



Commercial Branding & Transportation Division

# 3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430

Product Bulletin Series 3430

April 2023

For U.S.A.

Replaces Product Bulletin Series 3430 Dated October 2013

## 1 Description

3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430 (“**Sheeting**”) is a retroreflective sheeting designed for use in the production of reflective commercial signs and noncritical traffic control signs (“**Sign**”) that are exposed vertically in service. The Sheeting can easily be identified by its visible integral “EGP” marking.

For detailed features and benefits of the Sheeting, please refer to the 3M Transportation Safety Division website (<http://www.3M.com/roadsafety>).

3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430 is available in the following colors.

**Table 1.** Product Codes by Color

Color	Product Code
White	3430
Yellow	3431
Green	3437

## 2 Specifications

The Sheeting conforms to all current performance requirements of ASTM D4956 for Type I retroreflective sheeting. Refer to section 7 for information regarding imaging of Sheeting.

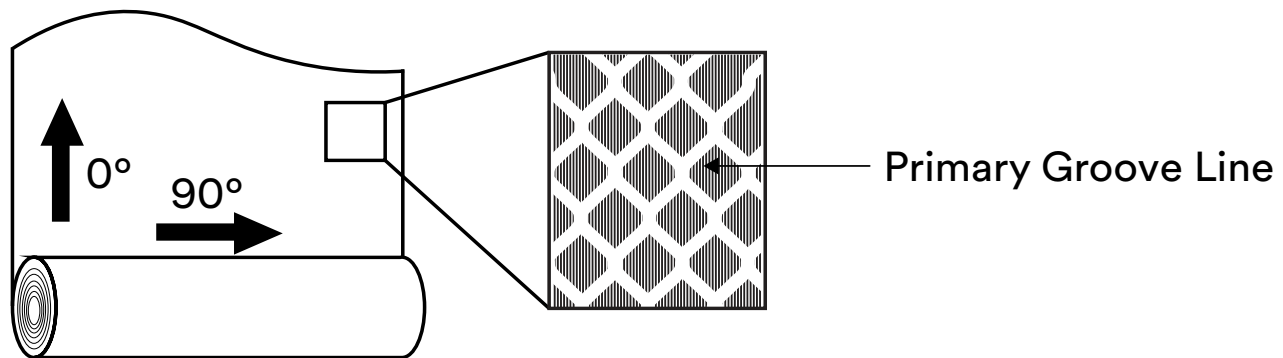
## 3 Physical Properties

### 3.1 Adhesive

Sheeting comes with a pressure-sensitive adhesive that is recommended for application at temperatures of 65 °F (18 °C) and higher.

### 3.2 Entrance Angularity Performance with Respect to Orientation

Sheeting has been designed to be an effective wide angle reflective sheeting regardless of its orientation on the substrate or the ultimate orientation of the Sign after installation. However, because the efficiency of light return from cube corner reflectors is not equal at all application orientations, especially at higher entrance angles, it is possible to get the widest entrance angle light return when the Sheeting is oriented in a particular manner. Sheeting orientation can be used to easily optimize high entrance angle (>50°) performance when it is required for a given Sign (e.g. “keep right” symbols). In such situations, the completed Sign should have the Sheeting positioned at the 0° orientation (downweb direction perpendicular to the road). When the “primary groove line” (which is oriented parallel to the flat sides of the diamond chain links) is vertical on the completed Sign, Sheeting is said to be in a 0° orientation. When the “primary groove line” is horizontal on the completed Sign, the Sheeting is said to be in a 90° orientation. See Figure 1 for details.



**Figure 1.** Primary groove lines used to define Sheeting orientation.

Unless a Sign’s location and/or position calls for extra-wide entrance angularity performance or a specific installation direction is required in a customer specification, Signs and applied copy (letters, arrows, borders, and shields) can be fabricated and installed using the application orientation that most efficiently utilizes the reflective Sheeting.

**Note:** For multi-panel Signs, it is recommended that all background panels be applied with the Sheeting oriented in the same direction.

Sheeting may be processed into traffic Signs using any of the imaging methods described below. 3M assumes no responsibility for the failures of Sign face legends or backgrounds that have been processed with non-3M process colors or with matched component imaging materials other than those listed below.

## 4 Substrates

Refer to [3M Information Folder 1.7](#) for surface preparation recommendations.

Sheeting has been designed primarily for application to flat substrates. Any application to a substrate with a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is required. **Sign failures caused by substrate failures or improper surface preparations are not the responsibility of 3M.**

## 5 Sign Fabrication

### 5.1 Squeeze Roll Application

Sheeting should be applied to Sign substrates at temperatures of 65°F (18°C) and higher using either of the following methods:

**Mechanical squeeze roll applicator** – refer to [3M Information Folder 1.4](#). Applications to extrusions that are edge wrapped require sufficient softening of the Sheeting prior to edge wrapping. Softening can be accomplished by directing additional heat to the “next to last” edge roller. This practice may increase productivity and minimize cracking.

**Hand squeeze roll applicator** – refer to [3M Information Folder 1.6](#) for details.

Background and complete Sign applications of Sheeting must be performed using a roll laminator, either mechanical or hand driven.

### 5.2 Hand Application

Hand application is recommended for legend and copy only. Refer to [3M Information Folder 1.5](#) for more details.

Hand applications will show some visual irregularities which may be objectionable to aesthetically critical customers. These irregularities are more noticeable on darker colors. To obtain a uniform close-up appearance, a roll laminator must be used.

All direct-applied copy and border **MUST** be cut and squeegeed at all metal joints.

### 5.3 Splices

Sheeting must be butt spliced when more than one piece of Sheeting is used on a single piece of substrate. Sheeting pieces should not touch one another. Avoiding overlap prevents the buckling that can occur as Sheeting expands under extreme temperature and humidity conditions.

### 5.4 Double Faced Signs

The Sheeting on the bottom side of a double faced Sign can be damaged if rolled through a squeeze roll applicator using an unprotected steel bottom roller. The use of a semi-soft flat sheet between the steel roller and the applied Sign face will protect the Sign face from damage. Use of a rubber mat, tag board, or cardboard is recommended.

## 6 Imaging

Sheeting may be processed into traffic Signs using the imaging methods described below.

### 6.1 Digital Imaging

Digitally imaged areas of white Sheeting that have been processed according to 3M instructions shall provide coefficients of retroreflection of not less than 70% of the values of the corresponding ASTM D4956 Type I sheeting colors. The daytime luminance and chromaticity shall conform to ASTM D4956 tables 2 and 11, respectively.

Conformance to the ASTM D4956 performance requirements for Type I sheeting has been established when 3M printing requirements and procedures are followed. Most consistent results are achieved when 3M's system of matched component materials (Tables 5 and 6) are used.

Use of Sheeting is not restricted to the inks/printers listed below. Sheeting may perform adequately with select latex, solvent and UV ink jet inks and printers. Please contact your 3M representative for more information on ink and print system compatibilities.

**Table 2.** Matched components and traffic color availability for permanent regulated or non-regulated traffic control signs and stickers.

3M Digital Printing Solutions <sup>a</sup>	Traffic Colors	Ink	Overlay Film
HP Latex 360/365	Red, green, and black	HP Series 831 Inkjet Ink	3M™ ElectroCut™ Film Series 1170C or 3M™ Premium Protective Overlay Film Series 1160i

a. Must be printed according to all requirements described in printer specific 3M Information Folders, including printer settings and profiles.

## 6.2 Screen Processing

The Sheeting may be screen processed into traffic Signs, using 3M Process Colors Series 880I (see [3M Product Bulletin 880I](#)) or Series 880N (see [3M Product Bulletin 880N](#)), before or after being mounted onto a Sign substrate. Series 880I and 880N process colors can be screened at temperatures of 60-100°F (16-38°C) and relative humidities of 20-50%. A P.E. 157 screen mesh with a fill pass is recommended. See [3M Information Folder 1.8](#) for details regarding screen processing. The use of process colors other than Series 880I or 880N is not recommended. 3M assumes no responsibility for failures of Sign face legends or backgrounds that have been processed with process colors other than those listed above.

The  $R_A$  values of areas of white Sheeting screen printed with 3M transparent inks or covered with 3M™ ElectroCut™ Film Series 1170 should be no less than 70% of the minimum  $R_A$  values of the corresponding Sheeting colors.

3M process colors and colored film, when used according to 3M recommendations, will meet the applicable ASTM D4956 specifications of the equivalent integrally colored sheeting. However, dilution of color and atmospheric conditions may result in reduced durabilities. 3M ElectroCut Film Series 1170 can be expected to perform satisfactorily for the life of the Sign when direct applied to the Sheeting.

Care should be taken to avoid flexing Sheeting before, and especially after, screening to minimize the possibility of cracking from improper handling.

## 6.3 3M™ ElectroCut™ Film

3M™ ElectroCut™ Film Series 1170 may be used on Sheeting to provide transparent colored background copy for traffic control Signs. Refer to [3M Product Bulletin 1170](#) for fabrication procedures.

## 6.4 Applying Cut-Out Copy

3M™ Engineer Grade Prismatic Reflective Sheeting may be applied to sheeting backgrounds to create Sign legends. Refer to [3M Information Folder 1.10](#) for more information.

# 7 Cutting

Sheeting may be cut into letters and shapes with heights of at least 3 inches and stroke widths of at least ½ inch. Smaller sizes are not recommended. Sealing the cut edges of Sheeting is not required.

## 7.1 Plotter Cutting

- 1 Flat bed plotters can be used to cut Sheeting and offer the most consistent and reliable performance.
- 2 Friction fed plotters can be used to kiss cut only. This is achieved using 600 grams of down force and a 60° cutting blade. Additional drive wheels may be needed to improve tracking. Alternatively, Sheeting can be cut from the liner side. To do so, the blade force and knife depth must be set to score, but not cut through, the top film. After scoring, break apart individual copy or apply premask to retain spacing.

## 7.2 Other Cutting Methods

Sheeting may be hand cut or die cut one sheet at a time. Cutting procedures can be found in [3M Information Folder 1.10](#).

## 8 Installation

Nylon washers are required when twist style fasteners are used to mount Signs

## 9 Shelf-Life, Processing, Storage, Packaging, and Cleaning

Please refer to [3M Information Folder 1.11](#).

## 10 Durability

Please refer to [3M Information Folder 1.7](#). Periodic Sign inspection and regular Sign replacement are strongly recommended in order to help Sign owners establish their own effective service life expectations, beyond the warranty period.

## 11 Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheets (SDS), Article Information Sheets, and products labels of any materials for important health, safety, and environmental information prior to handling or use. To obtain SDSs and Article Information Sheets for 3M products, go to [3M.com/SDS](http://3M.com/SDS), contact 3M by mail, or for urgent requests call 1-800-364-3577.

## 12 Warranty Information

### 12.1 3M Standard Warranty

The Sheeting is warranted ("3M Standard Warranty") to be free of defects in materials and manufacture at the time of shipment and to meet the specifications stated in this product bulletin. If the Sheeting is proven not to have met the 3M Standard Warranty on their shipment date, then a buyer's exclusive remedy, and 3M's sole obligation, at 3M's option, will be refund or replacement of the Sheeting.

### 12.2 Disclaimer

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM, OR USAGE OF TRADE.

### 12.3 Limitation of Liability

Except for the limited remedy stated above, and except where prohibited by law, 3M will not be liable for any loss or damage arising from the Signs or any 3M product, whether direct, indirect, special, incidental, or consequential damages (including but not limited to lost profits, business, or revenue in any way), regardless of the legal theory asserted including warranty, contract, negligence, or strict liability.

## 13 Other Product Information

Always confirm that you have the most current version of the applicable product bulletin, information folder, or other product information from 3M's Website at <http://www.mmm.com/roadsafety>.

## 14 Literature References

<a href="#">3M IF 1.4</a>	Instructions for Interstate Squeeze Roll Applicator
<a href="#">3M IF 1.5</a>	Hand Application Instructions
<a href="#">3M IF 1.6</a>	Hand Squeeze Roll Applicator
<a href="#">3M IF 1.7</a>	Sign Base Surface Preparation
<a href="#">3M IF 1.8</a>	Process Colors Series 880 and 900 Instructions for Use
<a href="#">3M IF 1.10</a>	Cutting, Premasking, and Prespacing
<a href="#">3M IF 1.11</a>	Sign Maintenance Management
<a href="#">3M PB 880I</a>	3M™ Process Color Series 880I
<a href="#">3M PB 880N</a>	3M™ Process Color Series 880N
<a href="#">3M PB 1170</a>	3M™ ElectroCut™ Film Series 1170

ASTM Test Methods are available from ASTM International, West Conshohocken, PA.

## For Information or Assistance

Call: 1-800-553-1380

In Canada Call:

1-800-3M HELPS (1-800-364-3577)

## Internet:

<http://www.3M.com/roadsafety>

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Commercial Branding &  
Transportation Division  
3M Center, Building 223-3S-33  
St. Paul, MN 55144-1000 USA

Phone [1-800-553-1380](tel:1-800-553-1380)  
Web [3M.com/roadsafety](http://3M.com/roadsafety)

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Transportation Safety Division

# 3M™ High Intensity Prismatic Reflective Sheeting Series 3930

Product Bulletin Series 3930  
February 2023

Replaces Product Bulletin Series 3930 Dated June 2021

## 1 Description

3M™ High Intensity Prismatic Reflective Sheeting Series 3930 (“**Sheeting**”) is a reflective prismatic sheeting designed for use in the production of durable reflective traffic control and guidance signs (“**Signs**”) that are exposed vertically in service.

For details of the features and benefits of Sheeting, please refer to the 3M Transportation Safety Division website (<http://www.3M.com/roadsafety/>).

The Sheeting is available in the following colors.

**Table 1.** Product codes by color.

Color	Product Code
White	3930
Yellow	3931
Red	3932
Orange	3934
Blue	3935
Green	3937
Brown	3939



## 2 Specifications

The Sheeting conforms to all current performance requirements of ASTM D4956 for Type III and Type IV retroreflective sheeting. Refer to section 7 for information regarding imaging of Sheeting.

## 3 System of Matched Components

For a complete list of matched components for the Sheeting, please see the [3M™ Sign Warranty Bulletin](#).

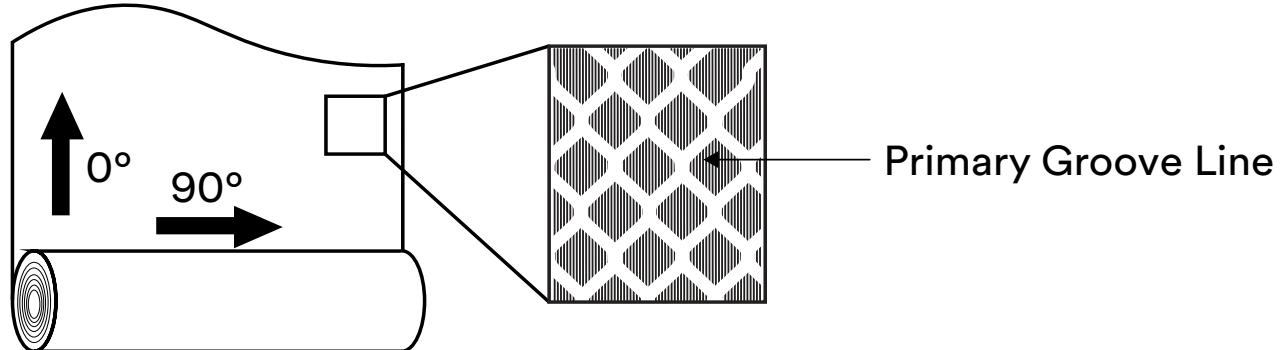
## 4 Physical Properties

### 4.1 Adhesive

Sheeting has a pressure-sensitive adhesive that is recommended for application at temperatures of 65 °F (18 °C) and higher. Meets ASTM D4956 Class I adhesive requirement.

### 4.2 Entrance Angularity Performance with Respect to Orientation

Sheeting has been designed to be an effective wide angle reflective sheeting regardless of its orientation on the substrate or the ultimate orientation of the Sign after installation. However, because the efficiency of light return from cube corner reflectors is not equal at all application orientations, especially at higher entrance angles, it is possible to get the widest entrance angle light return when the Sheeting is oriented in a particular manner. Sheeting orientation can be used to easily optimize high entrance angle (>50°) performance when it is required for a given Sign (e.g. “keep right” symbols). In such situations, the completed Sign should have the Sheeting positioned at the 0° orientation (downweb direction perpendicular to the road). When the “primary groove line” (which is oriented parallel to the flat sides of the diamond chain links) is vertical on the completed Sign, Sheeting is said to be in a 0° orientation. When the “primary groove line” is horizontal on the completed Sign, the Sheeting is said to be in a 90° orientation. See Figure 1 for details.



**Figure 1.** Primary groove lines used to define Sheeting orientation.

Unless a Sign’s location and/or position calls for extra-wide entrance angularity performance or a specific installation direction is required in a customer specification, Signs and applied copy (letters, arrows, borders, and shields) can be fabricated and installed using the application orientation that most efficiently utilizes the reflective Sheeting.

**Note:** For multi-panel Signs, it is recommended that all background panels be applied with the Sheeting oriented in the same direction.

## 5 Substrates

Refer to [3M Information Folder 1.7](#) for surface preparation recommendations.

Sheeting has been designed primarily for application to flat substrates. Any application to a substrate with a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is required. **Sign failures caused by substrate failures or improper surface preparations are not the responsibility of 3M.**

## 6 Sign Fabrication Methods

### 6.1 Squeeze Roll Application

Sheeting should be applied to Sign substrates at temperatures of 65 °F (18 °C) and higher using either of the following methods:

**Mechanical squeeze roll applicator** – refer to [3M Information Folder 1.4](#). Applications to extrusions that are edge wrapped require sufficient softening of the Sheeting prior to edge wrapping. Softening can be accomplished by directing additional heat to the “next to last” edge roller. This practice may increase productivity and minimize cracking.

**Hand squeeze roll applicator** – refer to [3M Information Folder 1.6](#) for details.

Background and complete Sign applications of Sheeting must be performed using a roll laminator, either mechanical or hand driven.

### 6.2 Hand Application

Hand application is recommended for legend and copy only. Refer to [3M Information Folder 1.5](#) for more details.

Hand applications are more likely to show visual irregularities that may be objectionable to aesthetically critical customers. These irregularities are more noticeable on darker colors. To obtain a uniform close-up appearance, a roll laminator must be used.

All direct applied copy and border **MUST** be cut and squeegeed at all metal joints.

### 6.3 Splices

Sheeting must be butt spliced when more than one piece of Sheeting is used on a single piece of substrate. Sheeting pieces should not touch one another. Avoiding overlap prevents the buckling that can occur as Sheeting expands under extreme temperature and humidity conditions.

### 6.4 Double Faced Signs

The Sheeting on the bottom side of a double faced Sign can be damaged if rolled through a squeeze roll applicator using an unprotected steel bottom roller. The use of a semi-soft flat sheet between the steel roller and the applied Sign face will protect the Sign face from damage. Use of a rubber mat, tag board, or cardboard is recommended.

## 7 Imaging

Sheeting may be processed into traffic Signs using the imaging methods described below. Compatibility is backed with a 3M™ MCS™ Warranty or 3M™ MCS™ Warranty for Traffic when the printing guidelines referred to in the Literature References of Section 15 are followed. See Section 13 of this document for more information regarding the warranties. 3M assumes no responsibility for the failures of Sign face legends or backgrounds that have not been processed according to the [3M Sign Warranty Bulletin](#).

### 7.1 Digital Imaging

Sheeting is compatible with 3M qualified latex inkjet printers and ink systems. Refer to [3M Information Folder 1.17](#) and [HP Large Format Printing Knowledge Center](#) for details. Use of 3M™ ElectroCut™ Film 1170C or 3M™ Premium Protective Overlay Film Series 1160i is required.

### 7.2 Screen Processing

Sheeting may be screen processed into traffic Signs using 3M™ Process Colors Series 880I or 3M™ Process Colors Series 880N before or after being mounted onto a substrate. Refer to [3M Information Folder 1.8](#) for details. Clear coating is neither required nor recommended. Use of process color series other than 880I or 880N is not recommended.

### 7.3 3M™ ElectroCut™ Film

3M™ ElectroCut™ Film Series 1170 may be used on Sheeting to provide transparent colored background copy for traffic control Signs. Refer to [3M Product Bulletin 1170](#) for fabrication procedures.

### 7.4 Applied Cut-Out Copy

Sheeting cut-out copy may be applied to Sheeting backgrounds to create Sign legends. Refer to [3M Information Folder 1.10](#) for more information.

## 8 Cutting

Sheeting may be cut into letters and shapes with heights of at least 3 inches and stroke widths of at least ½ inch. Smaller sizes are not recommended. Sealing the cut edges of Sheeting is not required.

### 8.1 Plotter Cutting

- 1 Flat bed plotters can be used to cut Sheeting and offer the most consistent and reliable performance.
- 2 Friction fed plotters can be used to kiss cut only. This is achieved using 600 grams of down force and a 60° cutting blade. Additional drive wheels may be needed to improve tracking. Alternatively, Sheeting can be cut from the liner side. To do so, the blade force and knife depth must be set to score, but not cut through, the top film. After scoring, break apart individual copy or apply premask to retain spacing.

### 8.2 Other Cutting Methods

Sheeting may be hand cut or die cut one sheet at a time. Cutting procedures can be found in [3M Information Folder 1.10](#).

## 9 Installation

Nylon washers are required when twist style fasteners are used to mount Signs.

## 10 Shelf-Life, Processing, Storage, Packaging, and Cleaning

Please refer to [3M Information Folder 1.11](#).

## 11 Durability

Please refer to [3M Information Folder 1.7](#). Periodic Sign inspection and regular Sign replacement are strongly recommended in order to help Sign owners establish their own effective service life expectations, beyond the warranty period.

## 12 Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheets (SDS), Article Information Sheets, and products labels of any materials for important health, safety, and environmental information prior to handling or use. To obtain SDSs and Article Information Sheets for 3M products, go to [3M.com/SDS](#), contact 3M by mail, or for urgent requests call 1-800-364-3577.

## 13 Warranty Information

### 13.1 3M Standard Product Warranty

The Sheeting is warranted (“3M Standard Warranty”) to be free of defects in materials and manufacture at the time of shipment and to meet the specifications stated in this product bulletin. If the Sheeting is proven not to have met the 3M Standard Warranty on their shipment date, then a buyer’s exclusive remedy, and 3M’s sole obligation, at 3M’s option, will be refund or replacement of the Sheeting.

### 13.2 3M™ MCS™ Warranty and 3M™ MCS™ Warranty for Traffic

For warranty on digitally printed Sheeting, please refer to the [3M Sign Warranty Bulletin](#).

### 13.3 Disclaimer

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM, OR USAGE OF TRADE.

### 13.4 Limitation of Liability

Except for the limited remedy stated above, and except where prohibited by law, 3M will not be liable for any loss or damage arising from the Signs or any 3M product, whether direct, indirect, special, incidental, or consequential damages (including but not limited to lost profits, business, or revenue in any way), regardless of the legal theory asserted including warranty, contract, negligence, or strict liability.

## 14 Other Product Information

Always confirm that you have the most current version of the applicable product bulletin, information folder, or other product information from 3M's Website at <http://www.3M.com/roadsafety>.

## 15 Literature References

<a href="#">3M IF 1.4</a>	Instructions for Interstate Squeeze Roll Applicator
<a href="#">3M IF 1.5</a>	Hand Application Instructions
<a href="#">3M IF 1.6</a>	Hand Squeeze Roll Applicator
<a href="#">3M IF 1.7</a>	Sign Base Surface Preparation
<a href="#">3M IF 1.8</a>	Process Colors Series 880 and 900 Instructions for Use
<a href="#">3M IF 1.10</a>	Cutting, Premasking, and Prespacing
<a href="#">3M IF 1.11</a>	Sign Maintenance Management
<a href="#">3M IF 1.17</a>	User Guide 3M™ Reflective Sheeting and HP Latex 360/365 Printers
<a href="#">3M PB 880I</a>	3M™ Process Color Series 880I
<a href="#">3M PB 880N</a>	3M™ Process Color Series 880N
<a href="#">3M PB 1160</a>	Premium Protective Overlay Film
<a href="#">3M PB 1160i</a>	3M™ Premium Protective Overlay Film 1160i
<a href="#">3M PB 1170</a>	3M™ ElectroCut™ Film Series 1170
<a href="#">3M PB Slipsheeting</a>	3M™ Slipsheeting
<a href="#">3M Sign Warranty Bulletin</a>	
<a href="#">3M™ MCS™ Warranty for Traffic Matrix for ElectroCut™ Film Series 1170</a>	
<a href="#">3M™ MCS™ Warranty for Traffic Matrix for Screen Printed Signs</a>	
<a href="#">3M™ MCS™ Warranty for Traffic Matrix for Unimaged 3M™ Retroreflective Sheeting</a>	
<a href="#">3M™ MCS™ Warranty Matrix for HP Latex 360/365 Printers</a>	
<a href="#">3M™ MCS™ Warranty for Traffic Matrix HP 360-365</a>	
<a href="#">3M™ MCS™ Warranty Matrix for HP Latex 1500 Printer</a>	
<a href="#">3M™ MCS™ Warranty Matrix for Traffic for HP Latex 1500 Printer</a>	
<a href="#">HP 700, HP 800 Matrix</a>	
<a href="#">HP 700, HP 800 Matrix for Traffic</a>	

[HP Large Format Printing Knowledge Center](#)

ASTM Test Methods are available from ASTM International, West Conshohocken, PA.

## For Information or Assistance

Call: 1-800-553-1380

In Canada Call:

1-800-3M HELPS (1-800-364-3577)

## Internet:

<http://www.3M.com/roadsafety>

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**Transportation Safety Division**  
3M Center, Building 223-3S-33  
St. Paul, MN 55144-1000 USA

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# Diamond Grade™ Fluorescent VIP Reflective Sheeting

Visual Impact Performance (VIP)  
Series 3980

Product Bulletin 3980

September 2005

Replaces PB 3980 dated November 2002

## Description

3M™ Diamond Grade™ Fluorescent VIP Reflective Sheeting is a visible-activated fluorescent wide angle prismatic lens reflective sheeting designed for the production of durable traffic control signs and delineators that are exposed vertically in service. This sheeting is designed to provide higher nighttime sign brightness than sheetings that use glass bead lenses and higher daytime brightness than ordinary (non-fluorescent) colored sheetings. It is intended to also provide high sign brightness in the legibility distance where other sheetings do not. This feature is shown by the values at 1.0° observation angle in Table C which represents these viewing geometries. VIP sheeting also provides brightness at high entrance angles shown by the values at 40° in Table C. Applied to properly prepared sign backings, fluorescent VIP sheeting should provide long term service.

### Color

Fluorescent Yellow  
Fluorescent Yellow Green

### Product Code

3981  
3983

## Photometrics

### Daytime Color (x,y,Y)

The chromaticity coordinates and total luminance factor of the retroreflective sheeting conform to Table A.

### Color Test

Conformance to daytime color requirements of Table A shall be determined instrumentally on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 illuminating and viewing geometry<sup>1</sup>. The bispectral radiance factor matrix (Donaldson matrix) shall be obtained in accordance with ASTM E 2153 "Practice for Obtaining Bispectral Photometric Data for Evaluation of Fluorescent Color". The total chromaticity coordinates and total luminance factor shall be computed from the Donaldson matrix in accordance with ASTM E2152 "Practice for Computing the Colors of Fluorescent Objects from Bispectral Data" for CIE illuminant D65 and the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

Table A - CIE Daytime Chromaticity Coordinate Limits\* and Total Luminance Factor Minimum

Color	x	y	x	y	x	y	x	y	Total Luminance Factor Y (%) Min.
Yellow	.521	.424	.557	.442	.479	.520	.454	.491	45
Yellow Green	.390	.610	.460	.540	.421	.486	.368	.539	60

\*The four pairs of chromaticity coordinates define the acceptable color limits for CIE D65 illumination in terms of the CIE 1931 Standard Colorimetric System when measured using a 2-monochromator spectrophotometer employing annular 45/0 illuminating and viewing geometry.



## Fluorescence ( $Y_F$ )

Fluorescent luminance properties differentiate fluorescent sheeting from ordinary (non-fluorescent) sheeting. The Fluorescence Luminance Factor,  $Y_F$ , provides a standardized measure of the sheeting fluorescent properties. The numerical value of  $Y_F$  sheeting under specified illumination and viewing conditions verifies the fluorescent properties of the sign sheeting (for non-fluorescent sheeting  $Y_F=0$ ). The minimum fluorescence luminance factor ( $Y_F$ ) values of the retroreflective sheeting conform to Table B.

**Table B - Fluorescence Luminance Factor Minimum for New Sheeting**

Color	$Y_F$ (%) min.
Yellow	25
Yellow Green	35

## Fluorescence Test

Conformance to fluorescence luminance factor requirements shall be determined instrumentally, on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0/45) illuminating and viewing geometry.<sup>1&2</sup> The fluorescence luminance factor shall be calculated from the fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-308 “Practice for Computing the Colors of Objects by Using the CIE System” for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

<sup>1</sup> “Design and testing of a two-monochromator reference spectrofluorimeter for high-accuracy total radiance factor measurements” by Joanne C. Zwinkels, D.S. Gignac, M. Nevins, I. Powell, and A. Bewsher, Applied Optics, Vol. 36 no. 4, pp. 892-902 (1997).

<sup>2</sup> “Principles of Bispectral Fluorescence Colorimetry” by Jim Leland, N. Johnson, and A. Arecchi, Proceedings of SPIE - The International Society for Optical Engineering: Vol. 3140, pp. 76-87 (1997).

## Coefficients of Retroreflection ( $R_A$ )

The values in Table C are minimum coefficients of retroreflection expressed in candelas per lux per square meter ( $\text{cd/lux/m}^2$ ).

## Test for Coefficients of Retroreflection

Conformance to coefficient of retroreflection requirements shall be determined by instrumental method in accordance with ASTM E-810 “Test Method for Coefficient of Retroreflection of Retroreflective Sheeting”, and per E-810 the values of 0° and 90° rotation are averaged to determine the  $R_A$  in Table C.

**Table C - Minimum Coefficient of Retroreflection  $R_A$  for New Sheeting ( $\text{cd/lux/m}^2$ )**

Sheeting	Observation <sup>3</sup> Angle	Entrance Angle <sup>4</sup>		
		-4°	30°	40°
Fluorescent Yellow	0.2°	240	150	55
	0.5°	165	81	15
	1.0°	48	27	6
Fluorescent Yellow Green	0.2°	325	200	75
	0.5°	236	110	23
	1.0°	65	36	9

<sup>3</sup> Observation (Divergence) Angle - The angle between the illumination axis and the observation axis.

<sup>4</sup> Entrance (Incidence) Angle - The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

## Nighttime Color (x,y)

The chromaticity coordinates of the reflective sheeting conform to Table D.

## Nighttime Color Test

Conformance to nighttime color requirements shall be determined instrumentally on sheeting applied to aluminum test panels. Testing shall be in accordance with ASTM E-811. The total chromaticity coordinates shall be calculated from the total spectral radiance factors measured under

**Table D - Nighttime Color Specification Limits For New Sheeting\* Chromaticity Coordinate**

Color	x	y	x	y	x	y	x	y
Fluorescent Yellow	0.554	0.445	0.610	0.390	0.569	0.394	0.527	0.436
Fluorescent Yellow Green	0.480	0.520	0.550	0.449	0.524	0.439	0.472	0.492

\*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with CIE standard illuminant A.

CIE illuminant A and computed in accordance with ASTM E-308 "Practice for Computing the Colors of Objects by Using the CIE System" for the CIE 1931 (2°) standard colorimetric observer.

## Orientation

Diamond Grade fluorescent VIP sheeting is designed to be an effective wide angle reflective sheeting regardless of its orientation on the substrate or ultimate orientation after installation. However, because the efficiency of light return from cube corner reflectors is not equal at all rotation angles, it is possible to get the widest entrance angle light return when the sheeting is oriented in a particular way.

When extra wide entrance angle performance is important for a given sign type or situation, you may elect to make the signs with a specific orientation. However, unless the location and/or position calls for extra-wide entrance angularity performance signs can be manufactured and installed using the orientation that most efficiently utilizes the reflective sheeting.

For purposes of test measurement of the sheeting, it is important for the material to have a datum mark (the orientation arrows) so that the sample can be properly oriented in the test machinery. In those situations where extra wide entrance angle performance is required, this arrow can be used to assure the preferred orientation.

## Interlocking Diamond Seal Pattern

Series 3980 sheeting has the same interlocking seal pattern as series 3990 sheeting. This pattern is unique to 3M wide angle prismatic retroreflective sheetings. Because of the small cube corners used in series 3980 sheeting, the seal cell walls or "legs" appear smooth.

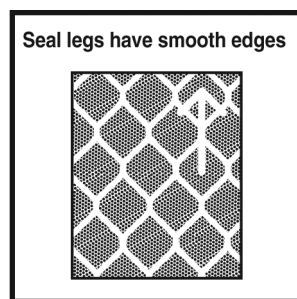


Figure 1 - Sheeting is positioned at a 0° angle.

## Datum Marks (Arrows)

Series 3980 sheeting is made with small arrows in the surface repeated down the roll staggered at 20 inches and across the roll at regular intervals (Figure 2). These arrows which point down the length of the roll serve as reference marks for

photometric testing. The arrows are also used as visual aids to sheeting orientation when fabricating signs for special high entrance angle situations. The design of these arrows differentiate VIP sheeting from other Diamond Grade sheetings.

## Tooling Lines

The manufacturing of a prismatic sheeting results in tooling lines being present in the product. In Diamond Grade fluorescent VIP sheeting these lines are slightly thicker than the seal pattern legs. Tooling lines are noticeable in shop light but are not observable on the road either in daylight or at night under typical use conditions (Figure 2).

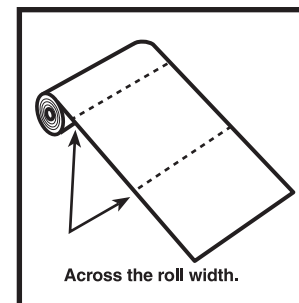


Figure 2 - Tooling Lines

## Adhesive

Series 3980 sheeting has a pressure-sensitive adhesive that is recommended for room temperature application. Room temperature application is defined as 65°F (18°C) or higher.

## Test Methods of Adhesive and Film

### Standard Test Panels

Unless otherwise specified, herein, sheeting shall be applied to test panels in accordance with ASTM D4956-01, section 7.2 and test conditions shall conform to ASTM D4956 section 7.1.

### Properties

Standard Conditioning - all mounted and unmounted test specimens shall be conditioned for 24 hours at 73°F ± 2°F (23°C ± 1°C) and 50% ± 4% R.H. before testing.

#### 1. Adhesive

The retroreflective sheeting shall comply with the liner removal and adhesion requirements contained in ASTM D4956 sections 7.10 and 7.5 respectively.

#### 2. Impact Resistance

Test Method - Apply sheeting to a standard panel 3 inch x 6 inch (7.6x15.2cm) and condition. Subject sheeting to a 50 inch pounds (5.7Nm) impact in accordance with ASTM D-2794.

Requirement - No separation from panel or cracking outside immediate impact area.



### 3. Shrinkage

The retroreflective sheeting shall comply with the shrinkage requirements contained in ASTM D4956 sections 7.10 and 7.5 respectively.

### 4. Flexibility

Test Method - Following conditioning of 1 inch x 6 inch sample, remove liner and dust adhesive with talc. At standard conditions, bend in one second around 1/8 inch (3.2mm) mandrel with adhesive side facing mandrel.

Requirement - No cracking, peeling or delamination.

### 5. Gloss

Test Method - Test in accordance with ASTM D523 using an 85° glossmeter.

Requirement - Rating not less than 50.

### 6. Optical Stability

Test Method - Apply sheeting to standard panel and condition. Measure coefficients of retroreflection for all test geometries. Expose panel in an air circulating oven at  $160 \pm 5^\circ\text{F}$  ( $71 \pm 3^\circ\text{C}$ ) for a period of 24 hours. Re-condition after exposure and re-measure at all test geometries.

Requirement - Coefficients of retroreflection measured after exposure shall be between 85% and 115% of the values measured before exposure.

## Sign Fabrication Methods

### Application

Diamond Grade fluorescent VIP sheeting series 3980 incorporates a pressure-sensitive adhesive and should be applied to the sign substrate at room temperature ( $65^\circ\text{F}/18^\circ\text{C}$ ) or higher by any of the following methods:

Mechanical squeeze roll applicator - IF 1.4\*

Application to extrusions requires heat directed at the next-to-last edge roller. Cracking may occur if the top film is not sufficiently softened.

Hand squeeze roll applicator - IF 1.6

Hand application - IF 1.5

\*Note - never direct the Calrod™ heater at the sheeting during application. If the heater is needed to warm to the minimum application temperature of  $65^\circ\text{F}$ , direct it at the substrate only.

### Hand Application

Hand application is recommended for legend and copy only. Application of Diamond Grade sheeting for complete signs or backgrounds must be done with a roll laminator, either mechanical or hand. See Information Folder 1.5 for more details.

Hand applications will show some visual irregularities which are objectionable to

aesthetically critical customers. These are more noticeable on darker colors. To obtain a close-up uniform appearance, a roll laminator must be used.

All direct applied copy and border MUST be cut at all metal joints and squeegeed at the joint.

### Splices

Series 3980 sheeting should be butt spliced when more than one piece of sheeting is used on one piece of substrate. The sheeting pieces should not touch each other at the splice and a gap of up to 1/16 inch is acceptable. This is to prevent buckling as the sheeting expands in extreme temperature/humidity exposure.

If the visual appearance of the splice is important or a slight gap is undesirable, the following procedures must be followed:

1. Overlap the sheeting at least one inch, with or without the liner attached.
2. Using a straight edge and a sharp utility knife, cut through both layers of reflective sheeting.
3. Peel back and remove cut remnants. If liner was left on, remove and roll down remaining sheeting.
4. Seal edge with thinned 880 Clear using a fine artist paint brush.

### Double Faced Signs

Series 3980 sheeting on the first side must be protected from damage from the steel bottom roll of squeeze roll applicators with FR-2 sponge rubber and SCW82.

### Substrates

For traffic sign use, product application is limited to properly prepared aluminum (see Information Folder 1.7). Extrusions are to be wrapped, and flat panel signs are to be carefully trimmed so that sheeting from adjacent panels do not touch on the assembled signs. Users are urged to carefully evaluate all other substrates for adhesion and sign durability. Diamond Grade fluorescent VIP sheeting is designed primarily for application to flat substrates. Any use that requires a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is essential. Sign failures caused by the substrate or improper surface preparation are not the responsibility of 3M.

### Screen Processing

Fluorescent VIP sheeting may be screen processed into traffic signs before or after mounting on a sign substrate, using 3M™ Process Colors Series 880 (see Product Bulletin 880).

Series 880 process colors can be screen processed at 60-100°F (16-38°C) at relative humidity of 20-50%. A PE 157 screen mesh with a fill pass is recommended. See Information Folder 1.8 for details. Use of other process colors series is not recommended.

3M assumes no responsibility for failure of sign face legends or backgrounds that have been processed with non-3M process colors or 3M process colors other than those listed above.

**Care should be taken to avoid flexing the sheeting before and especially after screening to eliminate the possibility of cracking from improper handling techniques.**

### **Cutting and Matching**

The sheeting may be hand cut or die cut one sheet at a time, and band sawed or guillotined in stacks. VIP sheeting can be hand cut from either side with a razor blade or other sharp hand tool. Like all reflective sheetings, when two or more pieces are used side by side on a sign, they must be matched to assure uniform day color and night appearance.

Cutting equipment such as guillotines and metal shears which have pressure plates on the sheeting when cutting may damage the optics. Padding the pressure plate and easing significantly reduces it down onto the sheets being cut will eliminate damage. Maximum stack height for cutting VIP sheeting is 1-1/2 inch or 50 sheets. Details on cutting can be found in Information Folder 1.10.

Multi-piece signs should have all panels or pieces oriented identically for uniform appearance (arrow and the seal pattern in the same direction).

Edge sealing VIP sheeting is generally not required. Following extended exposure, airborne dust particles may become trapped within the row of cut cells along the sheeting edge. This should have no adverse effect on sign performance. If the user chooses to edge seal, series 880 toner should be used.

### **Health and Safety Information**

Read all health hazard, precautionary and first aid statements found in the Material Safety Data Sheet and/or product label of chemicals prior to handling or use.

### **General Performance Considerations**

The durability of Diamond Grade fluorescent VIP reflective sheeting Series 3980 will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance.

Maximum durability of Series 3980 sheeting can be expected in applications subject to vertical

exposure on stationary objects when processed and applied to properly prepared aluminum according to 3M recommendations provided in Information Folder 1.7 on Sign Substrate Surface Preparation.

The user must determine the suitability of any nonmetallic sign backing for its intended use. Applications to unprimed, excessively rough or non-weather-resistant surfaces, or exposure to severe or unusual conditions can shorten the performance in such applications.

Signs in mountainous areas that are covered by snow for prolonged periods may also have reduced durability.

**Color stability** - Diamond Grade fluorescent VIP sheeting will change in color appearance at a rate comparable to non-fluorescent sheeting during the warranty period.

After the warranty period, the color of fluorescent VIP sheeting may degrade more rapidly than nonfluorescent sheeting. The rate of fluorescent degradation is accelerated in climates with high levels of solar irradiation and high temperatures. Color changes may be expected to first appear on south-facing signs.

Periodic sign inspection and regular sign replacement are strongly recommended in order for agencies to establish their own effective service life expectation, beyond the warranty period.

3M™ Scotchcal™ Film 3655 Black, Scotchcal film 7720-12, 3M™ Controltac™ Film 180-12 Black, and 3M™ Electrocut™ Film Series 1170 can be expected to perform satisfactorily for the life of the sign when direct applied to series 3980 sheeting, except where shortened durability is stated in the literature.

### **Cleaning**

Signs that require cleaning should be flushed with water, then washed with a detergent solution and bristle brush or sponge. Avoid pressure that may damage the sign face. Flush with water following washing. Do not use solvents to clean signs. See Information Folder 1.10.

### **Storage and Packaging**

Fluorescent VIP sheeting should be stored in a cool, dry area, preferably at 65-75°F (18-24°C) and 30-50% relative humidity and should be applied within one year of purchase.

Rolls should be stored horizontally in the shipping carton. Partially used rolls should be returned to the shipping carton or suspended horizontally from a rod or pipe through the core. Unprocessed sheets should be stored flat.

Finished signs and applied blanks should be stored on edge.

Screen processed signs must be protected with SCW 568 slipsheet paper. Place the glossy side of the slipsheeting against the sign face and pad the face with closed cell packaging foam. Double faced signs must have the glossy side of the slip-sheet against each face of the sign.

Unmounted screened faces must be stored flat and interleaved with SCW 568 slipsheet, glossy side against the sign face. Packages of finished sign faces must include sufficient nylon washers for mounting.

Avoid banding, crating, or stacking signs.

Package for shipment in accordance with commercially accepted standards to prevent movement and chafing. Store sign packages indoors on edges.

Panels or finished signs must remain dry during shipment and storage. If packaged signs become wet, unpack immediately and allow signs to dry. See Information Folder 1.11 for instructions on packing for storage and shipment.

## Installation

Nylon washers are recommended between the heads of all twist fasteners (such as screw heads, bolts, or nuts) and the sheeting to protect the sheeting from the twisting action of the bolt heads.

## Warranty

3M warrants that Diamond Grade™ Fluorescent VIP Reflective Sheeting Series 3980, sold by 3M after June 1, 2000, to be used as components for traffic control and guidance signs in the United States and Canada will remain effective for its

intended use for ten years\* (see footnote for warranty exceptions), subject to the following provisions.

If a Diamond Grade fluorescent sign surface is processed and applied to sign blank materials in accordance with all 3M application and fabrication procedures found in 3M's product bulletins, information folders and technical memos (which will be furnished to the agency upon request), including the exclusive use of 3M matched component systems, process colors, clear coatings, electronic cuttable films, 1160 protective overlay films, and recommended application equipment; and if the sign deteriorates due to natural causes to the extent that: (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision; or (2) the coefficient of retroreflection, after cleaning, is less than the minimums specified in Table E; or (3) the total luminance factor and the fluorescence luminance factor, after cleaning, are less than the minimums specified in Table E; or (4) the daytime chromaticity, after cleaning, falls outside the limits specified in Table A; or (5) the nighttime chromaticity, after cleaning, falls outside the limits specified in Table D; 3M's sole responsibility and purchaser's and user's exclusive remedy will be:

For those states with a 10 year warranty, if the failure occurs within the first 7 years from the date of fabrication, 3M will, at its expense, restore the sign surface to its original effectiveness. If the failure occurs in the 8<sup>th</sup> through the 10<sup>th</sup> year from the date of fabrication, 3M will furnish the necessary amount of Diamond Grade fluorescent

**Table E - Minimum Coefficient of Retroreflection and Luminance Factors**  
(All measurements shall be made after cleaning according to 3M recommendations.)

Color	Minimum Coefficient of Retained Retroreflection ( $R_A$ ) cd/lux/m <sup>2</sup> at -4° Entrance Angle		Minimum Fluorescent Luminance Factor $Y_F$ %	Minimum Total Luminance Factor $Y_T$ %
	Observation Angle	$R_A$		
Yellow	0.2°	165	20	45
	1.0°	30		
Yellow Green	0.2°	225	20	60
	1.0°	45		

\* Due to climatic conditions, the warranty for Alabama, Arizona, Florida, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, South Carolina, and Texas will to be seven years.

sheeting to restore the sign surface to its original effectiveness.

For those states with a 7 year warranty, if the failure occurs within the first 5 years from the date of fabrication, 3M will, at its expense, restore the sign surface to its original effectiveness. If the failure occurs in the 6<sup>th</sup> or 7<sup>th</sup> year from the date of fabrication, 3M will furnish the necessary amount of Diamond Grade fluorescent sheeting to restore the sign surface to its original effectiveness.

### **Conditions**

Such failure must be solely the result of design or manufacturing defects in the Diamond Grade fluorescent reflective sheeting and not of outside causes such as: improper fabrication, handling, maintenance or installation; use of process colors, thinner, coatings, or overlay films and sheetings not made by 3M; use of application equipment not recommended by 3M; failure of sign substrate; exposure to chemicals, abrasion and other mechanical damage from fasteners used to mount the sign; snow burial; collisions, vandalism or malicious mischief.

3M reserves the right to determine the method of replacement.

Replacement sheeting will carry the unexpired warranty of the sheeting it replaces.

Claims made under this warranty will be honored only if the signs have been dated at the time of sheeting application, which constitutes the start of the warranty period.

Claims made under this warranty will be honored only if 3M is notified of a failure within a reasonable time, (reasonable information requested by 3M is provided, and 3M is permitted to verify the cause of failure.)

### **Limitation of Liability**

3M's liability under this warranty is limited to replacement as stated herein, and 3M assumes no liability for any incidental or consequential damages, such as lost profits, business or revenues in any way related to the product regardless of the legal theory on which the claim is based. THIS WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OF FITNESS FOR A PARTICULAR PURPOSE, AND ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM OR USAGE OF TRADE.

## **Literature Reference**

Instructions for Squeeze Roll Applicator	IF 1.3
Hand Application Instructions	IF 1.5
Instructions for Hand Squeeze Roll Applicator	IF 1.6
Sign Base Materials	IF 1.7
Color Application Instructions	IF 1.8
Cutting, Matching, Premasking, and Prespacing Instructions	IF 1.10
Storage Maintenance, and Removal Instructions	IF 1.11
Sign Fabrication Guidelines for Maximizing Legibility and for High Entrance Angle Signs	
Process Colors	PB 880
ASTM Test Methods are available from ASTM International, West Conshohocken, PA.	

## **FOR INFORMATION OR ASSISTANCE**

### **CALL:**

**1-800-553-1380**

### **IN CANADA CALL:**

**1-800-265-1840**

### **Fax-on-Demand in the U.S. and Canada:**

**1-800-887-3238**

### **Internet:**

**[www.3M.com/tss](http://www.3M.com/tss)**

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**Traffic Safety Systems Division**

3M Center, Building 0225-05-S-08  
St. Paul, MN 55144-1000  
1-800-553-1380  
[www.3M.com/tss](http://www.3M.com/tss)

**3M Canada Company**

P.O. Box 5757  
London, Ontario N6A 4T1  
1-800-3MHELPS

**3M México, S.A. de C.V.**

Av. Santa Fe No. 55  
Col. Santa Fe, Del. Alvaro Obregón  
México, D.F. 01210

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Transportation Safety Division

# 3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990

Product Bulletin Series 3990  
November 2020

Replaces PB 3990 Dated September 2005

## 1 Description

3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990 (“Sheeting”) is a wide angle prismatic lens reflective sheeting, designed for use in the production of durable traffic control and guidance signs and delineators that are exposed vertically in service. The Sheeting has been designed to provide higher sign brightness than beaded sheetings. The Sheeting provides good high-observation-angle brightness and is ideal for signs in locations with relatively short viewing distances. Applied to properly prepared sign backings, the Sheeting should provide long term service. The Sheeting, as manufactured by 3M, meets the stringent retroreflective requirements given in the ASTM D4956 standard for Type IX retroreflective sheeting.

For details of the features and benefits of the Sheeting, please refer to the 3M Transportation Safety Division website (<http://www.3M.com/roadsafety/>).

The Sheeting is available in the following colors.

**Table 1.** Product codes by color.

Color	Product Code
White	3990
Yellow	3991
Red	3992
Blue	3995
Green	3997

## 2 Specifications

### 2.1 Daytime Color (x,y,Y)

The chromaticity coordinates and total luminance factors of the Sheeting conform to limits presented in Table 2.

**Table 2.** CIE daytime chromaticity coordinate limits<sup>a</sup> and total luminance factor ranges.

Color	1		2		3		4		Daytime Luminance Limit (Y%)	
	x	y	x	y	x	y	x	y	Min.	Max.
White	0.305	0.305	0.355	0.355	0.355	0.375	0.285	0.325	27	N/A
Yellow	0.487	0.423	0.545	0.545	0.465	0.534	0.427	0.483	15	45
Red	0.690	0.310	0.595	0.315	0.569	0.341	0.655	0.345	2.5	15
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	1	10
Green	0.030	0.398	0.166	0.364	0.286	0.446	0.201	0.794	3	12

- a. The four pairs of chromaticity coordinates define the acceptable color limits for CIE D65 illumination in terms of the CIE 1931 Standard Colorimetric System, when measured using a 2-monochromator spectrophotometer employing an annular 45/0 illuminating and viewing geometry.

### 2.2 Color Test

Conformance to color requirements shall be determined instrumentally, in accordance with ASTM E1164, on Sheeting applied to aluminum test panels. Measurements shall be made using a HunterLab Labscan 6000 0/45 spectrophotometer with option CMR 559 or equivalent. Calculations shall be performed for the 2° observer in accordance with ASTM E308.

### 2.3 Coefficients of Retroreflection ( $R_A$ )

Table 3 presents the minimum initial coefficients of retroreflection,  $R_A$ , for each available color of Sheeting. Per ASTM E810, the  $R_A$  values presented in Table 3 are the averages of the values obtained at 0° and 90° rotations.

**Table 3.** Minimum coefficient of retroreflection,  $R_A$ , [cd/lx/m<sup>2</sup>] values for new Sheeting.

Sheeting Color	Observation <sup>a</sup> Angle	Entrance <sup>b</sup> Angle	
		-4°	30°
White	0.2°	380	215
	0.5°	240	135
	1.0°	80	45
Yellow	0.2°	285	162
	0.5°	180	100
	1.0°	60	34
Red	0.2°	76	43
	0.5°	48	27
	1.0°	16	9.0
Blue	0.2°	17	10
	0.5°	11	6.0
	1.0°	3.6	2.0
Green	0.2°	38	22
	0.5°	24	14
	1.0°	8.0	4.5

- a. Observation (divergence) Angle - The angle between the illumination axis and the observation axis.  
b. Entrance (incidence) Angle - The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

## 2.4 Test for Coefficient of Retroreflection

Conformance to  $R_A$  requirements shall be determined instrumentally, in accordance with ASTM E810 “Test Method for Coefficient of Retroreflection of Retroreflective Sheeting.”

## 2.5 $R_A$ Values of Digitally Printed, Screen Processed, and Overlaid Films

When processed according to 3M recommendations, areas of white Sheeting that have been digitally printed, screen processed with transparent 3M Process Colors Series 880I or 880N, or covered with 3M™ ElectroCut™ Film Series 1170 shall have initial  $R_A$  values not less than 70% of the values presented in Table 3 for the corresponding colors.

## 2.6 Resistance to Corrosion

The retroreflective sheeting applied to a test panel and conditioned as in 5.0, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain a minimum of 80% of the original coefficient of retroreflection when measured at 0.2° observation angle, -4° entrance angle, and 0° rotation angles after 1000 hours exposure to a 5% concentration salt spray at 35 °C (95 °F) when tested in accordance with ASTM B117.

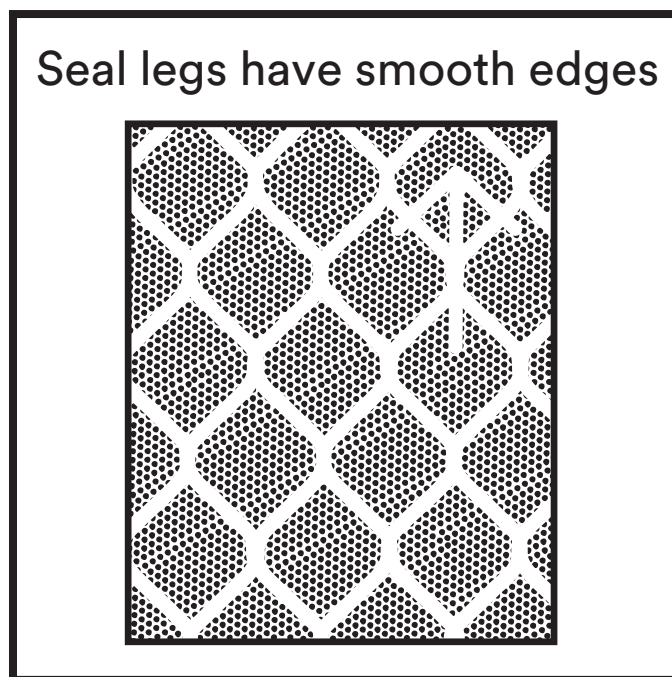
# 3 System of Matched Components

The Sheeting is compatible with a wide range of 3M screen print and digital inks, translucent films, overlay films and other processing components. For a complete list of matched components for the Sheeting, please see the [3M MCS™ Warranty Bulletin](#).

# 4 Construction Attributes

## 4.1 Interlocking Diamond Seal Pattern

The interlocking seal pattern found on the Sheeting is unique to 3M wide angle prismatic retroreflective sheeting products. Because of the small cube corners used in the Sheeting, its seal cell walls, or “legs,” appear smooth. Figure 1 presents a representation of the seal legs found in of 3M wide angle prismatic retroreflective sheetings.



**Figure 1.** Geometry of seal legs and datum marks of Sheeting positioned at a 0° angle.



## 4.2 Datum Marks (Arrows)

The surface of a roll of Sheeting contains small arrows, as shown in Figure 1, that repeat three times across a 36 inch roll, at 12 inch intervals along the roll. These arrows, which point down the length of the roll, serve as reference marks for photometric testing. They also act as visual aids, making it easier to orient the Sheeting when fabricating signs for special high entrance angle applications. The design of these arrows differentiates the Sheeting from other 3M Diamond Grade sheeting products.

## 4.3 Fabrication Lines

The Sheeting manufacturing process results in periodic fabrication lines in the product, as illustrated in Figure 2. Fabrication lines may be noticeable in shop light but do not impact Sign functionality on the road, either in daylight or at night, under typical use conditions.

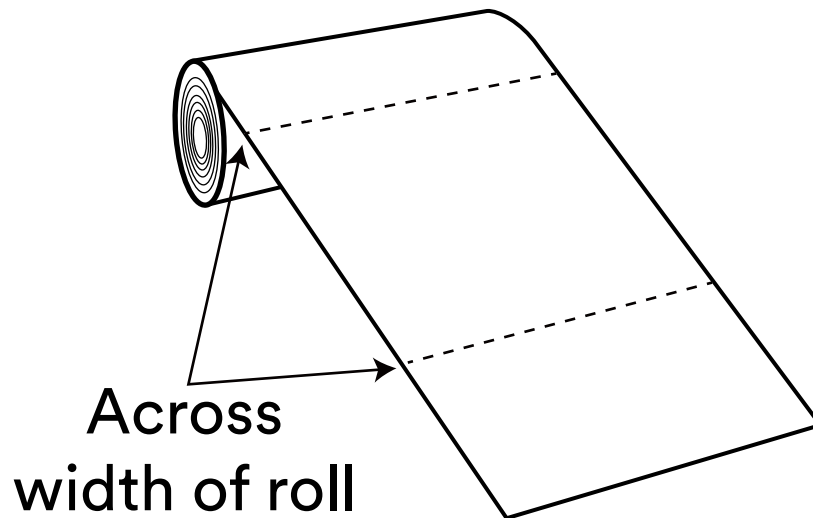


Figure 2. Fabrication lines

## 4.4 Adhesive

Sheeting comes with a pressure-sensitive adhesive that is recommended for application at temperatures of 65 °F (18 °C) and higher.

# 5 Sign Fabrication Methods

## 5.1 Application

Sheeting should be applied to Sign substrates at temperature of 65 °F (18 °C) and higher using any of the following methods:

Mechanical squeeze roll applicator - refer to [3M Information Folder 1.4](#) for details. Applications to extrusions that are edge wrapped require sufficient softening of Sheeting. This can be accomplished by directing additional heat to the “next to last” edge roller. This practice may increase productivity and minimize cracking.

Hand squeeze roll applicator - refer to [3M Information Folder 1.6](#) for details.

Application of Sheeting for complete Signs or backgrounds must be done using a roll laminator, either mechanical or hand driven.

## 5.2 Hand Application

Hand application is recommended for legend and copy only. Refer to [3M Information Folder 1.5](#) for more details.

Hand applications will show some visual irregularities which may be objectionable to aesthetically critical customers. These irregularities are more noticeable on darker colors. To obtain a uniform close-up appearance, a roll laminator must be used.

All direct applied copy and border **MUST** be cut and squeegeed at all metal joints.

## 5.3 Splices

Sheeting must be butt spliced when more than one piece of Sheeting is used on a single piece of substrate. Sheeting pieces should not touch one another. This is to prevent the buckling that can occur as Sheeting expands under extreme temperature and humidity conditions.

## 5.4 Double Faced Signs

The Sheeting on the bottom side of a double faced Sign can be damaged if rolled through a squeeze roll applicator with an unprotected steel bottom roller. The use of a semi-soft flat sheet between the steel roller and the applied Sign face will provide protection from damage. A material such as a rubber mat, tag board, or cardboard is recommended.

# 6 Substrates

For traffic Sign use, the substrates found to be most reliable and durable are properly prepared aluminum sheets and extrusions. **Users are urged to carefully evaluate adhesion and Sign durability properties of all other substrates.** Other substrates suitable for secure and durable applications of Sheeting have the following characteristics:

- Clean
- Smooth
- Flat
- Rigid
- Dimensionally stable
- Weather resistant
- Non-porous
- High surface energy (pass water break test)

Refer to [3M Information Folder 1.7](#) for surface preparation recommendations. Substrates with low surface energies may require additional preparation steps, such as flame treatment, mechanical abrasion, or use of adhesion promoters prior to Sheeting application. Guide Sign extrusions may be edge wrapped. Flat panels and unwrapped extrusions must be carefully trimmed so that Sheeting sections on adjacent panels do not touch on assembled Signs.

Sheeting is designed primarily for application to flat substrates. Any application to a substrate with a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is required. **Sign failures caused by substrate failures or improper surface preparations are not the responsibility of 3M.**

# 7 Imaging

Diamond Grade DG<sup>3</sup> prismatic Sheeting may be processed into traffic Signs using any of the imaging methods described below. 3M assumes no responsibility for the failures of Sign face legends or backgrounds that have been processed with non-3M process colors or with matched component imaging materials other than those listed below.

## 7.1 Digital Imaging

Sheeting is compatible with the HP Latex 360/365 printers in combination with HP 831/HP 871 Latex inks. This compatibility is backed with a 3M MCS™ Warranty and 3M MCS Warranty for Traffic when the printing guidelines in [3M Information Folder 1.18](#) are followed and 3M ElectroCut™ Film 1170C Clear is applied over the finished graphics. See the “Limited Warranty” section of this document for more information on the MCS Warranties.

## 7.2 Screen Processing

Sheeting may be screen processed into traffic Signs using 3M Process Colors Series 880I or Series 880N before or after mounting onto Sign substrates. Series 880I and 880N process colors can be screened at temperatures of 60–100 °F (16–38 °C) and at relative humidities of 20–50%. A P.E. 157 screen mesh with a fill pass is recommended. Refer to [3M Information Folder 1.8](#) for details. Clear coating is neither required nor recommended. Use of process colors series other than 880I or 880N is not recommended.

## 7.3 3M ElectroCut Film

3M ElectroCut Film Series 1170 may be used on Sheeting to provide transparent colored background copy for traffic control Signs. Refer to 3M Product Bulletin 1170 for fabrication procedures.

## 7.4 Applying Cut-Out Copy

Diamond Grade DG<sup>3</sup> Prismatic Sheeting cut-out copy may be applied to sheeting backgrounds to create Sign legends. Such cut-out copy may be applied directly to the background sheeting or in a demountable form. Direct applied copy must be cut at all panel seams and carefully trimmed back so that the Sheeting sections of adjacent panels do not touch one another on assembled Signs. Refer to [3M Information Folder 1.10](#) for more information.

# 8 Cutting

Sheeting may be cut into letters and shapes with heights of at least 3 inches and stroke widths of at least ½ inch. Smaller sizes are not recommended. Sealing the cut edges of Sheeting is not required.

## 8.1 Plotter Cutting

Programmable knife cut (electronic cutting):

- 1 Flat bed plotters can be used to either die cut or kiss cut Sheeting and offer the most consistent and reliable performance.
- 2 Friction fed plotters can be used to kiss cut only. This is achieved using 600 grams of down force and a 60° cutting blade. Additional drive wheels may be needed to improve tracking. Alternatively, Sheeting can be cut from the liner side. To do so, the blade force and knife depth must be set to score, but not cut through, the topfilm. After scoring, break apart individual copy or apply premask to retain spacing.

## 8.2 Other Cutting Methods

Sheeting may be hand cut or die cut one sheet at a time, and band sawed or guillotined in stacks. Cutting equipment such as guillotines and metal shears, which place pressure plates on the Sheeting when cutting, may damage the optics. Padding the pressure plate and easing it down onto the sheets being cut will significantly reduce damage. Maximum stack height for cutting Sheeting is 1 ½ inches, or 50 sheets. Cutting procedure details can be found in [3M Information Folder 1.10](#).

## 9 Processing, Storage, and Packaging

Sheeting should be stored in a cool, dry area, preferably at 65–75 °F (18–24 °C) and 30–50% relative humidity, and applied within two years of date of manufacture. Rolls should be stored horizontally in their shipping cartons. Partially used rolls should be returned to their shipping cartons or suspended horizontally from rods or pipes through their cores. Unprocessed sheets should be stored flat. Finished Signs and applied blanks should be stored on edge.

Avoid banding, crating, or stacking Signs. Package for shipment in accordance with commercially accepted standards to prevent movement and chafing. Store Sign packages indoors on edges.

Panels and finished Signs must remain dry during shipment and storage. If packaged Signs become wet, unpack immediately and allow Signs to dry. Refer to [3M Information Folder 1.11](#) for instructions on packing for storage and shipment.

## 10 Installation

Nylon washers are required when twist style fasteners are used to mount Signs.

## 11 Cleaning

Signs that require cleaning should be flushed with water, then washed with a detergent solution and soft bristle brush or sponge. Avoid pressure that may damage Sign faces. Flush with water following washing. Do not use solvents to clean Signs.

## 12 Durability

The durability of the Sheeting will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance. Maximum durability can be expected in applications subject to vertical exposure on stationary objects, when processed and applied to aluminum substrates prepared according to the recommendations provided in [3M Information Folder 1.7](#). The user must determine the suitability of any nonmetallic Sign backing for its intended use. **Sign failures caused by substrate failures or improper surface preparations are not the responsibility of 3M.** Application to unprimed, excessively rough or non-weather resistant surfaces, or exposure to severe or unusual conditions can shorten the performance lifetime of Sheeting. Signs that are in mountainous areas and covered by snow for prolonged periods may also have reduced durabilities. Atmospheric conditions in certain geographic areas may result in reduced durability.

Periodic Sign inspection and regular Sign replacement are strongly recommended in order to help Sign owners establish their own effective service life expectations.

## 13 Health and Safety Information

Read all health hazard, precautionary, and first aid statements found in the Safety Data Sheets (SDS), Article Information Sheets, and product labels of any materials for important health, safety, and environmental information prior to handling or use. To obtain SDSs and Article Information Sheets for 3M products, go to [3M.com/SDS](#), contact 3M by mail, or for urgent requests call 1-800-364-3577.

## 14 Warranty Information

### 14.1 3M Warranty

3M warrants to the manufacturer of the Sign (“Sign Manufacturer”) that the Sheeting will meet the specifications described in section 2 of this Product Bulletin (“3M Warranty”).

### 14.2 3M MCS™ Warranty and MCS Warranty for Traffic

For warranty on screen-printed or digitally printed Sheeting, or Sheeting imaged using translucent films, please refer to the [3M MCS™ Warranty Bulletin](#).

### 14.3 3M Warranty Terms and Conditions

- o The Sheeting must be stored, processed, applied, and maintained as described in this product bulletin and in accordance with all applicable, written 3M procedures provided in the applicable 3M Information Folders listed in Section 16.
- o A failure to meet the 3M Warranty must be solely the result of design or manufacturing defect in the 3M Sheeting, and not a result of (a) outside causes, including improper fabrication, handling, packing, storing, shipping, maintenance, or installation; (b) non-vertical applications where the Sign is more than +/- 10° from vertical; (c) use of any material or product not recommended by 3M in this product bulletin, in the 3M Information Folders listed in Section 16, or in applicable 3M Technical Memorandums; (d) use of application equipment not recommended by 3M; (e) failure of Sign substrate; (f) loss of adhesion due to incompatible or improperly prepared substrate; (g) exposure to chemicals, abrasion, or other mechanical damage; (h) snow burial or any other Sign burial; (i) collisions, vandalism, or malicious mischief; or (j) an act of God.
- o Claims made under this warranty will be honored only if (a) the Sign is dated with the Fabrication Date using a permanent method (sticker, marker, metal stamp, etc.), (b) 3M is notified in writing of the claim within thirty days of discovery, (c) 3M is provided with the information reasonably required to validate the claim, and (d) 3M is permitted to verify the cause of the failure.
- o 3M is not responsible for any additional warranties that the Sign Manufacturer offers to its customers beyond the 3M Warranty.

### 14.4 Exclusive Limited Remedy

Valid claims under the 3M Warranty will receive either the Sign Restoration or Materials Replacement as detailed in Table 4.

**Table 4.** Warranty Duration and Type of Limited Remedy as a Function of Age of Sign.

Legibility Warranty [years from Fabrication Date]	Limited Remedy Period [years from Fabrication Date]	
	Sign Restoration	Materials Replacement
0–12	Up to 7 Years	Years 8–12

#### Sign Restoration

During the Sign Restoration period as provided in Table 4, if Sheeting is proven to not meet the 3M Warranty, then the Sign Manufacturer's exclusive remedy, and 3M's sole obligation, at 3M's option, shall be that 3M, at its expense, will either refund the Sign Manufacturer's total original cost of the Sign, or refabricate the Sign, including (i) Sheeting and (ii) the aluminum Sign substrate (as needed). However, 3M will not provide other hardware or labor to install the replacement Sign. The Fabrication Date of the replacement Sign will be considered to be the original Fabrication Date of the Sign it replaces under the 3M Warranty.

#### Materials Replacement

During the Materials Replacement period as provided in Table 4, if Sheeting is proven to not meet the 3M Warranty, then the Sign Manufacturer's exclusive remedy, and 3M's sole obligation, at 3M's option, shall be that 3M, at its expense, will either refund the Sign Manufacturer's total original cost of the Sheeting, or provide the necessary Sheeting quantity to restore the Sign's surface. However, 3M will not provide the substrate or any labor to refabricate or reinstall the Sign.

### 14.5 Disclaimer

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM, OR USAGE OF TRADE.

## 14.6 Limitation of Liability

Except for the limited remedy stated above, and except where prohibited by law, 3M will not be liable for any loss or damage arising from the Signs or any 3M product, whether direct, indirect, special, incidental, or consequential damages (including but not limited to lost profits, business, or revenue in any way), regardless of the legal theory asserted including warranty, contract, negligence, or strict liability.

## 14.7 Additional Limitations

See the [3M Digitally-Imaged Sign Warranty Bulletin](#) for terms, additional limitations of your warranty, if any, and limitations of liability.

## 15 Other Product Information

Always confirm that you have the most current version of the applicable product bulletin, information folder, or other product information from 3M's Website at <http://www.3M.com/roadsafety>.

## 16 Literature References

<a href="#">3M IF 1.3</a>	Interstate Squeeze Roll Applicator 48 Inch
<a href="#">3M IF 1.4</a>	Instructions for Operation of the Interstate Squeeze Roll Applicator Using Pressure-Sensitive Adhesive-Coated 3M Reflective Sheeting
<a href="#">3M IF 1.5</a>	Hand Application Instructions
<a href="#">3M IF 1.6</a>	Hand Squeeze Roll Applicator
<a href="#">3M IF 1.7</a>	Sign Base Surface Preparation
<a href="#">3M IF 1.8</a>	Process Colors Series 880 and 900 Instructions for Use
<a href="#">3M IF 1.10</a>	Cutting, Premasking, and Prespacing
<a href="#">3M IF 1.11</a>	Sign Maintenance Management
<a href="#">3M PB 880I</a>	Process Color Series 880I
<a href="#">3M PB 880N</a>	Process Color Series 880N

ASTM Test Methods are available from ASTM International, West Conshohocken, PA.

## **For Information or Assistance**

**Call: 1-800-553-1380**

**In Canada Call:**

**1-800-3M HELPS (1-800-364-3577)**

## **Internet:**

**<http://www.3M.com/roadsafety>**

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## **Important Notice**

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable at the time of this publication, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, or conditions express or implied. Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct, indirect, special, or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his/her intended use, and user assumes all risk and liability whatsoever in connection therewith. Statements or recommendations not contained herein shall have no force or effect unless in an agreement signed by officers of seller and manufacturer.



## **Transportation Safety Division**

3M Center, Building 0225-04-N-14  
St. Paul, MN 55144-1000 USA

Phone 1-800-553-1380

Web [3M.com/roadsafety](http://www.3M.com/roadsafety)

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# 3M

## Diamond Grade™

### DG<sup>3</sup> Reflective Sheeting Series 4000

Product Bulletin 4000

January 2012

#### Description

3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting Series 4000 is a super-high efficiency, full cube retroreflective sheeting designed for the production of traffic control signs and delineators that are exposed vertically in service. DG<sup>3</sup> sheeting is designed to have the highest retroreflective characteristics at medium and short road distances as determined by the  $R_A$  values at 0.5° and 1.0° observation angles in Table B. Performance at these observation angles represents the most common nighttime viewing geometries encountered by the driving public. During the daytime, Diamond Grade DG<sup>3</sup> fluorescent reflective sheeting provides higher visibility than ordinary (non-fluorescent) colored sheetings.

Applied to properly prepared sign substrates Diamond Grade DG<sup>3</sup> reflective sheeting provides long-term retroreflectivity and durability. Series 4000 sheeting is available in the following colors.

Color	Product Code
White. ....	4090
Yellow. ....	4091
Red. ....	4092
Blue. ....	4095
Green. ....	4097
Brown. ....	4099
Fluorescent Yellow - FY. ....	4081
Fluorescent Yellow Green- FYG. ....	4083
Fluorescent Orange - FO. ....	4084

#### Color

#### Product Code

White - thermal transfer printable . . . . . 4090TT  
 Yellow - thermal transfer printable . . . . . 4091TT  
 Fluorescent Yellow - TT printable . . . . . 4081TT  
 Fluorescent Yellow - Green - TT printable . . . 4083TT

#### Photometrics

##### Daytime Color (x, y, Y)

The chromaticity coordinates and total luminance factor of the retroreflective sheeting conform to Table A.

##### Color Test – Fluorescent Sheetings

Conformance to standard chromaticity (x, y) and luminance factor (Y %) requirements shall be determined by instrumental method in accordance with ASTM E 991 on sheeting applied to smooth aluminum test panels cut from Alloy 6061-T6 or 5052-H38. The values shall be determined on a HunterLab ColorFlex 45/0 spectrophotometer. Computations shall be done for CIE Illuminant D65 and the 2° standard observer.<sup>2</sup>

##### Color Test – Ordinary Colored Sheeting

Conformance to standard chromaticity (x, y) and luminance factor (Y %) requirements shall be determined by instrumental method in accordance with ASTM E 1164 on sheeting applied to smooth aluminum test panels cut from Alloy 6061-T6 or 5052-H38. The values shall be determined on a HunterLab ColorFlex 45/0 spectrophotometer. Computations shall be done for CIE Illuminant D65 and the 2° standard observer.<sup>2</sup>

Table A - Daytime Color Specification Limits<sup>1</sup>

Color	x y		x y		x y		x y		Daytime Luminance Limit (Y%)	
	x	y	x	y	x	y	x	y	Min.	Max.
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	27	
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	15	45
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	2.5	15
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	1	10
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	3	12
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390	1	9
FY	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	40	
FYG	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	60	
FO	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	20	

<sup>1</sup>The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Colorimetric System.



<sup>2</sup>The instrumentally determined color values of retroreflective sheeting can vary significantly depending on the make and model of colorimetric spectrophotometer as well as the color and retroreflective optics of the sheeting (David M. Burns and Timothy J. Donahue, Measurement Issues in the Color Specification of Fluorescent Retroreflective Materials for High Visibility Traffic Signing and Personal Safety Applications, Proceedings of SPIE: Fourth Oxford Conference on Spectroscopy, 4826, pp. 39-49, 2003). For the purposes of this document, the HunterLab ColorFlex 45/0 spectrophotometer shall be the referee instrument.

### Coefficients of Retroreflection ( $R_A$ )

The values in Table B are minimum coefficients of retroreflection expressed in candelas per lux per square meter (cd/lux/m<sup>2</sup>).

### Test for Coefficients of Retroreflection

Conformance to coefficient of retroreflection requirements shall be determined by instrumental method in accordance with ASTM E-810 “Test Method for Coefficient of Retroreflection of Retroreflective Sheeting”, and per E-810 the values of 0° and 90° rotation are averaged to determine the  $R_A$  in Table B.

**Table B - Minimum Coefficient of Retroreflection  $R_A$  for new sheeting (cd/lux/m<sup>2</sup>)**

<b>-4° Entrance Angle<sup>3</sup></b>		<b>Observation Angle<sup>4</sup></b>		
	<b>0.2°</b>	<b>0.5°</b>	<b>1.0°</b>	
White	580	420	120	
Yellow	435	315	90	
Red	87	63	18	
Green	58	42	12	
Blue	26	19	5	
Brown	17	13	4	
Fluorescent Yellow	350	250	72	
Fluorescent Yellow Green	460	340	96	
Fluorescent Orange	175	125	36	
<b>30° Entrance Angle<sup>3</sup></b>		<b>0.2°</b>	<b>0.5°</b>	<b>1.0°</b>
White	220	150	45	
Yellow	165	110	34	
Red	33	23	7	
Green	22	15	5	
Blue	10	7	2	
Brown	7	5	1	
Fluorescent Yellow	130	90	27	
Fluorescent Yellow Green	180	120	36	
Fluorescent Orange	66	45	14	

<sup>3</sup> Entrance Angle – The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

<sup>4</sup> Observation Angle – The angle between the illumination axis and the observation axis.

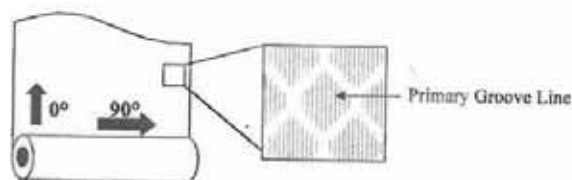
## Printed Colors and Overlay Films

For screenprinted or thermally transfer printed transparent color areas on white sheeting when processed according to 3M recommendations, the coefficients of retroreflection shall not be less than 70% of the value for the corresponding color in Table B. For white sheeting covered with 3M™ ElectroCut™ Film Series 1170 when processed according to 3M recommendations, the coefficients of retroreflection shall not be less than 100% of the value for the corresponding color in Table B. The color chromaticity and luminance shall conform to Table A on page 1.

## Entrance Angularity Performance in Regard to Orientation

Diamond Grade DG<sup>3</sup> Reflective Sheeting is designed to be an effective wide angle reflective sheeting regardless of its orientation on the substrate or ultimate orientation of the sign after installation. However, because the efficiency of light return from cube corner reflectors is not equal at all application orientations, especially with increasing entrance angles, it is possible to get the widest entrance angle light return when the sheeting is oriented in a particular manner. When high entrance angle (>50°) performance is required for given signs (e.g. Keep Right Symbols), it can be obtained easily by specifying the application orientation of the completed signs. In these situations the completed sign should have the sheeting positioned at the 0° orientation (downweb direction perpendicular to the road).

When the “primary groove line” (or, flat side of the diamond shape) is vertical in the completed sign, sheeting is said to be at a 0° orientation. When the “primary groove line” (or, flat side of the diamond shape) is horizontal in the completed sign, the sheeting is said to be at a 90° orientation. (Figure 1)



**Figure 1**

Unless the sign location and/or position calls for extra-wide entrance angularity performance, signs and applied copy (letters, arrows, borders and shields) can be fabricated and installed using the application orientation that most efficiently utilizes the reflective sheeting.

Note: For multi-panel signs it is recommended that all background panels be sheeted such that the sheeting direction is the same for all panels.

## Fabrication Lines

The manufacture of prismatic sheeting results in lines being present in the product. In Diamond Grade DG<sup>3</sup> sheeting these lines are slightly thicker than the seal pattern legs. Fabrication lines are noticeable in shop light but are not observable on the road either in daylight or at night under typical use conditions (Figure 2).

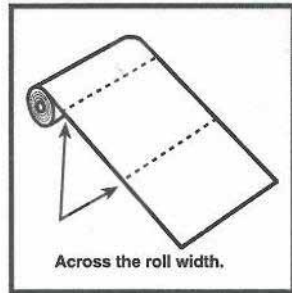


Figure 2 - Fabrication Lines

## Adhesive

Diamond Grade DG<sup>3</sup> sheeting has a pressure-sensitive adhesive that is recommended for application at temperatures of 65°F (18°C) or higher.

## Adhesive and Film Properties

### Standard Test Panels

Unless otherwise specified herein, sheeting shall be applied to test panels and conditioned in accordance with ASTM D4956 and test methods and conditions shall conform to ASTM D4956.

### Properties

The following properties shall conform to the requirements in ASTM D4956.

1. Adhesion
2. Outdoor weathering
  - retained coefficient of retroreflection
  - colorfastness
3. Shrinkage
4. Flexibility
5. Liner removal
6. Impact resistance
7. Night time color

In addition, DG<sup>3</sup> sheeting will conform to the following properties.

### 1. Gloss

Test Method – Test in accordance with ASTM D523 using a 60° glossmeter.

Requirement – Rating not less than 50.

### 2. Optical Stability

Test Method – Apply a 3-inch x 6-inch sample to a test panel. Measure  $R_A$  then place it in an oven at  $71^\circ\text{C} \pm 3^\circ\text{C}$  ( $160^\circ\text{F} \pm 5^\circ\text{F}$ ) for 24 hours followed by conditioning at standard conditions for two hours.

Remeasure  $R_A$ .

Requirement – The sheeting shall retain a minimum of 85% and a maximum of 115% of the original coefficient of retroreflection.

## Sign Fabrication Methods

### Application

Diamond Grade DG<sup>3</sup> sheeting incorporates a pressure sensitive adhesive and should be applied to the sign substrate at temperature of 65°F/18°C or higher by any of the following methods:

Mechanical squeeze roll applicator – refer to 3M Information Folder (IF) 1.4. Application to extrusions that are edge wrapped requires sufficient softening of the sheeting. This can be accomplished by directing additional heat to the “next to last” edge roller. This practice will increase productivity and minimize cracking.

Hand squeeze roll applicator – refer to 3M IF 1.6.

Application of Diamond Grade DG<sup>3</sup> sheeting for complete signs or backgrounds must be done with a roll laminator, either mechanical or hand driven.

### Hand Application

Hand application is recommended for legend and copy only. Refer to 3M Information Folder 1.5 for more details.

Hand applications will show some visual irregularities, which are objectionable to aesthetically critical customers. These are more noticeable on darker colors. To obtain a close-up uniform appearance, a roll laminator must be used.

All direct applied copy and border MUST be cut at all metal joints and squeegeed at the joints.

### Splices

Series 4000 sheeting must be butt spliced when more than one piece of sheeting is used on one piece of substrate. The sheeting pieces should not touch each other. This is to prevent buckling as the sheeting expands in extreme temperature and humidity exposure.

### Double Faced Signs

The sheeting on the bottom side of a double faced sign can be damaged if rolled through a squeeze roll applicator with an unprotected steel bottom roller. The use of a semi-soft flat sheet between the steel roller and the applied sign face will provide protection from damage. A material such as a rubber mat, tag board or cardboard is recommended.

## Substrates

For traffic sign use, substrates found to be most reliable and durable are properly prepared aluminum sheets and extrusions. **Users are urged to carefully evaluate all other substrates for adhesion and sign durability.** Other substrates that may be satisfactory for proper application of sheeting will have the following characteristics:

- Clean
- Smooth
- Flat
- Rigid
- Dimensionally stable
- Weather resistant
- Non-porous
- High surface energy (passes water break test)

Refer to Information Folder 1.7 for surface preparation recommendations. Substrates with low surface energy may require additional preparation such as flame treatment, mechanical abrasion or use of adhesion promoters prior to sheeting application. Guide sign extrusions may be edge wrapped. Flat panels or unwrapped extrusions are to be carefully trimmed so that sheeting from adjacent panels does not touch on assembled signs.

Diamond Grade DG<sup>3</sup> sheeting is designed primarily for applications to flat substrates. Any use that requires a radius of curvature of less than five inches should also be supported by rivets or bolts. Plastic substrates are not recommended where cold shock performance is required. **Sign failures caused by the substrate or improper surface preparation are not the responsibility of 3M.**

## Imaging

Diamond Grade DG<sup>3</sup> sheeting may be processed into traffic signs by any of the imaging methods described below. 3M assumes no responsibility for failure of sign face legends or backgrounds that have been processed with non-3M process colors or matched component imaging materials other than those listed below.

### Screen Processing

Diamond Grade DG<sup>3</sup> sheeting may be screen processed into traffic signs before or after mounting on a sign substrate, using 3M Process Colors Series 880I or Series 880N. Series 880I or 880N process colors can be screened at 60-100°F (16-38°C) at relative humidity of 20-50%. A PE 157 screen mesh with a fill pass is recommended. Refer to Information Folder 1.8 for details. No clear coating is required or recommended. Use of other process colors series is not recommended.

**Care should be taken to avoid flexing DG<sup>3</sup> sheeting before and especially after screening to eliminate the possibility of cracking from improper handling techniques.**

### Thermal Transfer Printing

Diamond Grade DG<sup>3</sup> TT sheeting may be imaged with 3M™ Thermal Transfer Ribbon Series TTR2300 in conjunction with the Matan SprinG3 or Matan Spot4 thermal transfer printers. For regulated traffic signs, Series TTR2300 Spot Traffic Colors are to be applied using these printers and must be covered with 3M™ ElectroCut™ Film 1170. Refer to Product Bulletin TTR2300 for more information.

### 3M™ ElectroCut™ Film

3M™ ElectroCut™ Film Series 1170 may be used to provide transparent colored background copy for traffic control signs on Diamond Grade DG<sup>3</sup> sheeting. Refer to Product Bulletin 1170 for fabrication procedures.

### Applied Cut-Out Copy

Diamond Grade DG<sup>3</sup> cut letters may be applied to a DG<sup>3</sup> sheeting background to create a sign legend. Such cut-out copy may be directly applied to the background sheeting, or may be applied in a demountable form. Direct applied copy must be cut at all panel seams and carefully trimmed back so that sheeting from adjacent panels does not touch on assembled signs. Refer to Information Folder 1.10 for more information.

Note: It is recommended to fabricate all but the largest signs using 1170 electronic cuttable overlay film instead of direct applied copy.

## Cutting

Diamond Grade DG<sup>3</sup> sheeting may be cut into letters and shapes of at least three inches in height and stroke widths of at least one half inch. Smaller sizes are not recommended. Sealing cut edges of DG<sup>3</sup> sheeting is not required.

### Plotter Cutting

Programmable knife cut (electronic cutting)

1. Flat bed plotters can either die cut or kiss cut and offer the most consistent and reliable performance.
2. Friction Fed plotter. Kiss cut only. Success has been achieved using plotters that have 600 grams of down force and a 60° cutting blade. Additional drive wheels may need to be added to improve tracking. An alternative procedure is to cut sheeting from the liner side. Blade force and knife depth must be set to score but not cut through the topfilm. Break apart individual copy or apply premask to retain spacing.

## Other Cutting Methods

Diamond Grade DG<sup>3</sup> sheeting may be hand cut or die cut one sheet at a time, and band sawed or guillotined in stacks. Cutting equipment such as guillotines and metal shears, which have pressure plates on the sheeting when cutting, may damage the optics. Padding the pressure plate and easing it down onto the sheets being cut will significantly reduce damage. Maximum stack height for cutting Series 4000 sheeting is 1½ inch or 50 sheets. Details on cutting can be found in Information Folder 1.10.

## Storage and Packaging

3M Diamond Grade DG<sup>3</sup> Sheeting should be stored in a cool, dry area, preferably at 65-75°F (18-24°C) and 30-50% relative humidity and should be applied within one year of purchase. Rolls should be stored horizontally in the shipping carton. Partially used rolls should be returned to the shipping carton or suspended horizontally from a rod or pipe through the core. Unprocessed sheets should be stored flat. Finished signs and applied blanks should be stored on edge.

Screen processed signs must be protected with SCW 568 slipsheet paper. Place the glossy side of the slipsheet against the sign face and pad the face with closed cell packaging foam. Double faced signs must have the glossy side of the slipsheet against each face of the sign.

Unmounted screened faces must be stored flat and interleaved with SCW 568 slipsheet, glossy side against the sign face.

Avoid banding, crating, or stacking signs. Package for shipment in accordance with commercially accepted standards to prevent movement and chafing. Store sign packages indoors on edges.

Panels or finished signs must remain dry during shipment and storage. If packaged signs become wet, unpack immediately and allow signs to dry. Refer to Information Folder 1.11 for instructions on packing for storage and shipment.

## Installation

Nylon washers are required when twist style fasteners are used to mount the sign.

## Cleaning

Signs that require cleaning should be flushed with water, then washed with a detergent solution and soft bristle brush or sponge. Avoid pressure that may damage the sign face. Flush with water following washing. Do not use solvents to clean signs. Refer to 3M Information Folder 1.10.

## Health and Safety Information

Read all health hazard, precautionary and first aid statements found in the Material Safety Data Sheet and/or product label of any materials prior to handling or use.

## General Performance Considerations

The durability of Diamond Grade DG<sup>3</sup> sheeting and finished signs using 3M Matched Component materials will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance. Maximum durability of Diamond Grade DG<sup>3</sup> sheeting can be expected in applications subject to vertical exposure on stationary objects when processed and applied to properly prepared aluminum according to 3M recommendations provided in Information Folder 1.7. The user must determine the suitability of any nonmetallic sign backing for its intended use. **Sign failures caused by the substrate or improper surface preparation are not the responsibility of 3M.** Applications to unprimed, excessively rough or non-weather resistant surfaces or exposure to severe or unusual conditions can shorten the performance of such applications. Signs in mountainous areas that are covered by snow for prolonged periods may also have reduced durability. 3M process colors and ElectroCut™ Film, when used according to 3M recommendations, are generally expected to provide performance comparable to colored reflective sheeting. Custom colors, certain lighter colors, heavily toned colors or blends containing yellow or gold may have reduced durability. Atmospheric conditions in certain geographic areas may result in reduced durability.

Periodic sign inspection and regular sign replacement are strongly recommended in order for sign owners to establish their own effective service life expectation, beyond the warranty period.

## 3M Basic Product Warranty and Limited Remedy

3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting Series 4000 (“Product”) is warranted to be free of defects in materials and manufacture at the time of shipment and to meet the specifications stated in this Product Bulletin. If DG<sup>3</sup> Sheeting is proven not to have met the Basic Warranty on its shipment date, then a buyer’s exclusive remedy, and 3M’s sole obligation, at 3M’s option, will be refund or replacement of the sheeting.



## General Warranty Terms:

1. 3M makes the Additional Warranty (as defined below) as to any traffic control and guidance sign in the United States and Canada (“Sign”) made with 3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting Series 4000 (“Product”) and the Matched Component materials listed in Table E. Any Additional Warranty is contingent on all components involved in that Additional Warranty being stored, applied, installed, and used only as 3M recommends in its Product Bulletins and Other Product Information.

2. The Basic Warranty and any applicable Additional Warranty are collectively referred to as the “3M Warranty.” EXCEPT TO THE EXTENT PROHIBITED BY APPLICABLE LAW, THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES, RIGHTS OR CONDITIONS, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE AND THOSE ARISING FROM A COURSE OF DEALING, CUSTOM OR USAGE OF TRADE. A BUYER IS RESPONSIBLE FOR DETERMINING IF A PRODUCT IS SUITABLE FOR ITS PARTICULAR PURPOSE AND APPLICATION METHODS.

3. A Sign’s failure to meet the 3M Warranty must be solely the result of the Product or the matched component materials’ design or manufacturing defects. 3M has no obligation under the 3M Warranty if a sign failure is caused by:

improper fabrication, handling, maintenance or installation; non-vertical applications where the Sign face is more than +/- 10% from vertical; use of any material or product not made by 3M or not included in Table E; use of application equipment not recommended by 3M; failure of sign substrate; loss of adhesion due to incompatible or improperly prepared substrate; exposure to chemicals, abrasion and other mechanical damage; snow burial or any other sign burial; collisions, vandalism or malicious mischief.

4. 3M reserves the right to determine the method of replacement, and any replacement Product will have the remainder of the original Product’s unexpired 3M Warranty. Claims made under this warranty will be honored only if

–The Sign was dated upon completion of fabrication (“Fabrication Date”) using a permanent method (sticker, permanent marker or crayon, metal stamp, etc.)

–3M is notified of a 3M Warranty claim during any applicable Warranty Period and the owner or fabricator provides the information reasonably required by 3M to verify if a 3M Warranty is applicable.

## Additional Warranty & Limited Remedy for Ordinary colored Product

1. The Additional Warranty for a Sign made with ordinary colored Product is that the Sign will: (a) **remain effective for its intended use when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision**, and (b) after cleaning, will meet the **minimum values for coefficient of retroreflection stated in Table C** for Table C’s applicable Warranty Period measured from the Sign’s Fabrication Date.

**Table C – Minimum Percent Retained of Table B Initial R<sub>A</sub> for applicable Warranty Period for Ordinary Colors (white, yellow, red, green, blue and brown)**

Warranty Period	Minimum Percentage R <sub>A</sub> Retained
1-7 Years	80%
8-12 Years	70%

2. If any Sign made with Ordinary Product is proven not to have met the Additional Warranty, then a buyer’s **exclusive remedy**, and 3M’s sole obligation, at 3M’s option:

(a) if this occurs within seven years after the Fabrication Date, then 3M will, at its expense, restore the Sign’s surface to its **original effectiveness**; or

(b) if this occurs during the remainder of the Additional Warranty Period, then 3M will furnish only the necessary 3M sheeting Product and matched component materials quantity to restore the Sign’s surface to its original effectiveness.

## Additional Warranty & Limited Remedy for Fluorescent Product

1. The Additional Warranty for a Sign made with Fluorescent Product is that the Sign will: (a) **remain effective for its intended use when viewed from a moving vehicle under normal day and night driving conditions by a driver with normal vision**; (b) after cleaning, will **retain 70% of the minimum values for coefficient of retroreflection stated in Table B** for the applicable Warranty Period stated in Table D, measured from Fabrication Date; and (c) after cleaning, the fluorescent Product will **maintain daytime luminance equal to or greater than the minimums specified in Table A**.

**Table D – Warranty Period for Fluorescent Colors.**

Color	Warranty Period
Fluorescent Yellow	10/7 Years <sup>5</sup>
Fluorescent Yellow Green	10/7 Years <sup>5</sup>
Fluorescent Orange	3 Years

<sup>5</sup> Due to climatic conditions, Signs in Alabama, Arizona, Florida, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, South Carolina and Texas have the 7-year Additional Warranty Period.

2. If a Sign made with Fluorescent Product is proven not to have met the Additional Warranty, then a buyer's exclusive remedy, and 3M's sole obligation, at 3M's option:

(a) for those Fluorescent Products with a 10-year Additional Warranty Period, 3M will, at its expense: (a) restore the Sign's surface to its **original effectiveness** if this occurs within seven years after the Fabrication Date; or (b) furnish only the necessary 3M Fluorescent Product and matched component materials quantity to restore the Sign's surface to its original effectiveness if this occurs during the remainder of the Warranty Period.

(b) for those Fluorescent Products with a 7-year Additional Warranty Period, 3M will, at its expense: (a) restore the Sign's surface to its **original effectiveness** if this occurs within five years after the Fabrication Date; or (b) furnish only the necessary 3M Fluorescent Product and matched component materials quantity to restore the Sign's surface to its original effectiveness if this occurs during the remainder of the Warranty Period.

(c) for those Fluorescent Products with a 3-year Additional Warranty Period, 3M will furnish only the necessary Fluorescent Product and matched component materials quantity to restore the Sign's surface to its original effectiveness.

**Table E. Matched Component Materials.**

Matched Components	
Process Colors	Series 880I
Process Colors	Series 880N
Thermal Transfer Ribbons – Spot Traffic Colors only*	Series TTR2300
ElectroCut™ Film	Series 1170
Premium Protective Overlay Film	Series 1160
Slipsheet	SCW 568
Prespacing Tape	SCPS-2
Premasking Tape	SCPM-3
Transfer Tape	TPM-5

\* Must be covered with 3M™ ElectroCut™ Film 1170

Refer to 3M Information Folders and Product Bulletins for detailed information about recommended application procedures and equipment.

## Other Product Information

**Always confirm that you have the most current version of the applicable Product Bulletin, Information Folder or Other Product Information.**

IF 1.4	Instructions for Interstate Squeeze Roll Applicator
IF 1.5	Hand Application Instructions
IF 1.6	Hand Squeeze Roll Applicator
IF 1.7	Sign Base Surface Preparation
IF 1.8	Process Color Application Instructions
IF 1.10	Cutting, Premasking, and Prespacing
IF 1.11	Sign Maintenance Management
PB 880I	Process Color 880I
PB 880N	Process Color 880N
PB 1170	ElectroCut™ Film
PB TTR2300	Thermal Transfer Ribbons Series TTR2300
PB 1160	Protective Overlay Film 1160

## Limitation of Liability

3M WILL NOT UNDER ANY CIRCUMSTANCES BE LIABLE TO A BUYER FOR DIRECT (other than the applicable Limited Remedy stated above), SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES (INCLUDING, WITHOUT LIMITATION, LOSS OF PROFITS) IN ANY WAY RELATED TO A PRODUCT OR THIS PRODUCT BULLETIN, REGARDLESS OF THE LEGAL OR EQUITABLE THEORY ON WHICH SUCH DAMAGES ARE SOUGHT.

ASTM Test Methods are available from ASTM International, West Conshohocken, PA.

3M assumes no responsibility for any injury, loss or damage arising out of the use of a product that is not of our manufacture. Where reference is made in literature to a commercially available product, made by another manufacturer, it shall be the user's responsibility to ascertain the precautionary measures for its use outlined by the manufacturer.

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#### Traffic Safety Systems Division

3M Center, Building 0235-03-A-09  
St. Paul, MN 55144-1000  
1-800-553-1380  
[www.3M.com/tss](http://www.3M.com/tss)

#### 3M Canada Company

P.O. Box 5757  
London, Ontario N6A 4T1  
1-800-3MHELPS

#### 3M México, S.A. de C.V.

Av. Santa Fe No. 55  
Col. Santa Fe, Del. Alvaro Obregón  
México, D.F. 01210

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# Process Color

## Series 880N

Product Bulletin 880N

January 2013

Replaces PB 880N dated July 2010

### Description

3M™ Process Color Series 880N is designed as part of the matched component system for application by screen processing. 3M process color series 880N can be screen processed on both applied and unapplied 3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430, 3M™ High Intensity Prismatic Reflective Sheeting Series 3930, 3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990 and 3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting Series 4400. Please reference the appropriate product bulletin. Application to other grades or types of sheetings or surfaces is not recommended.

### Colors

Signs made using these materials will have a similar appearance when viewed from a vehicle in daylight or at night. The following 880N series process colors are applied by screen processing:

880N Toner  
882N Traffic Sign Red Process Color  
883N Blue Process Color  
884N Yellow Process Color  
885N Black Process Color  
886N Orange Process Color  
887N Brown Process Color  
888N Green Process Color  
892 F low Additive  
711N Thinner

Series 880N process colors should not be blended with any other series process colors produced by 3M or any other manufacturer. 3M assumes no responsibility for premature failure of sign face legends that have been processed with non-3M process colors.

### Screen Processing

#### 1. Equipment and Set-up

Proper color and durability is achieved by using a high grade polyester, monofilament screen fabric mesh size P.E. 157. Other screen fabric mesh sizes do not produce satisfactory color or durability and are not recommended. Screen processing should be accomplished using the off-contact screening method. Direct contact screen printing should not be used. Refer to Information Folder 1.8 for the proper techniques of off-contact screen processing. Be sure that screens, sheeting, plus screening and drying areas are dust, dirt, and lint free.

#### 2. Coverage

Transparent process colors screened through a P.E. 157 screen fabric will cover approximately 1200 sq. ft. per gallon. Coverage will be affected by the extent of thinning, equipment used, and application procedure. **Do not reclaim any unused ink that remains in the screen. Dispose of appropriately.**

#### 3. Mixing

Process colors must be mixed prior to use. Shake for at least one minute by paint shaker or three minutes by hand. For best results, after shaking, mix mechanically for at least five minutes at 1000 - 2000 RPM with the equivalent of a 3 blade, 2 inch (5.1 cm) diameter propeller powered by an air-driven motor. Let stand for one hour. Cover as soon as possible after mixing and during use.

#### 4. Thinning and Flow Additive

Series 880N process colors are formulated to be at screening viscosity directly out of the can. If a lower viscosity process color is needed for screening, there are two choices for thinners. 3M™ 711N thinner is a general purpose thinner that will work in most applications. 3M™ CGS-80 thinner/retarder is a more specialized thinner that will slightly increase drying times and should be used if drying in the screen is a problem.



Thinners should be added sparingly and only to a point that results in a good quality screened image. Over-thinning may result in screening errors such as non-wets, or “fish” eyes. A good general rule is to add thinner until the color lifted with the stationary propeller “piles” just slightly, on the surface as it flows back into the container

892 Flow Additive can be used to improve flow characteristics. Refer to Information Folder 1.8.

**NOTE:** If at all possible, the mixing and thinning should be done the night before and then just before screening, hand mix with a spatula.

**CAUTION:** Do not retard drying (use CGS-80) on unmounted sheeting in cold weather (< 30°F) or dry humidity (< 30 % RH), as cracking may occur. Use 3M™ 711N thinner ONLY in these conditions.

## 5. Clear Coating

Series 880N transparent or opaque colors need not be clear coated.

## Edge Sealing

Edge sealing is not recommended.

## Air Drying

Air drying is best done at temperatures of 60-100°F (15-38°C) and relative humidity of 20-50%.

Drying rates may be slowed by high humidity, low temperature, poor air circulation, a too heavy coat of color, or excessive thinning. [Exhaust ventilation must also be provided in the screening or drying room to prevent a build up of solvent vapors which may affect drying or create a health or re hazard.] Addition of drying agents is not recommended since they adversely affect color adhesion and durability.

**NOTE:** If screen printed materials are not sufficiently dried, blocking, sticking or severe surface impressions of the screened images may occur when stored or packaged for shipment. If adequate drying is in question, the following steps are recommended to determine if the image has been sufficiently dried.

1. Press a dried screen printed area face to another dried screen printed face with moderate hand pressure.
2. Place the touched area close to your ear and separate by pulling apart. If the process color is dry, there will be a slightly discernible or no sound heard. If the color is not adequately dried a crackling sound will be heard. The louder the sound the more additional drying will be required.

It is imperative that the newly processed sheets be placed on racks with adequate air flow (approximately 125 lin. ft./min. minimum) through the racks while they are being filled, so as to rapidly remove any exhaust solvents. Follow these procedures:

1. Signs should be racked with unobstructed space for air flow between layers.
2. Fans should be placed 4-6 ft. in front of and air directed through all parts of the racks with horizontal air flow between the layers. Two fans per rack are required for most commercial racks.
3. Racks should not be placed in a corner or near a wall where the air flow or exhaust is restricted.

## Minimum Dry Times

Between Colors 2 hrs.

Before Packaging 3 hrs.

## Oven Drying

Processed sheeting must be racked individually with sufficient unobstructed air flow space between layers and at the end of rack. Ovens must be designed to provide adequate horizontal air flow through the oven (125 lin. ft./min. minimum). The freshly screened processed sign must be allowed to flow-out (air dry with fans) before it is placed in the oven. (See Table 1).

**Table 1**

Diamond Grade™ and 3M™ High Intensity Grade Sheeting				
	Flow-Out Times (1)	Bake Each Color (2)	Bake Final Color (2)	Oven Temp
880N Series	10 min.	30 min.	30 min.	105°+ 5°F (41° + 3°C)
1. Before placing in oven, rack individually to permit flow-out of color.				
2. Excessive baking can deaden adhesive.				
3. Oven must be provided with horizontal air flow of adequate volume.				

## Conveyor Drying

Signs to be dried must be placed to allow unobstructed air flow. The conveyor speed must be able to be adjusted to meet the requirements for flow-out times and heat. If immediate packaging is planned, a cooling zone capable of cooling the sign faces to room temperature of 65°-75°F (18°-24°C) is needed. Typically, the cooling zone should be the same length as the heating zone. The temperatures stated are at the sign face and not the oven temperatures. (See Table 2).

**Table 2**

Series 880N		
Flow-Out Time	Between Colors	Final Color
30 seconds	2 minutes @ 185°F (65°C)	2 minutes @ 185°F (65°C)

### Slipsheeting and Packaging

Screen processed signs must be protected with SCW 568 slipsheet paper. Place the glossy side of the slipsheeting against the sign face and pad the face with closed cell packaging foam. Double faced signs must have the glossy side of the slipsheet against each face of the sign.

Unmounted screened faces must be stored at and interleaved with SCW 568 slipsheet, glossy side against the sign face. Packages of finished sign faces must include sufficient nylon washers for mounting. Avoid banding, crating, or stacking signs. Package for shipment in accordance with commercially accepted standards to prevent movement and Store sign packages indoors on edge.

Panels or finished signs must remain dry during shipment and storage. If packaged signs become wet, unpack immediately and allow signs to dry. See Information Folder 1.11 for instructions on packing for storage and shipment.

### Storage

3M™ Process Color Series 880N should be stored at general warehouse storage (16°C/60°F to 27°C/80°F). The color has a shelf life of 12 months from customer receipt.

### Environmental, Health and Safety Information

Read all health hazard, precautionary and first aid statements found in the Material Safety Data Sheet, and/or product label of chemicals prior to handling or use.

Consult federal, state and local air quality regulations that may regulate or restrict product use.

### General Performance Considerations

3M process color series 880N which is processed according to 3M recommendations can be expected to provide durability for traffic sign uses comparable to that of 3M sheeting on which they are applied.

Application to other grades or types of sheeting or surfaces is not recommended. Please reference the appropriate product bulletin.

The durability of sheeting or screen processed sheeting exposed in any position other than vertical or near vertical may be significantly reduced. The durability statements expressed herein do not apply for the use of sheeting for vehicle markings. Contact your 3M sales representative to clarify the durability of such applications. See sheeting product bulletins for specific warranty details.

### 3M Literature Reference

PB 3430	3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430
PB 3930	3M™ High Intensity Prismatic Reflective Sheeting Series 3930
PB 4000	3M™ Diamond Grade™ DG <sup>3</sup> Reflective Sheeting Series 4000
PB 3990	3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990
IF 1.4	Instructions for Operation of Interstate Squeeze Roll Applicator
IF 1.5	Hand Application Instructions for 3M™ Reflective Sheeting and Scotchcal™ Films with Pressure-Sensitive Adhesive
IF 1.7	Sign Base Surface Preparation for 3M™ Reflective Sheeting Application
IF 1.8	Application of 3M™ Process Color 700, 880 and 990 on 3M™ Reflective Sheatings
IF 1.11	Sign Maintenance Management for 3M™ Reflective Sheeting

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**CALL:  
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**IN CANADA CALL:  
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**Traffic Safety & Security Division**

3M Center, Building 235-3A-09  
P.O. Box 33225  
St. Paul, MN 55133-3225  
[www.3M.com/roadwaysafety](http://www.3M.com/roadwaysafety)

**3M Canada Company**

P.O. Box 5757  
London, Ontario N6A 4T1  
1-800-3MHELPS

**3M México, S.A. de C.V.**

Av. Santa Fe No. 55  
Col. Santa Fe, Del. Alvaro Obregón  
México, D.F. 01210

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# 3M

# Process Color

## Series 880I

**Product Bulletin 880I**

**April 2011**

Replaces PB 880 dated July 2010

### Description

3M™ Process Color Series 880I is designed as part of the matched component system for application by screen processing. 3M process color series 880I can be screen processed on both applied and unapplied 3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430, 3M™ High Intensity Prismatic Reflective Sheeting Series 3930, 3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990 and 3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting Series 4000. Please reference the appropriate product bulletin. Application to other grades or types of sheetings or surfaces is not recommended.

### Colors

Series 880I process color is intended for use in the production of traffic control signs. Signs made using these materials will have a similar appearance when viewed from a vehicle in daylight or at night.

The following 880I series process colors are applied by screen processing:

880I Toner	887I Brown
882I Traffic Sign Red	888I Green
883I Blue	891I Thinner
884I Yellow	893I Violet
885I Black (Opaque)	894I Lemon Yellow
886I Orange	895I Magenta

Series 880I process colors should not be blended with any other series process colors produced by 3M or any other manufacturer. 3M assumes no responsibility for premature failure of sign face legends that have been processed with non-3M process colors.

### Screen Processing

#### 1. Equipment and Set-up

Proper color and durability is achieved by using a high grade polyester, monofilament screen fabric mesh size P.E. 157. Other size screen fabric mesh sizes do not produce satisfactory color and durability and are not recommended. Screen processing should be accomplished using the off-contact screening method. Direct contact screen printing should not be used. Refer to Information Folder 1.8 for the proper techniques of off-contact screen processing. Be sure that screens, sheeting, plus screening and drying areas are dust, dirt, and lint free.

#### 2. Coverage

Transparent process colors screened through a P.E. 157 screen fabric will cover approximately 1200 sq. ft. per gallon. Coverage will be affected by the extent of thinning, equipment used, and application procedure.

#### 3. Mixing and Thinning

It is important that the colors and sheetings be brought to normal ambient room temperature and humidity of the screen processing area before processing. Thinning should not be necessary, except to replace solvents lost by evaporation during processing. Thin sparingly using 3M™ Thinner of the same series as the process colors. Do not use extenders, drying agents, or other materials as they will adversely affect performance life. Do not mix with any other series of process colors or clears produced by 3M or any other manufacturers. For detailed instructions, refer to Information Folder 1.8.

4. Clear Coating

3M™ Process Color Series 880I transparent or opaque colors **need not** be clear coated.

Edge Sealing

Edge sealing is not recommended.

Air Drying

Processed sheeting for air drying must be placed on open racks to allow adequate air circulation. High volume fans must be directed through the racks. Drying times will be increased by high humidity, low temperature, poor air circulation, heavy color coat, and excessive thinning. Addition of drying agents is not recommended. Sheeting processed with Series 880I colors must be air dried for a minimum of 3 hours per color.

Oven Drying

Processed sheeting for oven dried must be placed on open racks individually with sufficient open space for unobstructed air flow.

	Flow Out Time (1)	Bake Each Color (2)	Bake Final Color (2)	Oven Temp. (3)
Series 880I	10 min. (with fans)	30 min.	30 min.	105° ± 5°F (41° ± 3°C)

- 1. Before placing in the oven, rack individually to permit proper flow out of color.
- 2. Excessive baking can deaden adhesive.
- 3. Oven must provide horizontal air flow.

Conveyor Drying

Signs to be dried must be placed to allow unobstructed air flow. The conveyor speed must be able to be adjusted to meet the requirements for flow-out times and heat. If immediate packaging is planned, a cooling zone capable of cooling the sign faces to room temperature of 65°-75°F (18°-24°C) is needed. Typically, the cooling zone should be the same length as the heating zone. The temperatures stated are at the sign face and not the oven temperatures. (See Table 1).

Table 1

Series 880N		
Flow-Out Time	Between Colors	Final Color
30 seconds	2 minutes @ 185°F (65°C)	2 minutes @ 185°F (65°C)

Slipsheeting and Packaging

3M™ screen processed signs must be protected with SCW 568 Slipsheet Paper. Place the glossy side of the slipsheeting against the sign face and pad the face with closed cell packaging foam. Double faced signs must have the glossy side of the slipsheet against each face of the sign. Unmounted screened faces must be stored flat and interleaved with SCW 568 slipsheet, glossy side against the sign face. Packages of finished sign faces must include sufficient nylon washers for mounting.

Storage

Series 880I process color should be stored at general warehouse storage (16°C/60°F to 27°C/80°F). The color has a shelf life of 12 months from customer receipt.

Troubleshooting Tips

The following troubleshooting tips are suggestions to minimize the potential for cracking of sheeting after screening with Series 880I process colors:

- 1. Screen applied sheets rather than unapplied sheets.
- 2. Use piggy-back box fans to provide air flow through entire drying rack. Have these fans running from the time the first sheet or sign is racked until 3 hours after the last sheet or sign is racked.
- 3. When drying unapplied sheets, use a smooth cardboard underliner on the drying rack shelves.
- 4. Avoid flexing sheeting when color is wet.
- 5. Avoid adding excessive thinner to the color.
- 6. Use every other shelf on drying racks.
- 7. Avoid use of solvents when cleaning sheeting prior to screening. If necessary, use a tack cloth to clean sheeting.

Environmental, Health and Safety Information

Read all health hazard, precautionary and first aid statements found in the Material Safety Data Sheet, and/or product label of chemicals prior to handling or use.

Consult federal, state and local air quality regulations that may regulate or restrict product use.



## General Performance Considerations

3M process colors series 880I which is processed according to 3M recommendations can be expected to provide durability for traffic sign uses comparable to that of the 3M sheeting on which they are applied, with the following exceptions: Process Color 886I Orange processed on white reflective sheeting will provide 3 year durability; 894I Lemon Yellow and 895I Magenta will provide 5 year durability; 893I Violet and 887I Brown will provide 7 year durability. Durability will be substantially reduced by toning the colors. The durability of sheeting or screen processed sheeting exposed in any position other than vertical or near vertical may be significantly reduced. The durability statements expressed herein do not apply for the use of sheeting for vehicle markings. Contact your 3M sales representative to clarify the durability of such applications. See sheeting product bulletins for specific warranty details.

## Special Color Formulation Warranty Statement

3M has developed specific colors within 3M™ Process Color Series 880I that have been evaluated for their durability (in terms of retained translucency and resistance to fade) based on actual outdoor weathering. Customers who purchase specially blended colors from 3M or who blend these colors themselves can expect that the blended colors will last as long as the component colors would last individually. Many blended process colors will be durable for periods up to 10 years. However, since blended formulations often contain individual component colors that have differing expected durability, users will experience color shifts over time. More rapid color shift will occur with special colors that contain a higher percentage of shorter durability colors. In addition, toners significantly reduce durability. For these reasons, 3M cannot make a specific durability statement for any special colors.

## Literature Reference

PB 3430	3M™ Engineer Grade Prismatic Reflective Sheeting Series 3430
PB 3930	3M™ High Intensity Prismatic Reflective Sheeting
PB 3990	3M™ Diamond Grade™ VIP Reflective Sheeting Series 3990
PB 4000	3M™ Diamond Grade™ DG <sup>3</sup> Reflective Sheeting
IF 1.4	Instructions for Operation of Interstate Squeeze Roll Applicator
IF 1.5	Hand Application Instructions for 3M™ Reflective Sheeting and
IF 1.6	Hand Squeeze Roll Applicators
IF 1.7	Sign Base Surface Preparation for 3M™ Reflective Sheeting Application
IF 1.8	Application of 3M™ Process Color 700, 800 and 990 on 3M™ Reflective Sheetings
IF 1.11	Reflective Sheeting Sign Maintenance Management



**FOR INFORMATION OR ASSISTANCE**

**CALL:**

**1-800-553-1380**

**IN CANADA CALL:**

**1-800-265-1840**

**Internet:**

**[www.3M.com/tss](http://www.3M.com/tss)**

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**Important Notice**

All statements, technical information and recommendations contained herein are based on tests we believe to be reliable, but the accuracy or completeness thereof is not guaranteed, and the following is made in lieu of all warranties, or conditions express or implied. Seller's and manufacturer's only obligation shall be to replace such quantity of the product proved to be defective. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct, special or consequential, arising out of the use of or the inability to use the product. Before using, user shall determine the suitability of the product for his/her intended use, and user assumes all risk and liability whatsoever in connection therewith. Statements or recommendations not contained herein shall have no force or effect unless in an agreement signed by officers of seller and manufacturer.

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**Traffic Safety Systems Division**

3M Center, Building 235-3A-09  
St. Paul, MN 55144-1000  
1-800-553-1380  
[www.3M.com/tss](http://www.3M.com/tss)

**3M Canada Company**

P.O. Box 5757  
London, Ontario N6A 4T1  
1-800-3MHELPS

**3M México, S.A. de C.V.**

Av. Santa Fe No. 55  
Col. Santa Fe, Del. Alvaro Obregón  
México, D.F. 01210

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