



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 geometry¹. 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.^{1&2} 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.

¹ “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).

² “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 (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 (cd/lux/m^2)

Sheeting	Observation ³ Angle	Entrance Angle ⁴		
		-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

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

⁴ 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.

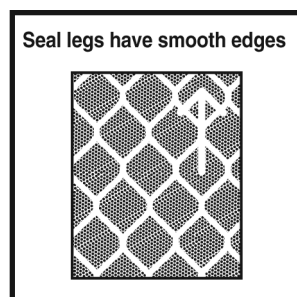


Figure 1 - Sheeting is positioned at a 0° angle.

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).

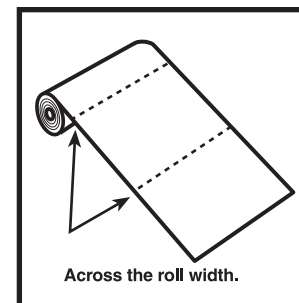


Figure 2 - Tooling Lines

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°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 8th through the 10th 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 ² 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 6th or 7th 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

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www.3M.com/tss

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