold bent and "creased" to create complex geometric shapes.

Makrofol® LM polycarbonate films can be easily cold formed to create curved shapes. They can be inserted into acrylic tubes to create cylindrical LED light diffusers.

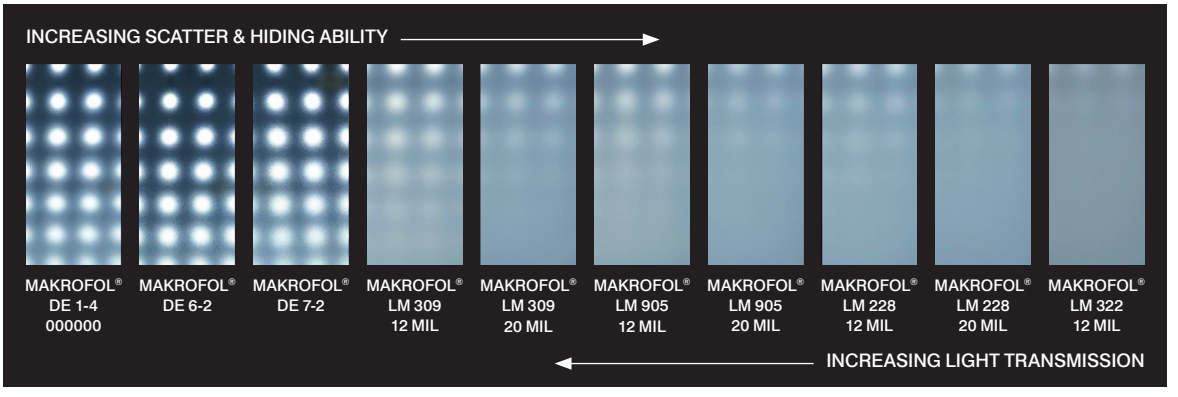
Makrofol® LM (light management) materials including Makrofol® LM 309, Makrofol® LM 905, and Makrofol® LM 228 are embossed polycarbonate films that are formulated with a light scattering agent. These materials are high performance LED light diffusers that create smooth, homogenous illumination on the front sides of backlighted parts. As shown is Figure 14, Makrofol® LM films vary in both light transmission and light diffusion characteristics depending on the formulation and the thickness of the film. Makrofol® DE 1-4 000000 clear embossed film and Makrofol® DE 1-4 020209 translucent white embossed film do not contain the LM light scattering agent. However, they are frequently used for light diffusing applications and they are included on the chart for reference.

Figure 14. Light Diffusion and Transmission of Makrofol® Grades

Makrofol® Grade	DIFFUSION (FWHM, degrees)			TRANSMISSION (ASTM D1003)		
	.010" thick	.012" thick	.020" thick	.010" thick	.012" thick	.020" thick
DE 1-4 000000 Clear	5	—	5	90	—	88
LM 309	—	16	28	—	86	81
LM 905	—	29	41	—	81	73
LM 228	—	39	51	—	73	65
DE 1-4 020209 White Translucent	59	—	58	25	—	21

Figure 15 shows the various grades of Makrofol® films' light scattering and LED hot spot hiding power. The pictures show the films placed over a light box with LED lamps placed at depths of 1 inch to 3 inches. Lighting designers can achieve a desired effect by specifying the particular film that has the best balance of hot spot hiding power and light transmitting capability when placed at a given distance from the LED lamps in a fixture.

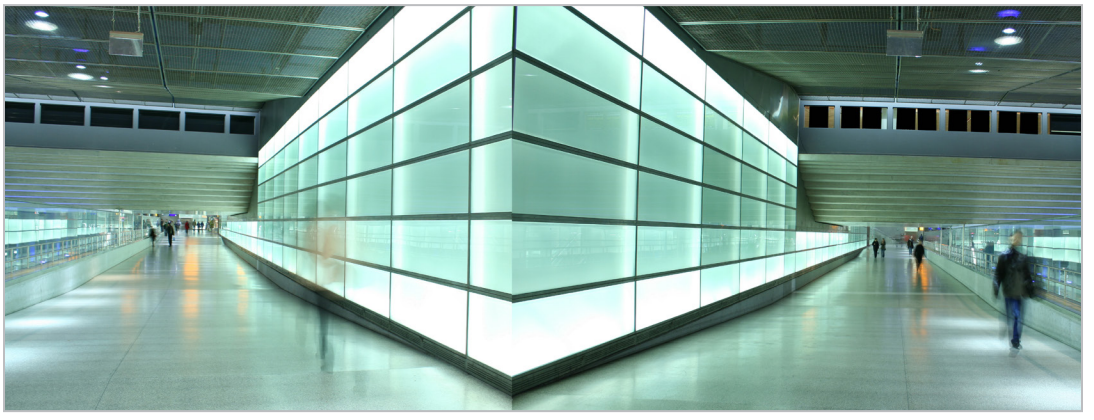
Figure 15. Makrofol® Films' Light Scattering and LED Hot Spot Hiding Power with LED Lamp Depths from 1" to 3"



It is important to note that a number of Makrofol® LM films have successfully passed the U.S. Department of Transportation's FMVSS 302 (Federal Motor Vehicle Safety Standard 302) test, which specifies the burn resistance requirements for the materials used in the interiors of motor vehicles. This allows these films to be used for certain back-lighted motor vehicle instrumentation applications.

LED Light Diffusing Acrylic Sheet Materials

Acrylic sheet has outstanding aesthetic properties and exposed edges can be polished to a high gloss. Acrylic LED light diffusers are typically lower cost than polycarbonate diffusers, which makes them suitable for applications where aesthetics, LED light diffusion, and light transmission are critical, but the performance characteristics of polycarbonate (impact resistance, high temperature capability, and flammability ratings) are not required.

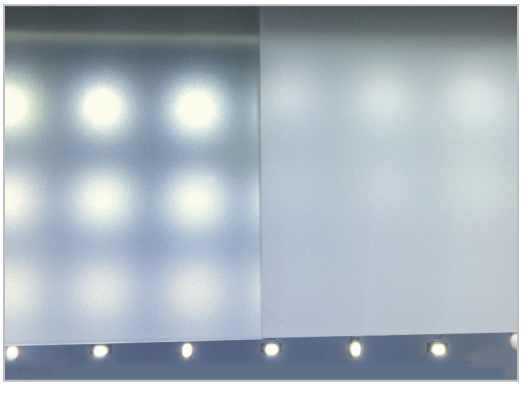


Acrylic has outstanding aesthetic properties including visually appealing, bright, high gloss edges.

The new high performance LED diffusion grades of acrylic have outstanding LED light transmission and light diffusing characteristics, which far surpass the optical performance of traditional white acrylic sheet diffusers. Figure 16 illustrates the diffusion properties of a high performance acrylic LED light diffuser (right) compared with a traditional acrylic light diffuser (left). The hot spot hiding power and light transmission properties of the high performance acrylic can be clearly seen in the photograph.

Figure 16. Acrylic sheets with different diffusion characteristics shown with lights turned on and off

LEDs TURNED OFF



LEDs TURNED ON

Although these two acrylic sheet materials have similar appearance when the LED lamps are turned off, the high performance LED light diffuser on the right exhibits superior hot spot hiding power compared with the traditional acrylic light diffuser on the left.

BRANDS OF LED LIGHT DIFFUSING ACRYLIC

Plaskolite, LLC and Altuglas International are the two leading manufacturers of LED light diffusing acrylic sheet materials and each offers unique products for the lighting market. Plaskolite supplies three different grades of their OPTIX® acrylic sheet that are engineered for use in LED applications: OPTIX® 95 LED, OPTIX® Frost LED, and OPTIX® LD 2406 White. Each has different levels of light transmission and diffusion and this allows designers to select the most appropriate grade depending on the light source, the distance between the lamp and the diffuser, and the desired appearance.

Altuglas International has recently introduced Plexiglas® Sylk, which also has outstanding LED light transmission and diffusion properties. Figure 18 shows the light transmission values for each of these four acrylic sheet materials.

Figure 17. Light Transmission of Acrylic Diffuser Materials

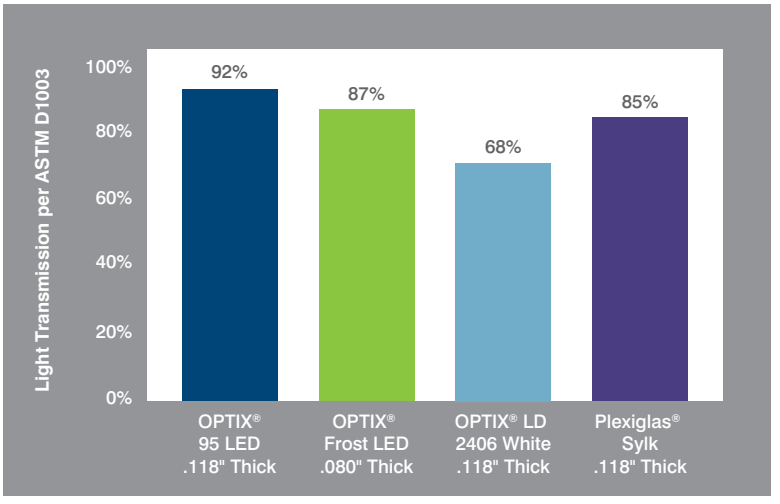


Figure 18 shows each of these 4 acrylic sheet materials backlighted. These plastics exhibit a range of light transmission and light diffusion properties.

Figure 18. Acrylic diffuser materials backlighted by LEDs set at depths from 0.50" to 1.75" from the surface of the light box.

Some images have been enhanced to better demonstrate material transmission and diffusion characteristics.

Acrylic sheet materials have different appearances when not backlighted by LEDs as demonstrated above.

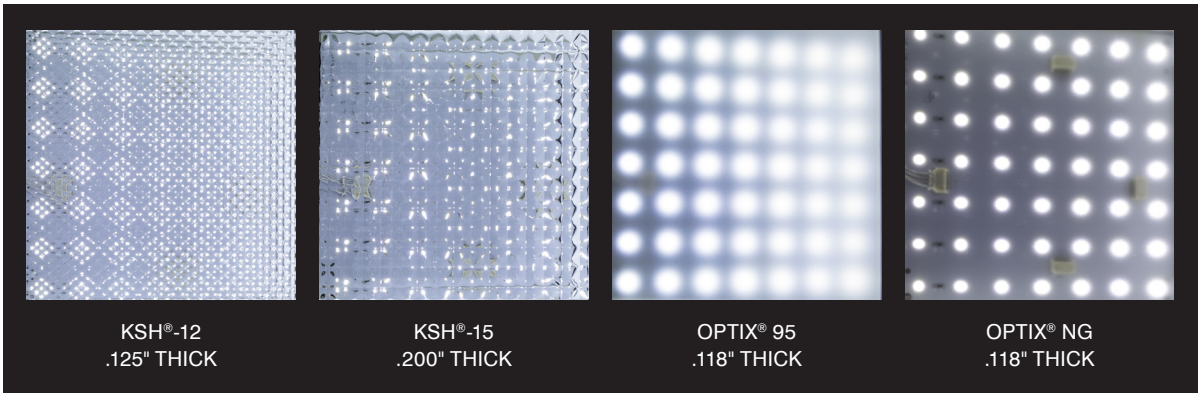
TRADITIONAL PATTERNED ACRYLIC SHEET

Although the use of new high performance LED light diffusing sheet and film products is growing each year, traditional patterned acrylics are still widely used for lighting applications. The most predominant pattern used in lighting fixtures is KSH®-12 prismatic, which has a diamond prismatic surface. This material has been used in commercial lighting for many years.

KSH®-15 has a similar diamond pattern to KSH®-12, but with larger prisms on the surface of the sheet. Both pattern 12 and pattern 15 create interesting effects when used with LED lamps as shown in Figure 20.

OPTIX® 95 acrylic sheet, with a matte finish on one side, is another acrylic that has been historically used in lighting fixtures. OPTIX® NG non-glare acrylic has a heavier matte texture than OPTIX® 95. OPTIX® 95 and OPTIX® NG acrylics are often used when printed graphics are needed on the smooth side of the sheet.

Figure 19. KSH® pattern acrylic and OPTIX® matte textured acrylic materials backlighted by LEDs set at depths from 0.50" to 1.75" from the surface of the light box.



Some images have been enhanced to better demonstrate light transmission and diffusion characteristics.

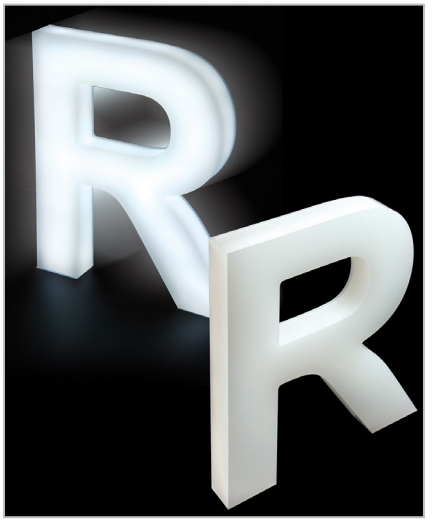
KSH® OVERLAYS FOR RETROFITTING EXISTING TROFFER LIGHT FIXTURES

In some cases, building owners may wish to retrofit existing troffer lighting fixtures with LED lamps. This necessitates upgrading the diffusers to accommodate the more intense LEDs. KSH® Overlays are thin (0.040" to 0.080" thick) acrylic diffuser panels that fit in between the troffer housing and the existing diffuser. KSH® Overlays diffuse LED hot spots and create more even lighting surfaces. They are designed to filter out the most damaging wavelengths of ultraviolet radiation.

KSH® Overlays allow building owners to retrofit existing troffers to diffuse the more intense LED lamps.

ALTUGLAS® LED BLOC FOR INTERNALLY ILLUMINATED SIGN LETTERS

Altuglas® LED Bloc allows lighting designers to create heavy-walled LED diffusers, back-lighted dimensional letters, and other lighted architectural features with simple designs that minimize manufacturing labor. The system consists of 30 mm thick acrylic sheet with a special light diffusing additive in the formulation. The sheet is cut into the desired shape and a 10 mm deep channel is then machined into the back side. LED lamps are inserted into the channel to create the finished unit. Using this approach, the front surface and all of the edges of the diffuser are evenly illuminated for a dramatic look.



The "R" for this backlighted sign letter was fabricated from a single piece of 30 mm thick Altuglas® LED Bloc system material.

Summary

Plastic film and sheet manufacturers have introduced new LED light diffusing polycarbonates and acrylics that can be used for a wide range of light diffusion applications. The chart below summarizes some of the advantages and limitations of each material.

LED DIFFUSING MATERIALS - ADVANTAGES & LIMITATIONS

Material & Base Polymer	Advantages	Limitations
TUFFAK® Lumen XT Sheet *Polycarbonate* *(formerly called Makrolon®)*	• Broad product range (warm and cool whites, range of diffusion and transmission properties) • Highest impact strength, tough and durable • Highest temperature capability • Best flammability characteristics • Can be die cut and cold formed • Outdoor grades available (TUFFAK® DX-NR) • Enhanced flammability grades available (TUFFAK® Lumen XT-V)	• Must be dried prior to thermoforming
Makrofol® LM Films *Polycarbonate*	• Broad product range of diffusion and transmission properties • Highest impact strength, tough and durable • Highest temperature capability • Best flammability characteristics • Can be die cut and cold formed • Some grades approved for use in backlighted motor vehicle instrumentation • Thin polycarbonate films are often lower cost than thicker plastic sheet diffuser materials.	• Must be dried prior to thermoforming
OPTIX® Light Diffusing and Patterned Acrylic Sheet Materials *Acrylic*	• Outstanding aesthetics when lights are on or off • Inherently UV stable • Easy to bond using solvent cements • Strongest and stiffest of the transparent plastics	• Low impact strength • Can't be cold formed or die cut
KSH® Overlay *Acrylic*	• Allows for inexpensive retrofits to increase the diffusion properties of existing light fixtures	• Low impact strength • Can't be cold formed or die cut
KSH® Patterned Acrylic Sheet *Acrylic*	• Patterns create interesting lighting effects. • KSH® Pattern 25 controls light spread for task lighting.	• Low impact strength • Can't be cold formed or die cut
Plexiglas® Sylk Sheet *Acrylic*	• Outstanding aesthetics when lights are on or off • Inherently UV stable • Easy to bond using solvent cements • Strongest and stiffest of the transparent plastics • Acrylics tend to be less expensive than other diffuser materials.	• Low impact strength • Can't be cold formed or die cut

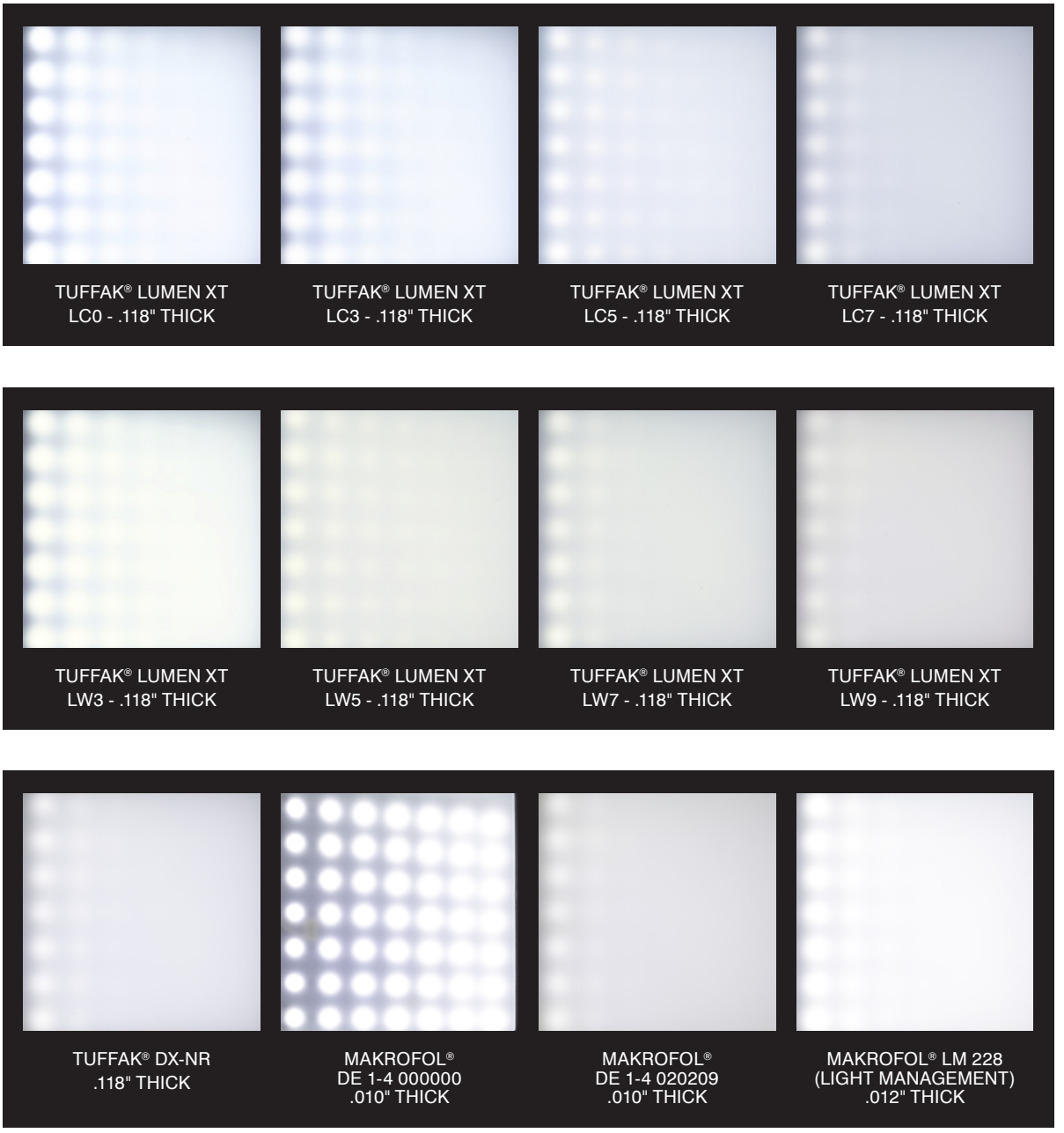
It is important to note that although plastic manufacturers take great care in reporting the engineering properties of their materials, subtle changes in gloss, tint, color, and texture can dramatically change the appearance of a light diffuser.

Human perception regarding the aesthetics of a diffuser will ultimately determine how well the finished product is received in the marketplace. In order to better inform lighting designers about the appearance of various light diffusing plastics, Appendix A includes photographic representations showing how these materials appear in transmitted light using standard LED light sources.

If you wish to compare samples of these materials, Curbell is pleased to offer a Plastic Light Diffuser Sample Kit for purchase. Each kit contains twenty-three 8" x 10" light diffusing materials discussed in this paper.
To purchase a kit, visit www.curbellplastics.com/LightSample

APPENDIX A

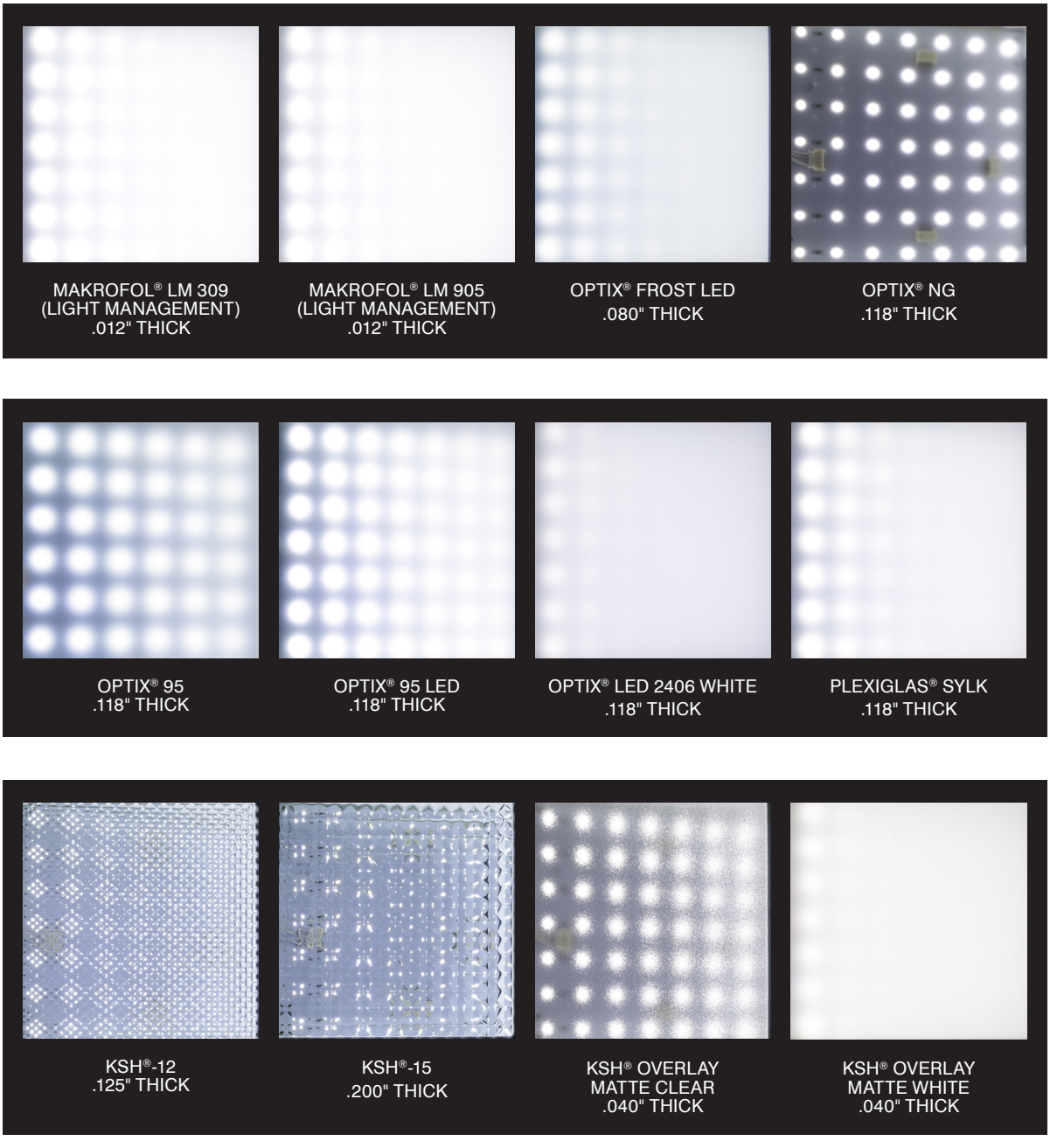
Plastic Diffuser Materials Photographed on an LED Light Box



Materials backlighted by LEDs set at depths from 0.50" to 1.75" from the surface of the light box.
Some images have been enhanced to better demonstrate light transmission and diffusion characteristics.

APPENDIX A

Plastic Diffuser Materials Photographed on an LED Light Box



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ABOUT THE AUTHOR

Dr. Keith Hechtel is Senior Director of Business Development for Curbell Plastics. Much of his work involves helping companies to identify plastic materials that can be used to replace metal components in order to achieve quality improvements and cost savings. Dr. Hechtel has over 30 years of plastics industry experience and he is a recognized speaker on plastic materials and plastic part design. He has conducted numerous presentations for engineers, designers, and fabricators in both industrial and academic settings.

He supports Curbell's customers by providing suggestions on plastic material selection, part geometry, and manufacturing methods.

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TECHNICAL EXPERTISE

Curbell white papers are intended to provide engineers and designers with basic information about the engineering polymers available as sheet, rod, tube, and film stock from Curbell Plastics. We invite you to contact Curbell via e-mail at **technicalsupport@curbellplastics.com** to discuss applications in detail.

ABOUT CURBELL PLASTICS

For 76 years, Curbell Plastics has been one of the nation's leading providers of plastic sheets, rods, tubes, and films, as well as fabricated parts, adhesives, and prototyping materials. Our customers range from small local businesses to large Fortune 500 companies and government agencies. We partner with organizations in dozens of industries, including aerospace, pharmaceutical, machinery manufacturers and sign fabricators. At Curbell, we understand the unique demands of each market and we have the expertise to help you meet your business needs. Whether your objective is to reduce manufacturing costs, improve productivity, or increase product reliability, Curbell can help.

OUR CAPABILITIES

Our branch network includes sales and warehouse locations throughout the United States. We offer a number of value-added services including custom cutting, fabrication, packaging, and kitting, as well as warehousing for just-in-time delivery. With Curbell, you get the plastics you want and the peace of mind you need, from technical support and design assistance at the earliest stages of product design, through production and after-sale support for each product we sell.

PUT US TO WORK FOR YOU

At Curbell, we are committed to providing the highest level of service to our customers. We recognize the urgency of customer needs, and we pride ourselves on providing quick and proactive solutions. Our tag line says it all – we appreciate the opportunity to earn your business and we invite you to "***Put us to work for you***."

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