Section 1015
Signs and Pavement Markings

1015.01 GENERAL REQUIREMENTS. Signs and pavement markings materials shall comply with these specifications, the plans and the MUTCD. When directed, the contractor shall furnish and prepare samples for testing in accordance with Department instructions.

1015.02 METALS.

1015.02.1 Ferrous Metals:

1015.02.1.1 Structural Steel: Structural steel for posts, stringers, framing and miscellaneous steel shall comply with AASHTO M 270, Grade 36. Steel shall be galvanized in accordance with 811.12.

1015.02.1.2 Steel Pipe: Steel pipe or tubing for structures shall be Schedule 40 (STD) complying with ASTM A53, Type E or Type S Grade B, or hot formed tubing complying with ASTM A36 and ASTM A501.

1015.02.1.3 U-Channel Steel Posts for Small Signs, Markers, and Delineators: Posts shall be steel of the flanged channel type shown on the plans, galvanized after fabrication in accordance with 811.12. Before fabrication, posts shall be within 3.5 percent of the specified weight.

Posts shall be fabricated from steel complying with either ASTM A499, Grade 60 with chemical properties conforming to ASTM A1 for 91 lb/yd or heavier rail steel, or ASTM A576, Grade 1080 with 0.10 to 0.20 percent silicon. Holes 3/8 inch in diameter shall be drilled or punched through the middle of each post on one inch centers for the full length of the post.

1015.02.1.4 Square Tubing for Small Signs, Markers, and Delineators: Use 2 inches x 2 inches square tubing.

The square tubing shall conform to ASTM A1011, Grade 50 for hot rolled carbon steel, structural quality. The average minimum tensile strength after cold-forming is 60,000 psi. The cross section of the square tubing shall be a square tube formed and carefully rolled to size and shall be welded by high frequency resistance welding and externally scarfed to agree with corner radii and dimensional tolerances shown in the DOTD Roadside Traffic Sign Standard Details. It shall be manufactured from hot-dipped galvanized steel conforming to ASTM A653, G90, Structural Quality, Grade 50, Class 1. The weld shall be hot zinc coated after the scarfing operation. The steel shall be coated with a chromate conversion coating and a clear organic polymer topcoat.

Perforated sign posts shall be 2 inches x 2 inches square tubing for the upright sign post and 2 1/4 inches x 2 1/4 inches x 3 feet shall be used for anchoring into soil using wet concrete in accordance with the Roadside Traffic Sign Standard Plans.

1015.02.1.5 Square Tubing Breakaway Supports, Hardware and Related Accessories: These items shall meet the specifications in DOTD Roadside Traffic Sign Standard Details. The breakaway support shall be a Kleen-Break Model 425 post coupler manufactured by Xcessories Squared.

1015.02.2 Aluminum Alloy: Structural members shall be aluminum complying with ASTM B221 or ASTM B429, Alloy 6061-T6. Miscellaneous aluminum shall comply with ASTM B209, Alloy 6061-T6.

1015.02.3 Connectors:

1015.02.3.1 Structural Bolts, Nuts and Washers: High strength bolts shall comply with ASTM A325, and other bolts shall comply with ASTM A307, Grade A or Grade B. Bolts shall have hexagonal heads and include two flat washers and one lock washer and one hexagonal-head nut. Bevel washers, where required, shall be wrought steel. Bolts, nuts and washers shall be galvanized in accordance with ASTM A153 or by an approved mechanical galvanizing process complying with ASTM B695 that provides the same coating thickness.

Anchor bolts shall comply with ASTM F1554. Anchor bolts shall be hot dip galvanized in accordance with ASTM A153.

Stainless steel bolts shall comply with ASTM F593, alloy groups 1, 2, or 3 (except alloys 303 or 303 Se), with a minimum tensile strength of 70,000 psi.

1015.02.3.2 Fasteners: Use vandal resistant aluminum alloy fasteners with brasier heads complying with ASTM B316, Alloy 2024-T4, to attach Interstate, Louisiana, and U.S. shields to the sign panel.

1015.03 FLEXIBLE POSTS. Flexible posts for delineators shall be from the Approved Materials List.

1015.04 SIGN PANELS. Flat sign panels shall be marked on the front bottom edge with MUTCD code, initials of the manufacturer and the date. Extruded panels shall be marked on the back in accordance with the standard plans.

1015.04.1 Permanent Sign Panels: New and recycled flat panels shall be aluminum sheets or plates complying with ASTM B209, Alloy 6061-T6 or Alloy 5052-H38. New and recycled extruded aluminum panels

shall comply with ASTM B221, Alloy 6063-T6 and after fabrication, shall have a flatness equal to or less than 0.031 inch per foot of length and 0.004 inch per inch of width. The traceability paperwork shall be maintained and available from the fabricator for 7 years.

1015.04.2 Temporary Sign Panels: Substrate for barricade panels shall be rigid thermoplastic. Substrate for portable signs shall be new or recycled aluminum, wood or plastic. Substrate for post mounted signs shall be new or recycled aluminum, wood, rigid thermoplastic or aluminum clad low density polyethylene plastic.

1015.04.2.1 Aluminum: Aluminum sheeting shall be 0.080 inch thickness complying with ASTM B209, Alloy 6061-T6 or Alloy 5052-H38.

1015.04.2.2 Wood: Plywood sheeting of exterior type Grades either High Density Overlay or Medium Density Overlay are acceptable for use provided the following requirements are met.

Panels shall be a minimum of 5/8 inch thick, shall comply with the latest American Plywood Association specifications, and shall be identified with the APA edge mark or back stamp to verify inspection and testing. Prior to application of reflective sheeting, the surface shall be abraded with steel wool or fine sandpaper, and wiped thoroughly clean. The surface shall dry a minimum of 8 hours prior to application of sheeting. Cut edges of plywood panels shall be sealed with an approved aluminum pigmented polyurethane sealer.

1015.04.2.3 Plastic: Plastic substrate for barricade panels and signs shall be as follows:

1015.04.2.3.1 Fiber Reinforced Vinyl (PVC): The substrate shall have a nominal composite thickness of 0.04 inches and be bonded to an approved retroreflective material by the manufacturer.

1015.04.2.3.2 Rigid Thermoplastic: Rigid thermoplastic substrate shall consist of either High Density Polyethylene (HDPE) or High Density Polycarbonate (HDPC). The rigid thermoplastic for barricade panels shall be hollow core HDPE or HDPC with a minimum thickness of 0.625 inch. The thermoplastic for sign panels shall be 0.40 inch thick thin wall, fluted substrate or 0.625 inch thick blow molded substrate. Substrates shall be sufficiently rigid to maintain a flat face and shall be capable of attachment to the sign mounting in such a manner as not to crush or otherwise deform the substrate. Reflectorized sheeting applied to rigid thermoplastic shall have its manufacturer's approval for use on the substrate.

1015.04.2.3.3 Aluminum Clad Low Density Polyethylene (AL/LDPE) Plastic: The aluminum clad low density polyethylene plastic substrate shall be 0.080 inch thick. The substrates shall be sufficiently rigid

to maintain a flat face and shall be capable of attachment to the sign mounting in such a manner as not to crush or otherwise deform the substrate. Reflectorized sheeting applied to aluminum clad low density polyethylene shall have its manufacturer's approval for use on this substrate.

1015.05 REFLECTIVE SHEETING.

1015.05.1 Permanent and Temporary Standard Sheeting: Reflective sheeting shall be one of the following standard types as specified on the plans and complying with ASTM D4956 except as modified herein. Permanent warning, regulatory, guide and supplemental guide sign sheeting shall meet the requirements of DOTD Type X as described below and detailed in 1015.05.3. Reflective sheeting for temporary signs and devices shall meet the requirements of ASTM D4956 Type III except as noted in 1015.05.6. Reflective sheeting for delineators shall meet the requirements of ASTM D4956 Type III or Type V, including Supplemental Requirements S2. Reflective sheeting shall be from the Approved Materials List.

Type III - A high-intensity retroreflective sheeting. This sheeting is typically encapsulated glass-bead retroreflective material.

Type V - A "super high-intensity" retroreflective sheeting, typically used for delineators. This sheeting is typically a metalized microprismatic retroreflective element material.

Type VI - An elastomeric, high-intensity retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material.

DOTD Type X - A super high-intensity retroreflective sheeting having highest retroreflectivity characteristics at medium distances. This sheeting is typically an unmetalized microprismatic retroreflective element material.

1015.05.2 Fluorescent Pink Retroreflective Sheeting: Signs for temporary control of traffic through incident management areas shall be Type VI fluorescent pink retroreflective sheeting and shall comply with the MUTCD. Temporary traffic control signs for incident management shall be placed to notify motorists of upcoming incidents on the roadway, and shall be removed from public view once the incident has been managed. Physical properties shall comply with ASTM D4956. Photometric properties shall be as follows.

1015.05.2.1 Retroreflectivity: Minimum Coefficients of Retroreflection shall be as specified in Table 1015-1.

Table 1015-1
Coefficients of Retroreflection for Fluorescent Pink Sheeting[1]

Observation Angle, degrees	Entrance Angle, degrees	Fluorescent Pink
0.2	-4	180
0.2	+30	72
0.5	-4	81
0.5	+30	31

[1]Minimum Coefficient of Retroreflection (R_A) (cd $lx^{-1}m^{-2}$)

1015.05.2.2 Color and Daytime Luminance: Color Chromaticity Coordinates and Daytime Luminance Factors shall be as specified in Table 1015-2.

Table 1015-2
Fluorescent Pink Color Specifications Limits (Daytime)

Chromaticity Coordinates (corner points) [1]										Luminance Factor, min.
1		2		3		4		5		Y%
x	y	x	y	x	y	x	y	x	y	20
0.600	0.340	0.450	0.332	0.430	0.275	0.536	0.230	0.644	0.290	

[1]The five pairs of chromaticity coordinates measured with CIE 2° Standard Observer and 45/0 (0/45) geometry and CIE D65 Standard Illuminant.

1015.05.3 DOTD Type X Retroreflective Sheeting: Physical properties shall comply with ASTM D4956. Color shall conform to ASTM D4956, Table 11. Luminance shall conform to ASTM D4956, Table 2. Retroreflectivity properties shall be as follows:

1015.05.3.1 Retroreflectivity: Minimum Coefficients of Retroreflection shall be as specified in Table 1015-3.

Table 1015-3
Coefficients of Retroreflection for DOTD Type X Sheeting[1]

Observation Angle, (degrees) Entrance Angle, (degrees)	0.2 -4	0.2 +30	0.5 -4	0.5 +30
White	560	280	200	100
Yellow	420	210	150	75
Orange	210	105	75	37
Green	56	28	20	10
Red	84	42	30	15
Blue	28	14	10	5.0
Brown	17	8.4	6.0	3.0
Fluorescent Yellow-Green	450	220	160	80
Fluorescent Yellow	340	170	120	60
Fluorescent Orange	170	84	60	30

[1]Minimum Coefficient of Retroreflection (R_A) (cd $lx^{-1}m^{-2}$)

1015.05.4 Adhesive Classes: The adhesive required for retroreflective sheeting shall be Class 1 (pressure sensitive) as specified in ASTM D4956.

1015.05.5 Accelerated Weathering: Reflective sheeting, when processed, applied, and cleaned in accordance with the manufacturer's recommendations, shall perform in accordance with the accelerated weathering standards in Table 1015-4.

Table 1015-4
Accelerated Weathering Standards[1]

Type	Retroreflectivity[2]				Colorfastness[3]	
	Orange/ Fluorescent Orange		All colors, except Orange/ Fluorescent Orange		Orange/ Fluorescent Orange	All colors, except Orange/ Fluorescent Orange
III	1 year	80[4]	3 years	80[4]	1 year	3 years
III (for drums)	1 year	80[4]	1 year	80[4]	1 year	1 year
V	1 year[5]	80[6]	3 years[5]	80[6]	1 year[5]	3 years[5]
VI	1/2 year	50[7]	1/2 year	50[7]	1/2 year	1/2 year
DOTD X	1 year	80[8]	3 years	80[8]	1 year	3 years

[1]At an angle of 45° from the horizontal and facing south in accordance with ASTM G7 at an approved test facility in Louisiana or South Florida.
[2]Percent retained retroreflectivity of referenced table after the outdoor test exposure time specified.
[3]Colors shall conform to the color specification limits of ASTM D4956 after the outdoor test exposure time specified.
[4]ASTM D4956, Table 4.
[5]If outdoor weathering data is not available, artificial weathering according to ASTM D4956, Supplemental Requirement S3 may be used.
[6]ASTM D4956, Table 6.
[7]ASTM D4956, Table 7.
[8]Table 1015-3.

Reflective sheeting for signs, when processed, applied, and cleaned in accordance with the manufacturer's recommendations shall perform outdoors in accordance with the performance standards in Table 1015-5.

Table 1015-5
Reflective Sheeting Performance Standards

Type	Retroreflectivity[1] — Durability[2]				Colorfastness[3]
	Orange/ Fluorescent Orange		All colors, except Orange/Fluorescent Orange		
III	3 years	80[4]	10 years	80[4]	3 years
DOTD X	3 years	80[5]	10 years	80[5]	3 years

[1]Percent retained retroreflectivity of referenced table after installation and the field exposure time specified.

[2]All sheeting shall maintain its structural integrity, adhesion and functionality after installation and the field exposure time specified.

[3]All colors shall conform to the color specification limits of ASTM D4956 after installation and the field exposure time specified.

[4]ASTM D4956, Table 4.

[5]Table 1015-3.

1015.05.6 Temporary Signs, Barricades, Channelizing Devices, Drums and Cones: Reflective sheeting for temporary signs, barricades, and channelizing devices shall meet the requirements of ASTM D4956, Type III, except that temporary warning construction signs used on the mainline of freeways and expressways shall be fluorescent orange and meet the requirements of DOTD Type X.

Reflective sheeting for vertical panels shall meet the requirements of ASTM D4956, Type III.

Reflective sheeting for drums shall be a minimum of 6 inches (150 mm) wide and shall meet the requirements of ASTM D4956, Type III, and the Supplementary Requirement S2 for Reboundable Sheeting as specified in ASTM D4956. Reflective sheeting for traffic cone collars shall meet the requirements of ASTM D4956, Type III or Type VI.

1015.05.7 Sheeting Guaranty: The contractor shall provide the Department with a guaranty from the sheeting manufacturer stating that if the retroreflective sheeting fails to comply with the performance requirements of this subsection, the sheeting manufacturer shall do the following:

Table 1015-6
Manufacturer's Guaranty-Reflective Sheeting

Type	Manufacturer shall restore the sign face in its field location to its original effectiveness at no cost to the Department if failure occurs during the time period[1] as specified below		Manufacturer shall replace the sheeting required to restore the sign face to its original effectiveness at no cost to the Department if failure occurs during the time period[1] as specified below
	Orange/ Fluorescent Orange	All colors, except Orange/ Fluorescent Orange	All colors, except Orange/Fluorescent Orange
III	<3 years	<7 years	7 - 10 years
DOTD X	<3 years	<7 years	7 - 10 years

[1] From the date of sign installation.

Replacement sheeting for sign faces, material, and labor shall carry the unexpired guaranty of the sheeting for which it replaces.

The sign fabricator shall be responsible for dating all signs with the month and year of fabrication at the time of sign fabrication. This date shall constitute the start of the guaranty obligation period.

1015.06 NONREFLECTIVE SHEETING.

1015.06.1 General Requirements: Nonreflective sheeting film shall consist of an extensible, pigmented, weather-resistant plastic film. Face side of film shall be supported and protected by a paper liner which is readily removable after application without the necessity of soaking in water or other solvents. Colors shall match visually and be within the limits shown in Table 11 of ASTM D4956.

1015.06.2 Adhesive Requirements: Sheeting shall have a pre-coated pressure sensitive adhesive backing, which may be applied without additional coats on either sheeting or application surface. Adhesive shall comply with ASTM D4956, Class 1 (pressure sensitive).

1015.06.3 Physical Characteristics: The film shall be readily cut by normal fabricating methods without cracking, checking or flaking. Applied film shall be free from ragged edges, cracks, and blisters. The material shall have demonstrated its ability to withstand normal weathering without checking, cracking, or excessive color loss.

1015.07 SIGN ENAMELS, PAINTS, SILK SCREEN PASTE, AND OVERLAY FILM.

1015.07.1 Sign Enamels and Paints: These shall be applied in accordance with the sheeting manufacturer's recommendations. Final appearance as well as materials used shall be subject to approval.

1015.07.2 Silk Screen Paste: Silk screen paste shall be mixed at the factory, well ground to a uniform consistency and smooth texture, and shall be free from water and other foreign matter. It shall dry within 18 hours to a film that does not run, streak, or sag. Paste which has livered, hardened, or thickened in the container, or in which pigment has settled out so that it cannot be readily broken up with a paddle to a uniform usable consistency, will be rejected. Thinner shall be used in accordance with the sheeting manufacturer's recommendations.

Paste shall have proper pigmentation and consistency for use in silk screen equipment. The material shall produce the desired color and the same retroreflectivity values as required for reflective sheeting of the same type and color when applied on reflective sheeting background. Paste shall meet the quality and test requirements for appearance, coarse particles, and moisture and water resistance as specified for sign paints.

1015.07.3 Overlay Film: Transparent electronic cuttable overlay film shall produce the desired color and the same reflectivity values as required for reflective sheeting of the same type and color when applied on reflective sheeting background.

1015.08 TEMPORARY PAVEMENT MARKINGS.

1015.08.1 Temporary Tape: Temporary tape shall comply with ASTM D4592, Type I (removable) or Type II (non-removable) and shall be from the Approved Materials List.

1015.08.2 Painted Stripe: Paint shall be an approved traffic paint complying with 1015.12. Glass beads for drop-on application shall comply with 1015.13.

1015.08.3 Temporary Raised Pavement Markings for Asphalt Surface Treatment: Temporary raised pavement markers for asphalt surface treatment shall be flexible reflective tabs having a nominal width of 4 inches. The markers shall be yellow with amber reflective area on both sides. The body of the marker shall consist of a base and vertical wall made of polyurethane or other approved material and shall be capable of maintaining a reasonable vertical position after installation. The initial minimum Coefficient of Luminous Intensity at an entrance angle of -4

3M
Diamond Grade™ DG³ Reflective Sheeting Series 4000

Product Bulletin 4000 **January 2012**

Description

3M™ Diamond Grade™ DG³ 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. DG³ 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 DG³ fluorescent reflective sheeting provides higher visibility than ordinary (non-fluorescent) colored sheetings.

Applied to properly prepared sign substrates Diamond Grade DG³ 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.[2]

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.[2]

Table A - Daytime Color Specification Limits[1]

Color	x	y	x	y	x	y	x	y	Daytime Luminance Limit (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	

[1]The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Colorimetric System.

[2]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/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 the R_A in Table B.

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

-4° Entrance Angle[3]	Observation Angle[4]		
	0.2°	0.5°	1.0°
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
30° Entrance Angle[3]			
	0.2°	0.5°	1.0°
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

[3] Entrance Angle – The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.
[4] 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[3] 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)

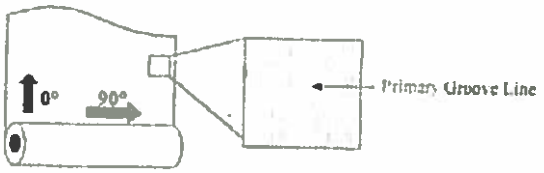

Figure 1

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 DG³ 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).

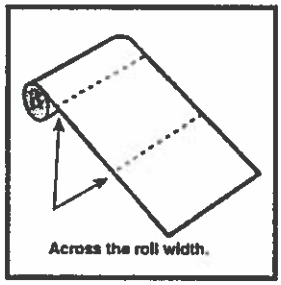

Figure 2 - Fabrication Lines

Adhesive

Diamond Grade DG³ 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, DG³ 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° C ± 3° C (160°F ± 5°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 DG³ 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 DG³ 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 DG³ 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 DG³ 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 DG³ 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 DG³ sheeting before and especially after screening to eliminate the possibility of cracking from improper handling techniques.

Thermal Transfer Printing

Diamond Grade DG³ 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 DG³ sheeting. Refer to Product Bulletin 1170 for fabrication procedures.

Applied Cut-Out Copy

Diamond Grade DG³ cut letters may be applied to a DG³ 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 DG³ 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 DG³ 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 DG³ 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 DG³ 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 DG³ 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 DG³ 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™ DG³ 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 DG³ 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™ DG³ 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_A for applicable Warranty Period for Ordinary Colors (white, yellow, red, green, blue and brown)

Warranty Period	Minimum Percentage R_A 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[5]
Fluorescent Yellow Green	10/7 Years[5]
Fluorescent Orange	3 Years

[5] 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

High Intensity Prismatic Reflective Sheeting Series 3930

Product Bulletin 3930 **January 2013**

Replaces PB 3930 dated January 2012

Description

3M™ High Intensity Prismatic Reflective Sheeting Series 3930 is a non-metalized microprismatic 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
Color – TT Series	
White – thermal transfer (TT) printable	3930TT
Yellow – TT printable	3931TT

Photometrics

Daytime Color (x,y,Y)

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

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.[2]

[2]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 squaremeter (cd/lux/m²).

Table A Daytime color specification limits[1]

Color	x	y	x	y	x	y	x	y	Daytime Luminance Limit 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	0.422	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
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404	10	30
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	.0390	0.550	0.450	0.430	0.390	1	9

[1]The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colormetric System.

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/m²)

-4° Entrance Angle[3]	Observation Angle[4]	
	0.2°	0.5°
White	560	200
Yellow	420	150
Red	84	30
Orange	210	75
Green	56	21
Blue	30	13
Brown	18	7.5
30° Entrance Angle[3]		
White	280	100
Yellow	210	75
Red	42	15
Orange	105	37
Green	28	10
Blue	14	6
Brown	8.5	3.5

[3]Entrance Angle – The angle from the illumination axis to the retroreflector axis. The retroreflector axis is an axis perpendicular to the retroreflective surface.

[4]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

High intensity prismatic 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. 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 high intensity prismatic 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 1).

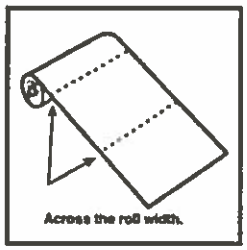

Figure 1 – Fabrication Lines

Adhesive

Series 3930 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, Series 3930 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. 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° C ± 3° C (160°F ± 5°F) for 24 hours followed by conditioning at standard conditions for 2 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

Series 3930 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 Series 3930 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 3930 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.

High intensity prismatic 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

High intensity prismatic 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

Series 3930 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 and is not recommended. Use of other process colors series is not recommended. **Care should be taken to avoid flexing high intensity prismatic sheeting before and especially after screening to eliminate the possibility of cracking from improper handling techniques.**

Thermal Transfer Printing

High intensity prismatic TT series 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 high intensity prismatic sheeting. Refer to Product Bulletin 1170 for fabrication procedures.

Applied Cut-Out Copy

High intensity prismatic cut letters may be applied to series 3930 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 (ECOF) instead of direct applied copy.*

Additional Imaging Options for Work Zone Signs

Vinyl Graphic Films

Scotchcal™ Vinyl Series 3650, Series 7720 and Series 7725 may be used to provide copy for traffic control signs on high intensity prismatic sheeting (typically orange, white or yellow sheeting) for use in construction work zones. Refer to Scotchcal™ product literature for more information.

Latex Ink Jet Printing

Series 3930 sheeting to be used in work zone signs may be imaged with HP 789 series black latex ink in conjunction with the HP Designjet L25500 Printer, or with 792 series black latex ink in conjunction with the HP Designjet L26500 Printer. Refer to Information Folder 3.4 for more information.

Note: *With the exception of 3M branded products, 3M does not represent that any printer or printer accessory recommended in 3M literature will meet customer requirements, any federal, state or local regulations or any applicable safety standards. Such determination is the responsibility of the printer owner.*

Cutting

Series 3930 sheeting may be cut into letters and shapes of at least 3 inches in height and stroke widths of at least 1/2 inch. Smaller sizes are not recommended. Sealing cut edges of Series 3930 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 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

Series 3930 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 3930 sheeting is 1 ½ inch or 50 sheets. Details on cutting can be found in 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 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 high intensity prismatic Series 3930 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 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 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 has tested HP Designjet Printers and black latex inks: L25500 printer/series 789 black ink, and L26500 printer/series 792 black ink; and when applied within parameters defined in IF 3.4 the resulting sign performance is considered to be commensurate with typically expected sign life. However, this imaging system is not covered as part of the 3M Matched Component system noted in the General Warranty Terms.

3M Basic Product Warranty and Limited Remedy

3M™ High Intensity Prismatic Reflective Sheeting Series 3930 ("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 Series 3930 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™ High Intensity Prismatic Reflective Sheeting Series 3930 ("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 and Limited Remedy

1. The Additional Warranty for a Sign made with the 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_A for applicable Warranty Period for white, yellow, red, green, blue and brown

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

2. If any Sign made with the 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 3934 Orange Product

1. The Additional Warranty for a Sign made with 3934 orange sheeting (Orange 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 the coefficient of retroreflection stated in Table D for three years measured from Fabrication Date; and (c) after cleaning, the Product will **maintain daytime luminance equal to or greater than the minimums specified in Table A.**

Table D

Minimum Coefficient of Retroreflection

for 3934 Orange sheeting Product (cd/lux/m²)

(0.2° observation and -4° entrance)

Warranty Period	Minimum R_A
Orange	80

If any Sign made with the 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, is that 3M will provide pro-rated replacement of the 3M materials.

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 Ink Jet Imaging with HP Designjet L25500
IF 3.4	Printer and HP 789 Series latex Inks

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.