3M™ Diamond Grade™ Fluorescent LDP Reflective Sheeting
9963 Fluorescent Yellow Green and 9924 Fluorescent Orange

Health & Safety
Refer to the package label and the Material Safety Data Sheet for health, safety and handling information on the products referenced in this bulletin. For 3M products, if necessary, you may contact our Toxicology/Product Responsibility Department for information on 3M products on 01344 858000.

Description
3M™ Diamond Grade™ Fluorescent LDP Reflective Sheetings are durable prismatic lens reflective sheetings that fluoresce when subjected to wavelengths in the visible spectrum. These sheetings are designed to be used for vehicle markings for greatly improved conspicuity. They will provide higher night-time brightness than glass bead based retroreflective sheetings and higher daytime brightness than ordinary (non-fluorescent) coloured sheeting. Applied to properly prepared substrates, Diamond Grade fluorescent LDP reflective sheeting should provide long-term service.

<table>
<thead>
<tr>
<th>Colour</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorescent Yellow Green</td>
<td>9963</td>
</tr>
<tr>
<td>Fluorescent Orange</td>
<td>9924</td>
</tr>
</tbody>
</table>

Photometrics
Daytime Colour (x, y, Y)
The chromaticity co-ordinates and total luminance factor of the retroreflective sheetings meet the requirements of Table A below.

Colour Test
Daytime colour requirements of sheeting applied to aluminium test panels shall be determined instrumentally using a 2-monochromator spectrophotometer employing annular 45°/0° (or equivalent 0°/45°) illuminating/viewing geometry. The chromaticity co-ordinates and total luminance factor shall be calculated from the total spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E-308 “Practice for Computing the Colours of Objects by Using the CIE System” for the CIE 1931 (2°) standard colorimetric observer. The measurements shall be made on a Labsphere BPC-450 Bispectral Fluorescent Colorimeter or equivalent.

Table A - CIE Chromaticity Co-ordinate Limits* and Minimum Total Luminance Factor for New Sheetings

<table>
<thead>
<tr>
<th>Colour</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Luminance Factor Y (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>y</td>
<td>X</td>
<td>y</td>
<td>x</td>
</tr>
<tr>
<td>Fluorescent Yellow Green</td>
<td>0.387</td>
<td>0.610</td>
<td>0.460</td>
<td>0.540</td>
<td>0.421</td>
</tr>
<tr>
<td>Fluorescent Orange</td>
<td>0.583</td>
<td>0.416</td>
<td>0.523</td>
<td>0.397</td>
<td>0.560</td>
</tr>
</tbody>
</table>

*The four pairs of chromaticity co-ordinates define the acceptable colour limits for CIE D65 illumination in terms of the CIE 1931 Colorimetric System.
Fluorescence ($Y_F$)

Fluorescent luminance properties differentiate fluorescent sheeting from ordinary (non-fluorescent) sheeting. The additional luminance produced by fluorescence is directly related to the increased visual performance of fluorescent markings under the varying conditions of daylight illumination encountered in outdoor applications. The Fluorescent Luminance Factor $Y_F$ provides a standardised measure of fluorescent luminance. The numerical value of $Y_F$ under specified illumination and viewing conditions 1) verifies the fluorescent properties of the sheeting (for non-fluorescent sheeting $Y_F=0$) and 2) quantifies the fluorescent content (efficiency) of its Total Luminance Factor. The magnitude of $Y_F$ can be used to assess whether the fluorescent content is sufficient to provide high daytime visibility under poor visibility conditions. The minimum fluorescence luminance factor ($Y_F$) values of the retroreflective fluorescent sheetings conform to Table B.

Table B - Minimum Fluorescence Luminance Factor for New Sheet

<table>
<thead>
<tr>
<th>Colour</th>
<th>$Y_F$ (%) min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Green</td>
<td>35</td>
</tr>
<tr>
<td>Orange</td>
<td>10</td>
</tr>
</tbody>
</table>

Fluorescence Test

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


Coefficients of Retroreflection ($R_A$)

The values in Table C are minimum coefficients of retroreflection expressed in candelas per lux per square metre (cd/lux/m\(^2\)). Measurements are made in accordance with CIE publication 54:1982. $R_A$ values are measured at 0° and 90° rotation and averaged to determine the minimum $R_A$ value in Table C.

Table C - Minimum Coefficient of Retroreflection $R_A$ for New Sheet

<table>
<thead>
<tr>
<th>Obs. Angle</th>
<th>Colour</th>
<th>Entrance Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2°</td>
<td>Yellow Green</td>
<td>625 525 135</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
<td>250 175 120</td>
</tr>
<tr>
<td>0.33°</td>
<td>Yellow Green</td>
<td>390 175 75</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
<td>175 105 55</td>
</tr>
<tr>
<td>0.5°</td>
<td>Yellow Green</td>
<td>255 140 45</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
<td>130 60 25</td>
</tr>
<tr>
<td>1.0°</td>
<td>Yellow Green</td>
<td>25 20 20</td>
</tr>
<tr>
<td></td>
<td>Orange</td>
<td>3 1.5 1.0</td>
</tr>
</tbody>
</table>

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

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

Interlocking Diamond Seal Pattern

3M™ Diamond Grade™ Fluorescent LDP Reflective Sheet 9963 and 9924 have the same interlocking seal pattern as series 9970 sheeting. This pattern is unique to 3M prismatic retroreflective sheetings. Under normal light, this seal pattern will appear lighter in colour than the reflective portion (Figure 1).

Seal legs have smooth edges

![Application Orientation](./Application Orientation Horizontal.png)

![Application Orientation](./Application Orientation Vertical.png)

Figure 1
Application Orientation

The 3M™ Diamond Grade™ Fluorescent LDP Sheetings are designed to reflect effectively regardless of their orientation on the substrate or ultimate orientation after installation.

However, because the efficiency of light return from cube corner reflectors is not equal at all rotation angles, optimum entrance angle performance can be achieved when the sheeting is oriented in a particular way.

When extra wide entrance angle performance is important for a given situation, you may elect to apply the material with a specific orientation.

Optimum wide-angle entrance performance is achieved by orientating Diamond Grade LDP sheeting horizontally. The sharp ends of the cell pattern point horizontally.

However, unless the location and/or position calls for extra-wide entrance angularity performance, Diamond Grade LDP Series sheetings can be manufactured and installed using the orientation that most efficiently utilises the reflective sheeting.

NOTE: In cases where panels, strips and text are placed on the same surface, it is recommended they be placed in the same orientation.

Datum Marks

Unlike 3M™ Diamond Grade™ VIP Reflective Sheet Series 3990, Diamond Grade LDP does not carry datum marks. The two sheetings can therefore be distinguished on a roll by the presence of datum marks on the Diamond Grade VIP sheeting.

Tooling Lines

The method of prismatic sheeting manufacture results in tooling lines being present in the product. In Diamond Grade fluorescent LDP sheeting these lines are slightly thicker than the seal pattern legs and occur down the web every 86cm (34 ins).

Tooling lines are noticeable in shop light but are not obvious in daylight or at night under typical use conditions (Figure 2).

Adhesive

Diamond Grade fluorescent LDP sheetings have pressure-sensitive adhesives and are recommended for room temperature application. Room temperature application is defined as 16 to 28°C.

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 1.6mm (0.063 inches) minimum thickness 6061-T6, 5052-H38 or equivalent aluminium panels that have been degreased and lightly acid etched.

Properties

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

1. 90° Peel Adhesion

Test Method - Apply 10cm (4") of 2.54cm x 15cm (1" x 6") strip to test panel and condition. Fix panel horizontally with applied strip down and suspend test weight (0.8kg (1-¾ lbs)) from free end.

Requirement - Not more than 5.0cm (2") of peel in 5 minutes.

2. Impact Resistance

Test Method - Apply sheeting to a standard panel 7.6cm x 15.2cm (3" x 6") and condition. Subject sheeting to a 5.7Nm (50 inch pounds) impact in accordance with ASTM D-2794.

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

Test Method - Following conditioning, remove the liner from 22.9cm x 22.9cm (9" x 9") samples and place specimens on flat surface with adhesive side up.

Requirement - shrinkage not greater than 0.8mm (1/32") in 10 minutes or more than 3.2mm (1/8") in 24 hours in any dimension.

4. Flexibility

Test Method - Following conditioning of 2.54cm x 15.2cm (1" x 6") sample, remove liner and dust adhesive with talc. At standard conditions, bend the sample in one second around 3.2mm (1/8") diameter mandrel with adhesive side facing mandrel.

Requirement - No cracking, peeling or delamination.

5. Gloss

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

Requirement - Rating not less than 50.

Substrates

Users are urged to carefully evaluate substrates for sheeting adhesion and compatibility. Sheet failures caused by the substrate or improper surface preparation are not the responsibility of 3M. 3M™ Diamond Grade™ sheeting is designed primarily for application to flat surfaces.

The user must determine the suitability of any non-metallic substrates for use with 3M sheetings.

Application to rusted, severely pitted, loose or chalking painted surfaces is not recommended. These surfaces must be clean of rust and painted using recommended practises before applying the sheeting.

Fabrication Methods

Application

Diamond Grade fluorescent LDP sheeting series 9963 and 9924 incorporate pressure-sensitive adhesives and should be applied to the substrate at room temperature (16 to 28°C).

Butt Joints - 9963 and 9924 sheetings should be butt joined when more than one piece of sheeting is required to form a continuous marking on one piece of substrate. All pieces of a marking must be applied with the same orientation on the finished sign.

Screen Printing

These sheetings may be screen printed using 3M™ Process Colour Series 880I (see Product Bulletin 880I). Printing conditions should be 16-28°C and relative humidity of 30-60%. Use of PE61T/62T screen mesh with a fill pass is recommended. Use of other screen printing inks is not recommended. 3M assumes no responsibility for failure of printed 9963 and 9924 sheeting that has been processed with non-3M process colours or 3M process colours other than Series 880I.

NOTE: For vehicle applications, screen processed sheeting must be clear coated using series 880I toner.

NOTE: Screen printed Diamond Grade LDP reflective sheeting should be kept flat especially during the drying process. Avoid bending sharply or folding when handling wet sheets to prevent cracking.

Edge Sealing

Edge sealing Diamond Grade LDP reflective sheeting is generally not required. Following outdoor exposure, dust particles may become trapped within the row of cut cells along the sheeting’s edge. This should not adversely affect the performance of the rest of the marking. Narrow width markings or letters should be a minimum of 18mm wide. Where possible reverse or direct screening processing is recommended.

Application of series 880I toner along the cut edges of the sheeting may limit the ingress of dirt and moisture.

Mechanical methods of edge sealing Diamond Grade fluorescent LDP sheeting are available. Although the performance of these systems are not warranted by 3M, they will limit the ingress of dirt and water into cut cells.

Cutting and Matching

9963 and 9934 sheeting may be hand cut or die cut one sheet at a time, and band sawed or guillotined in stacks. The sheeting can be hand cut from either side with a sharp knife or other sharp hand tool.

Cutting equipment such as guillotines and metal shears that use pressure plates to hold the sheeting when cutting may damage the optics. To reduce pressure on and eliminate damage to the sheets the pressure plate should be padded. Stack heights may vary with condition and type of equipment used.
NOTE: As with all reflective sheetings, when two or more pieces are used side by side on a surface. They must be matched to assure uniform daytime colour and night appearance.

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

Cleaning

9963 and 9924 sheeting may be washed with a sponge or soft cloth using cold or warm water (no greater than 60°C). If detergent is required it must be neutral and non-abrasive, used in dilute solution and followed by a clean water rinse.

When using pressure washing equipment, limit nozzle pressure to 80 bar (1000psi). Nozzle should be held at least 1 metre away from the vehicle using a wide fan pattern, and at an angle no more than 15 degrees from square on to the vehicle surface.

Caution: !

Any dirt collecting at the outer edges of the Diamond Grade sheeting will not affect the products’ overall performance. Do not attempt to remove this dirt with aggressive use of the pressure washing equipment as it may result in the edge lifting and/or top film layer delamination.

Acidic or abrasive brightening and cleaning solutions can have an adverse affect on 9963 and 9924 sheeting by lowering the surface gloss and retroreflection. These types of solutions should be avoided.

Storage and Packaging

3M™ Diamond Grade™ Fluorescent LDP sheeting should be stored in a cool, dry area, preferably at 18-28°C and 30-60% relative humidity and should be applied within one year delivery.

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.

Screen processed material must be protected with SCW-82 or SCW 568 slipsheet paper. Place the glossy side of the slip sheet against the sheeting face and pad the face with closed cell packaging foam. Unmounted, screened sheeting must be stored flat and interleaved with SCW-82 or SCW 568 slipsheet, glossy side against the sign face.

Avoid banding, crating or stacking of the sheeting. Package for shipment in accordance with commercially accepted standards to prevent movement and chafing.

NOTE: Finished material must remain dry during shipment and storage. If packaged material becomes wet, unpack immediately and allow to dry.

General Performance Considerations

The durability of 9963 and 9924 sheeting will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance.

Maximum durability of these sheetings can be expected in vertical applications when processed and applied to properly prepared substrates, see Table D. Horizontal applications are subjected to more extreme environmental effects and a reduction in durability can be expected. 3M does not warrant non-vertical applications.

Colour Stability

Diamond Grade fluorescent LDP sheetings have durable fluorescence. Any change in colour appearance will be at a rate comparable to non-fluorescent sheeting during the warranty period.

After the warranty period, the colour of the sheeting may degrade more rapidly than non-fluorescent sheeting. Fading will occur faster on south facing applications and applications in climates with high levels of solar radiation and high temperatures.

Where 3M™ Process Colour or other recommended 3M sheetings are used for imaging Fluorescent LDP sheeting, they are generally expected to provide durability comparable to coloured reflective sheeting. However, exposure angles and climatic conditions may affect the durability.
Table D

<table>
<thead>
<tr>
<th>Colour</th>
<th>Warranty Period</th>
<th>Minimum Coefficient of Retroreflection (R\textsubscript{A} cd/lux/m at -4\textdegree)</th>
<th>Minimum Fluorescent Luminance Y\textsubscript{F} %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Entrance Angle</td>
<td>Observation Angle</td>
</tr>
<tr>
<td>Yellow</td>
<td>5 years</td>
<td></td>
<td>0.2\textdegree</td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
<td>0.2\textdegree</td>
</tr>
<tr>
<td>Orange</td>
<td>5 years</td>
<td></td>
<td>0.2\textdegree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.2\textdegree</td>
</tr>
</tbody>
</table>

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