



High Intensity Prismatic Reflective Sheeting

Series 3930 with Pressure Sensitive Adhesive

Product Bulletin 3930

September 2006

Replaces PB 3930 dated Sept. 2005

Description

3M™ High Intensity Prismatic Reflective Sheeting Series 3930 is a non-metalized micro-prismatic lens reflective sheeting designed for production of reflective durable traffic control signs, work zone devices and delineators that are exposed vertically in service. Applied to properly prepared sign substrates, 3M high intensity prismatic sheeting provides long-term reflectivity and durability. Series 3930 sheeting is available in the following colors.

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

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 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.¹

¹The 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.

Table A - CIE Chromaticity Coordinate Limits* for new sheeting

Color	1		2		3		4		Limit Y (%)	
	x	y	x	y	x	y	x	y	Min.	Max
White	.303	.300	.368	.366	.340	.393	.274	.329	40	-
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	24	45
Red	.648	.351	.735	.265	.629	.281	.565	.346	3	12
Orange	.558	.352	.636	.364	.570	.429	.506	.404	14	30
Blue	.140	.035	.244	.210	.190	.255	.065	.216	1	10
Green	.026	.399	.166	.364	.286	.446	.207	.771	3	9
Brown	.430	.340	.610	.390	.550	.450	.430	.390	1	6

* The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

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/m²).

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 conformance to the R_A limits in Table B.

Table B - Minimum Coefficient of Retroreflection
R_A for new sheeting
(cd/lux/m²)

-4° Entrance Angle²

	Observation Angle ¹	
	0.2°	0.5°
White	560	200
Yellow	420	150
Red	84	30
Orange	210	75
Green	56	20
Blue	28	10
Brown	17	6

30° Entrance Angle²

	Observation Angle ¹	
	0.2°	0.5°
White	280	100
Yellow	210	75
Red	42	15
Orange	105	37
Green	28	10
Blue	14	5
Brown	8.4	3

¹Observation (Divergence) Angle - The angle between the illumination axis and the observation axis.

²Entrance (Incidence) Angle - The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

R_A for Screenprinted Colors and Overlay Films

For screenprinted transparent color areas on white sheeting, or white sheeting covered with 3M™ ElectroCut™ Film Series 1170 when processed according to 3M recommendations, the ratios of the R_A for the color to the R_A for the white shall be no less than 70% of the R_A listed for the integral color in Table B and the colors shall conform to Table A on page 1.

Adhesive

Series 3930 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, the reflective sheeting shall be applied according to the manufacturer's recommendations to smooth 0.063 inches (1.6mm) minimum thickness 6061-T6, 5052-H38 or equivalent aluminum panels that have been degreased and lightly acid etched. Lack of contamination of test panels must be confirmed by passing the water break test and tape snap test as described in 3M Information Folder 1.7.

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. Adhesion

Test Weight 1-3/4 lbs. (0.8 kg) Test Method - Apply 4 inches (10cm) of 1 inch x 6 inch (2.54x15cm) strip to panel and condition, face panel down and suspend test weight from free end. Requirement - Not more than 2 inches (5.0cm) of peel in five minutes.

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 pound (5.7Nm) impact in accordance with ASTM D-2794. Requirement - No separation from panel or cracking outside immediate impact area.

3. Shrinkage

Test Method - Following conditioning of 9 inch x 9 inch samples, remove liner, place specimen on flat surface with adhesive side up. Requirement - Shrinkage not greater than 1/32 inches (0.8mm) in 10 minutes or more than 1/8 inches (3.2mm) in 24 hours in any dimension.

4. Flexibility

Test Method - Following conditioning of 1 inch x 6 inch sample, remove liner and dust adhesive with talc. At standard conditions, holding the ends of the sample, 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.

Sign Fabrication Methods

Application

3M high intensity prismatic sheeting series 3930 incorporates a pressure sensitive adhesive and should be applied to the sign substrate at room temperature 65°F (18°C) or higher by any of the following methods:

Mechanical squeeze roll applicator - Reference 3M Information Folder 1.4 (Room temperature application)

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

Hand squeeze roll applicator - Reference 3M Information Folder 1.6

Hand Application

Hand application is recommended for legend and copy only. Application of sheeting for complete signs or backgrounds must be done with a roll laminator, either mechanical or hand. See 3M Information Folder 1.5 for more details.

Hand applications will show some visual irregularities that 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 3930 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 3M™ Process Color 880I Clear using a fine artist paintbrush.

Double Faced Signs - Series 3930 sheeting on the first side must be protected by damage from the steel bottom roll of squeeze roll applicators with FR-2 sponge rubber and SCW 568.

Substrates

For traffic sign use, product application is limited to properly prepared aluminum (see 3M Information Folder 1.7), and high density overlay plywood (HDOP). Extrusions can be wrapped or trimmed, 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. Series 3930 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

Series 3930 sheeting may be screen processed into traffic signs before or after mounting on a sign substrate, using 3M™ Process Colors Series 880I (see Product Bulletin 880I). Series 880I 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 3M 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 Series 3930 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. Series 3930 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, that 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 3930 sheeting is 1-1/2 inches or 50 sheets. Details on cutting can be found in 3M Information Folder 1.10.

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

Edge sealing Series 3930 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 880I process color should be used.

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 3M Information Folder 1.10.

Storage and Packaging

Series 3930 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 the adhesive liner or 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. 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 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.

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.

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 3M high intensity prismatic reflective sheeting series 3930 will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance.

Maximum durability of Series 3930 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 3M 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 of such applications. Signs in mountainous areas that are covered by snow for prolonged periods may also have reduced durability.

3M process colors, when used according to 3M recommendations, are generally expected to provide performance comparable to colored reflective sheeting, except for certain lighter colors, such as yellow, gold, or heavily toned colors or blends containing yellow or gold, whose durability depends on how much of each color is used.

Dilution of color and atmospheric conditions in certain geographic areas may result in reduced durability.

3M™ ElectroCut™ Film Series 1170 can be expected to perform satisfactorily for the life of the sign when direct applied to series 3930 sheeting.

Warranty

3M warrants that 3M™ High Intensity Prismatic Reflective Sheeting Series 3930 sold by 3M to be used as components for traffic control and guidance signs in the United States and Canada will remain effective for its intended use and meet the stated minimum values for coefficient of retroreflection for ten years, subject to the following provisions in:

Table C

Percentage of Table B Initial R_A Minimums Guaranteed Over 10 Year Warranty Period (Colors: white, yellow, red, green and blue)

Warranty Period	Minimum Percentage R_A Retained
1-7 Years	80%
8-10 Years	70%

R_A percentage retained above apply to all entrance and observation angles presented in Table B, and shall be measured per ASTM E 810.

All measurements shall be made after cleaning according to 3M recommendations. If a high intensity grade prismatic sign surface is processed and applied to sign blank materials in accordance with all 3M application and fabrication procedures provided 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, protective overlay films, and recommended applications 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 C, 3M's sole responsibility and purchaser's and user's exclusive remedy shall be:

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 within the 8th through the 10th year from the date of fabrication, 3M will furnish the necessary amount of high intensity prismatic sheeting to restore the sign surface to its original effectiveness.

Warranty for 3934 Sheeting

3M warrants that 3M™ High Intensity Prismatic Reflective Sheeting 3934 Orange sold by 3M to be used as components for traffic control devices used in work zones in the United States and Canada will remain effective for its intended use and meet the stated minimum values for coefficient of retroreflection for three years, subject to the following provisions:

**Minimum Coefficient of Retroreflection
Candelas per Foot Candle per Square Foot
Candelas per Lux per Square Meter
(0.2° observation and -4° entrance)***

Sheeting Color	Min. Coeff. of Retroreflection (Three Years)
Orange	80

*All measurements shall be made after sign cleaning according to 3M recommendations and in accordance with ASTM E 810 "Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting."

If a high intensity prismatic 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, 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 drivers with normal vision, or 2) the coefficient for retroreflection is less than the minimum herein specified, 3M's sole responsibility and purchaser's and user's exclusive remedy shall be that 3M will provide pro-rata replacement of the 3M materials:

If failure occurs within the first year from the date of fabrication, 3M will at its expense, restore the sheeting surface to its original effectiveness. If failure occurs in the second year, two-thirds of the sheeting will be replaced. If failure occurs in the third year, one-third of the sheeting will be replaced.

Conditions

Such failure must be solely the result of design or manufacturing defects in the 3M high intensity prismatic reflective sheeting and not of outside causes such as: improper fabrication, handling, maintenance or installation; use of process colors, thinners, 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; sign 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 the failure.

Limitation of Liability and Remedies

3M's liability under this warranty is limited to replacement or allowance as stated herein, and 3M assumes no liability for incidental or consequential damages such as lost profits, business or revenue in any way related to the product regardless of the legal theory on which the claim is based.

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Literature Reference

- IF 1.3 Instructions for Squeeze Roll Applicator
- IF 1.5 Hand Application Instructions
- IF 1.6 Instructions for Hand Squeeze Roll Applicator
- IF 1.7 Sign Base Materials
- IF 1.8 Color Application Instructions
- IF 1.10 Cutting, Matching, Premasking, and Prespacing Instructions
- IF 1.11 Storage Maintenance, and Removal Instructions

"Standard Highway Signs, As Specified in the Manual on Uniform Traffic Control Devices", U.S. Department of Transportation, Federal Highway Administration, 1979.

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

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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

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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