

Optical Efficiency

of Bright View Diffusers

Higher energy costs combined with government regulations are driving efforts to maximize the optical efficiency of luminaires. Bright View diffusers offer high efficiency without sacrificing aesthetics or lamp hiding performance. However, measuring diffuser efficiency in a luminaire is not completely straightforward. This application note will explain the nuances of measuring diffuser efficiency as well as provide some measurements of various diffusers.

A common industrial practice of measuring luminous transmittance and haze of a translucent material is specified in ASTM D1003. As light strikes the diffuser's surface, a portion of it is transmitted to the other side, a portion of it is reflected, and a portion of it is absorbed. ASTM D1003 only measures the transmitted portion of energy that travels through the diffuser. In a typical application of a diffuser film inside a luminaire as shown in Figure 1, the light reflected back from diffuser film has a second chance to penetrate the film again. This effect is called "light recirculation" and due to high efficiency reflectors found in many modern lighting designs has a significant impact. This recirculated energy and its angular distribution are not accounted for by ASTM D1003.

Another limitation of ASTM D1003 is that it takes its measurement from a single incident angle and does not take into account that in a typical luminaire, light hits that diffuser from various angles. Given the fact that the reflection properties vary significantly for each incident angle, the D1003 test will not give an accurate indication of the performance of the diffuser in a typical luminaire. With these two limitations, the single pass and single incident angle measurement technique of ASTM D1003 is inadequate to characterize diffuser performance in an illumination system.

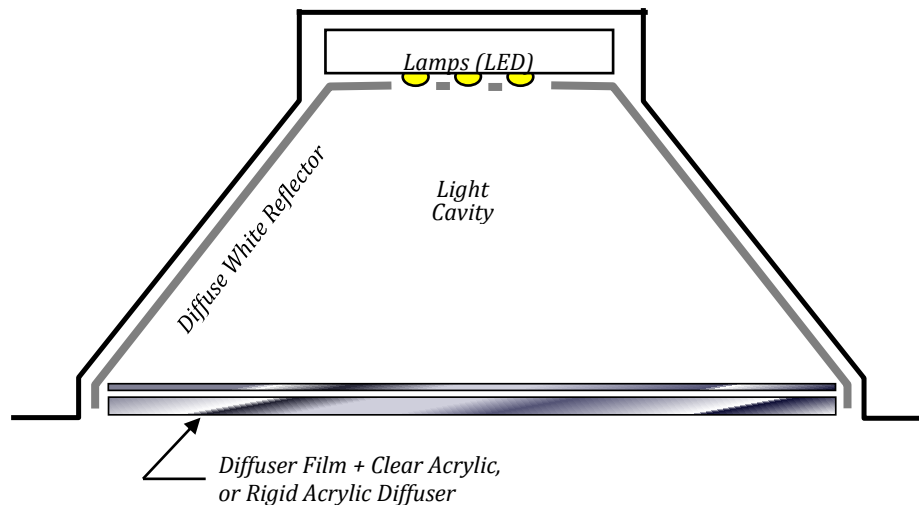


Figure 1. A Typical LED Down Light

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To overcome these shortcomings, Bright View characterizes diffuser efficiency by measuring the entire luminaire using the industry standard measurement method IES LM-79. To characterize the effect of the diffuser, the luminaire's total lumen output is measured first with the diffuser and then without the diffuser. The ratio of these two measurements is the *optical efficiency*. Although dependent on the luminaire used, this optical efficiency is the most appropriate and practical measure of the diffuser's performance.

Bright View's testing facility includes a goniophotometer as well as a 2-meter integrating sphere. With these capabilities, the actual diffuser efficiency can be measured in almost any given lighting fixture. There are many configurations that a diffuser film can be applied into an illumination system. It could be used as the only optic (diffuser only) between the light source and illumination field. It could be laminated (optically coupled) into a rigid clear substrate. In many cases, it is laid on top of a clear window without being optically coupled. Each configuration will have a different overall optical efficiency. Following are results for a typical LED downlight and a typical LED 2'x2' troffer using various diffuser configurations. While results will depend on overall system design, these data will provide reference information on the capability of BVT films in a typical application.

Test No. 1:

Diffuser Performance in a 4" LED (Can) Downlight

Light Engine: Typical industry LED module - 4" downlight

Diffuser Film: Bright View C-HE30

Clear Window (Lens) Material: 120 mil clear acrylic board

Case No.	Diffuser Assembly Order (in order from light source toward viewer)	Total Output Flux (lm)	Optical Efficiency relative to Case No. 1	Optical Efficiency relative to Case No. 2
1	No diffuser, no window	832.2	100%	
2	Clear window (acrylic) only	815.9	98.0%	100%
3	C-HE30 + Clear window	779.1	93.6%	95.5%
4	Clear window + C-HE30	774.7	93.1%	95.0%
5	Clear window laminated with C-HE30	778.1	93.5%	95.4%
6	Clear window + C-HE15	785.5	94.4%	96.3%
7	Clear window + C-HE55	748.2	89.9%	91.7%
8	Clear window + C-HH80	746.2	89.7%	91.5%

Table 1. Bright View C-HE30 Diffuser Performance Summary in Typical 4" Downlight

The data indicate that the clear acrylic window (or *lens*) causes about 2% optical loss. BVT obtains its diffuser efficiencies by comparing data between Case No. 2 and Case No. 3 or 4. In this particular luminaire, diffuser film position impacts its efficiency. C-HE30 efficiency is about 95.5% if it was placed before the window, and 95% if placed after the window. Optical coupling (lamination) to the lens/window causes approximately 0.4% of efficiency improvement. Data for a few other Bright View C-Series diffusers are also included.

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In a second case, the performance of a strong diffuser and clear windows are measured on a 2x2 LED troffer. This particular design did not use high-reflectivity white materials or tapered edges – the correspondingly lower efficiency (compared to the downlight above) illustrates the importance of best practices in efficient optical design.

Test No. 2:

Diffuser Performance in a 2x2 LED Troffer:

Light Engine: 2'x2' (600 mm) LED Troffer

Diffuser Film: Bright View C-HH80

Clear Window (Lens) Material: 60 mil (1.5 mm) Clear Acrylic

Case No.	Diffuser Assembly Order (in order from light source toward viewer)	Total Output Flux (lm)	Optical Efficiency relative to Case No. 1
1	No diffuser, no window	4536.7	100%
2	Clear window (acrylic) only	4359.1	96.1%
3	C-HH80 diffuser film only	3875.3	85.4%
4	C-HH80 + Clear Window	3720.3	82.0%
5	Clear window laminated with C-C-HH80	3820.2	84.2%

Table 2. Diffuser Performance in 2'x2' LED Troffer

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Summary:

- The industry-standard transmittance measurement (ASTM D-1003) method for diffuse materials is inadequate to characterize engineered diffuser performance. Due to the strong interaction between various optical components, an illumination system luminous efficiency is not the simple multiplication of component efficiencies.
- Measured total luminous output of two typical lighting fixtures with various diffuser film configurations is provided to demonstrate the efficiency impact of various diffuser sub-components. The data comparison between the two fixtures underscores the strong interaction between optical sub-components – efficiency performance of a simple acrylic window can vary significantly between different illumination systems.
- Bright View Technologies supports customers in every phase of the lighting fixture development cycle, from conceptual simulation stage to final product performance evaluation and optimization.

Both the ASTM D1003 and the LM-79 have limitations, the former due to not fully characterizing the film and the latter due to its strong dependence on the luminaire. Recently BVT has commissioned a more comprehensive characterization of its diffuser products using Bidirectional Scatter Distribution Function (BSDF) measurements. These measurements cover a variety of incident angles, and both transmitted and reflected light distributions. They can be used with optical modeling tools to predict performance before prototypes are built. In combination with those optical simulation capabilities, BSDF data brings tremendous value, enabling customers to evaluate, enhance, and optimize the performance, including efficiency, of their products systematically in a cost-effective manner. Concepts developed in modeling stage can be experimentally verified and measured, and the resulting photometric data can be used to further enhance optical simulation capabilities. The comprehensive BSDF data set for Bright View Technologies most popular films can be found on the web site at www.brightviewtech.com.