Preliminary Product Bulletin ESV 4090
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Diamond Grade™ DG³ Reflective Sheeting Series 4090

Health & Safety

Refer to the package label and, if relevant, 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 on 01344 858000.

Product Description

Diamond Grade DG³ Reflective Sheeting Series 4090 is a super-high efficiency, full cube retro-reflective sheeting designed for the production of durable vehicle conspicuity markings and vertical traffic signs. DG³ sheeting is designed to have the highest retro-reflective characteristics at medium and short road distances as determined by the R_A, value at 0.5° and 1.0° observation angle in Table A. The performance at this angle represents the most common viewing geometries encountered by the driving public. 4090 sheeting also provides brightness at high entrance angles shown in the values at 40° in Table A.

During the daytime and low ambient light levels, Diamond Grade DG³ Fluorescent Reflective Sheeting provides higher visibility to vehicle liveries and traffic signs than ordinary (non-fluorescent) coloured sheetings.

Applied to properly prepared substrates, Diamond Grade DG³ Series 4090 should provide long-term service.

Colour	Product Code
White	4090
Yellow	4091
Red	4092
Blue	4095
Interstate Green	4097
Fluorescent Yellow	4081
Fluorescent Yellow Green	4083
Fluorescent Orange	4084

Coefficients of Retroreflection

The minimum initial coefficient of retro-reflection R_A (cd/lux/m²) of Diamond Grade DG³ 4090 (averaged for 0° and 90° rotation), when measured in accordance with the procedure specified in CIE Publication No. 54, using CIE standard illuminant A, conforms to the values in Table A.

Table A

Obs Angle.	Colour	Entrance Angles		
		-4	30°	40°
0.20°	White	570	215	100
	Yellow	425	160	75
	Red	114	43	20
	Interstate Green	57	21	10
	Blue	26	10	4.5
	Fluorescent Yellow	340	130	60
	Fluorescent Yellow Green	460	170	80
	Fluorescent Orange	170	64	30
0.50°	White	400	150	50
	Yellow	300	112	37
	Red	80	30	10
	Interstate Green	40	15	5
	Blue	18	6.8	1.5
	Fluorescent Yellow	240	90	30
	Fluorescent Yellow Green	320	120	40
	Fluorescent Orange	120	45	15
1.0°	White	120	45	25
	Yellow	90	34	19
	Red	24	9	5
	Interstate Green	12	4.5	3
	Blue	5.4	2	0.8
	Fluorescent Yellow	72	27	15
	Fluorescent Yellow Green	96	36	20
	Fluorescent Orange	36	14	7

Table B

	1		2		3		4		Luminance Factor, Y
Colour	**x**	**y**	**x**	**y**	**x**	**y**	**x**	**y**	
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	Y >0.40
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	0.45 > Y >0.24
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	0.15 > Y >0.03
Blue	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216	0.10 > Y >0.01
Interstate Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	0.12 > Y >0.01
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442	Y >0.45
Fluorescent Yellow Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540	Y >0.60
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355	Y >0.25

Chromaticity

The chromaticity and the luminance factor shall comply with the limits defined in Table B when illuminated with CIE Standard Illuminant D65. The sample shall be illuminated at 0° to the surface and measure the reflected light in the direction of 45° to the normal to its surface (CIE O/45 geometry).

Performance Compliance

3M™ Diamond Grade™ DG^3 Reflective Sheeting Series 4090 complies with the UK Home Office Scientific Development Branch "Battenberg" Livery Film Specification.

Orientation

Diamond Grade DG^3 is designed to be an effective wide angle reflective sheeting regardless of the 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 application angles, especially at increasing entrance angles, it is possible to get the widest entrance angle light return when the sheeting is orientated in a particular manner.

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

If high entrance performance beyond 50^o is a requirement for your application, you can achieve this performance by positioning the applied sheeting at the 0^o application angle.

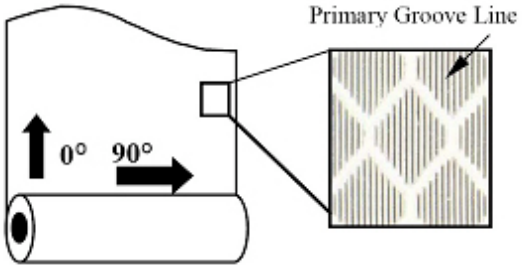


Figure 1 – Sheeting is positioned at 0^o application angle.

When the "primary groove line" is vertical in the applied sheeting, the Diamond Grade DG^3 is said to be at a 0^o orientation. When the "primary groove line" is horizontal in the applied sheeting, the Diamond Grade DG^3 is said to be at a 90^o orientation

However, unless the location and/or position calls for extra-wide entrance angularity performance, Diamond Grade DG^3 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.

Distinguishing Marks

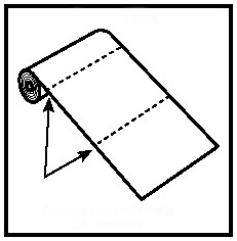
Diamond Grade™ DG^3 can be distinguished from other Diamond Grade products by the presence of the "primary groove line."

Tooling Lines

The manufacture of prismatic sheeting results in tooling lines being present in the product. In Diamond Grade DG^3 these lines are slightly thicker than the seal pattern legs. Tooling lines are more noticeable in shop light but are not observable on the road either in daylight or night under reflected light (Figure 2).

Figure 2

Tooling Lines



Across the roll width 86.36cm (34") centres

Substrates

See Instruction Bulletin 5.1 for recommended substrate preparation.

Users are urged to carefully evaluate all other substrates for adhesion and sheeting durability. Sheeting failures caused by the substrate or improper surface preparation are not the responsibility of 3M. Diamond Grade DG^3 Series 4090 is designed primarily for application to flat substrates.

Fabrication Methods

Application

Diamond Grade DG^3 Series 4090 incorporates a pressure-sensitive adhesive and should be conditioned prior to application to provide a minimum sheeting temperature of 15^{o}C throughout the material to be applied. Application should be conducted at at room temperature (15^{o}C) or higher.

For hand application, firm pressure with a rubber roller, felt squeegee or equivalent should be applied to obtain maximum initial adhesion. Use multiple, heavy overlapping strokes. Re-roll all edges.

Splicing

Diamond Grade DG^3 Series 4090 should be butt spliced when more than one piece of sheeting is used on one piece of substrate. Ideally the pieces should not touch each other. A splice gap of up to 1.5mm is acceptable. This is to prevent buckling as the sheeting expands in extreme temperature and humidity cycles.

All pieces must be applied with the same orientation on the same application. If pieces of the same colour are being used side by side on a surface, they should be matched to assure uniform day colour and night appearance.

Imaging

Screen Print Applications

- 3M™ Process Colors 880I

Copy Part Applications

- 3M™ Scotchcal™ Film 3650-12 (Black)
- 3M™ Scotchcal™ Film 7720-12
- 3M™ Controltac™ Scotchcal™ Film 180-12
- 3M™ ElectroCut™ FilmSeries 1170

All Applications

- Selected 3M application tapes

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

NOTE: Care should be taken to avoid flexing Series 4090 sheeting before and especially after screen printing. Screen-printed material must be sufficiently ventilated during the filling of the rack or immediately run through a conveyor. If the print is not ventilated properly, the solvents within the ink may damage the top-film of the Diamond Grade sheeting. Refer to Product Bulletin 880I for more details.

Edge Sealing

Edge sealing Diamond Grade DG^3 Series 4090 is generally not required to maintain overall product performance.

However, 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 sheeting performance unless occurring in legends or shapes with narrow stroke widths (small letters or numbers).

If the user chooses to edge seal, 3M recommend either of the following methods:

- 3M assured seal
- Series 880I Clear Coat should be applied to the cut edge after application.

Although the performance of these systems are not warranted by 3M, they will limit the possibility of dirt and water ingress into cut cells.

Cleaning

Diamond Grade™ DG^3 Series 4090 may be washed with a sponge or soft cloth using cold or warm water and soap or detergent, 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.

Acid brightening and cleaning solutions can have an adverse affect on Diamond Grade DG^3 Series 4090 over time by lowering the surface gloss and retroreflection. These solutions should not be allowed to soak on the sheeting to avoid immediate damage.

Storage and Packaging

Diamond Grade DG^3 Series 4090 should be stored in a cool, dry area, preferably at 18-24^{o}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.
Screen processed material must be protected with SCW-82 or SCW 568 slipsheet paper. Place the glossy side of the ship sheeting 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 sheeting face.

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

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

Expected Effective Performance Life

When fabricated and applied in accordance with 3M recommended procedures, and exposed vertically, the following performance typically may be expected. Performance is based upon field experience and exposure tests conducted throughout Europe and the United States. Performance can be affected by substrate selection and preparation, exposure conditions and maintenance of the marking.

Vertical Exposure

Standard Colours

Unprinted	7 years
Printed using 3M™ Process Colour Series 880I	7 years

Fluorescent Colours

Unprinted	5 years
Printed using 3M™ Process Colour Series 880I	5 years

Exceptions to the above are:

1. Horizontal exposure is not recommended.
2. The warranty applies to sheetings that are exposed at a vertical angle (defined as 90± 10°). A significant decrease in durability may be experienced if sheetings are exposed other than vertical. Such non-vertical applications must be on a test and approval basis to determine acceptability. 3M does not warrant non-vertical exposures.
3. Application to areas having frequent or long periods of continuous high heat (above 65°C) such as applications to areas on railroad engines, vehicle engine compartments, or repeated internal steam cleaning or non-insulated tankers, will decrease the effective performance life of the sheeting, by as much as two years.

General Performance Considerations

The durability of Diamond Grade™ DG^3 Series 4090 will depend upon substrate selection and preparation, compliance with recommended application procedures, geographic area, exposure conditions, and maintenance.

Maximum durability of Diamond Grade DG^3 Series 4090 can be expected in applications subject to vertical exposure when processed and applied to properly prepared substrates. Horizontal applications are subjected to maximum environmental effects and a reduction in durability can be accepted. 3M does not warrant non-vertical applications.

The user must determine the suitability of any non-metallic substrate for its intended use.

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 Diamond Grade sheeting

3M process colours, when used according to 3M recommendations, are generally expected to provide durability comparable to coloured reflective sheeting, except for certain lighter colours, such as yellow, gold, or heavily toned colours or blends containing yellow or gold, whose durability depend on how much of each colour is used. Dilution of colour and atmospheric conditions in certain geographical areas may result in reduced durability. 3M™ Scotchcal™ Film 3655 Black, Scotchcal film 7720-12 and 3M™ Controltac™ *Plus* Graphic Marking Film 180-12 Black can be expected to perform satisfactorily for the life of the sign when directly applied to series Diamond Grade DG^3 sheetings, except where shortened durability is stated in the literature.

Literature

Related 3M Literature	Bulletins
3M™ Process Colour Series 880I	**880I**
Substrate selection and preparation	**5.1**
Application, storage and cleaning	**5.13.1**
Removal	**6.4.1**

Important Notice To Purchaser

Technical information provided by 3M is based on experience and/or tests believed to be reliable but its accuracy is not guaranteed and the results may not be relevant to every user's application. 3M does not accept responsibility or liability, direct or consequential, arising from reliance upon any information provided and the user should determine the suitability of the products for their intended use.
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If any goods supplied or processed by or on behalf of 3M prove on inspection to be defective in material or workmanship 3M will (at its option) replace the same or refund to the Buyer the price of the goods or services.

Except as set out above, all warranties and conditions, whether expressed or implied, statutory or otherwise are excluded to the fullest extent permissible at law.

Technical Assistance

For help on specific questions relating to 3M Traffic Safety Systems Division products, contact your local Technical Service Representative.

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