

3M Science.
Applied to Life.™

3M™ Reflective Sheeting
for Traffic Signs

**Brighter signs
for safer
roads**



EXIT 106

Damansara
Petaling Jaya
Bdr. Utama





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Comprehensive Safety Solutions

As a world leader in reflective sheeting technology and innovation, 3M is uniquely positioned to help you select the products you need to meet your sign sheeting objectives. In addition, our staff of dedicated traffic safety professionals can provide the peace of mind of a long-term partnership for maintaining safety on your roadways.

Because driving at night is dangerous

A 3x higher rate of fatalities

According to the Federal Highway Administration (FHWA), the rate of traffic fatalities is three times higher at night than during the day.¹ One of the most important factors contributing to this tragic difference is nighttime drivers simply lack the visual cues they receive during daylight hours. A number of significant changes taking place on our nation's roadways could make this situation even worse in the years ahead.

More older drivers

According to the U.S. Census, more than 50 million people aged 65 and older will be driving by 2020 – about one in every five. It has been well documented that older drivers have slower response times and even less visual acuity at night than younger drivers.

Low cut-off headlights

Since the late 1990s, vehicle manufacturers have been installing VOA or low cut-off headlights on many vehicles. As shown in the photos at right, these headlights emit little light above the headlight level. This can effect on a vehicle's ability to illuminate road signs. In fact, one study found these headlights reduces the visibility of signs by as much as 53% in common sign configurations.²



Simulation of traditional headlights at 18.3m



Simulation of low cut-off headlights at 18.3m

More trucks

The number of trucks on U.S. highways has increased by 60% in the last ten years. Because trucks cabs are more elevated than car cabs, the angle between the driver's eyes and the headlights is significantly greater. This means little retroreflected light from road signs reaches these drivers, and signs appear dimmer, if visible at all.

¹http://safety.fhwa.dot.gov/roadway_dept/retro/gen/back_needs.htm

²Slivak, M., University of Michigan Transportation Research Institute, 2000-2001

Drivers read brighter signs faster

A recent study at the University of Iowa found a direct correlation between a sign's brightness and a driver's ability to comprehend the sign's message. Study participants were able to read and understand brighter signs substantially faster¹. This study suggests that brighter signs require less eyes-off-the-road time, leaving drivers more time to attend to the task of driving – an especially important advantage when driving at night.

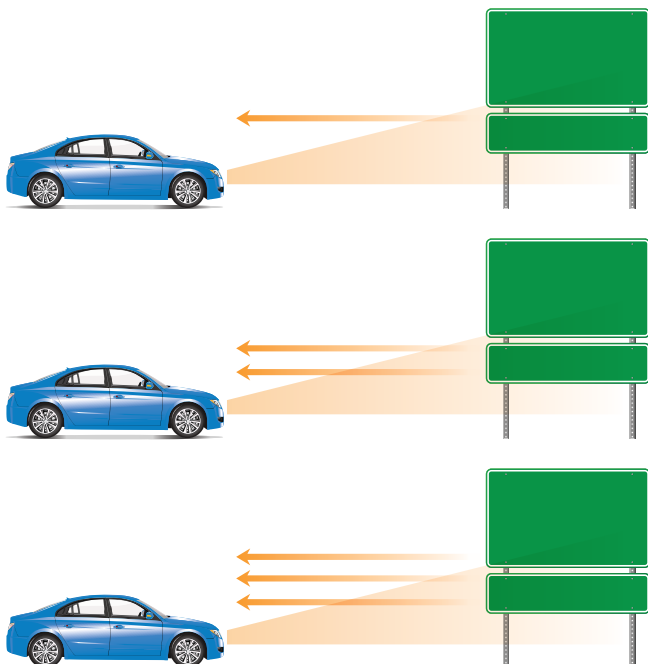


Stimulation of traffic sign with conventional micro prismatic sheeting at night.



Stimulation of traffic sign with 3M™ Full Cube Technology sheeting at night.

3M™ Full Cube Technology nearly doubles the effective brightness of road signs



Engineer Grade Reflective Sheeting

One of the original retroreflective technologies, encapsulated glass bead sheeting reflects only 14% of light back toward its source.

High Intensity Prismatic Reflective Sheeting

Truncated cube corner sheeting – the most common sign sheeting in use today – reflects about 32% of light back towards its source.

Diamond Grade Reflective Sheeting

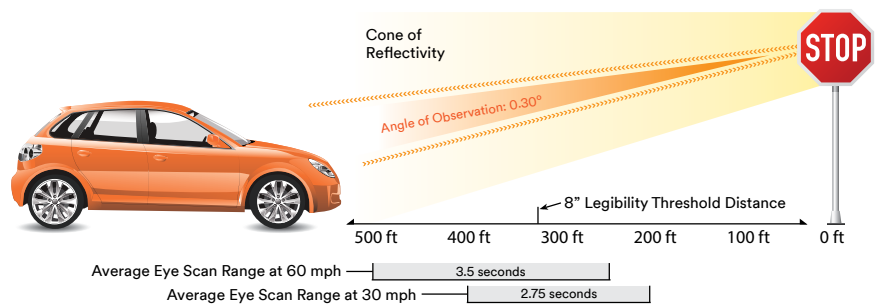
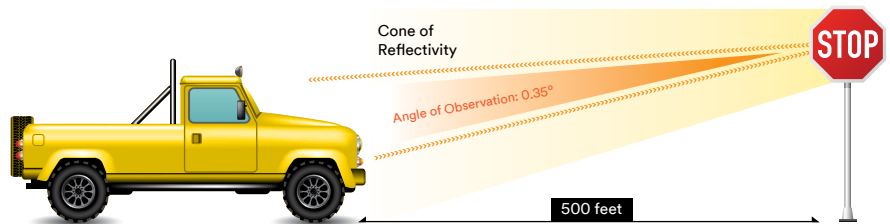
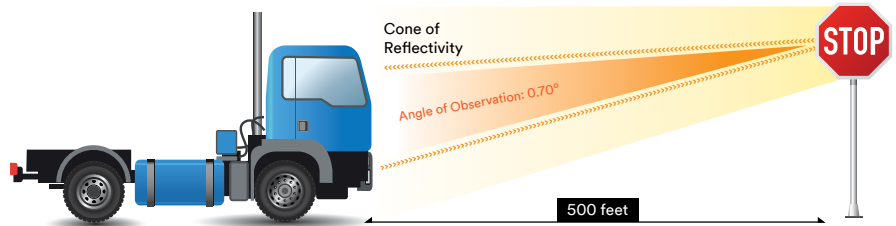
3M™ Diamond Grade™ DG³ Reflective Sheeting, made with 3M Full Cube Technology, reflects 58% of light back toward its source – almost doubling the overall brightness of road signs.

¹ Schell, T., Yekhshatyan, L., Daiker, R., Konz, J., Effect of Luminance on Information Acquisition Time and Accuracy from Traffic Signs. Paper accepted for presentation and publication, Transportation Research Record, Journal of the Transportation Research Board, 2008. Full report available at <http://www.ccad.uiowa.edu/ded/opl/projects/luminance>

Vehicle size affects sign performance

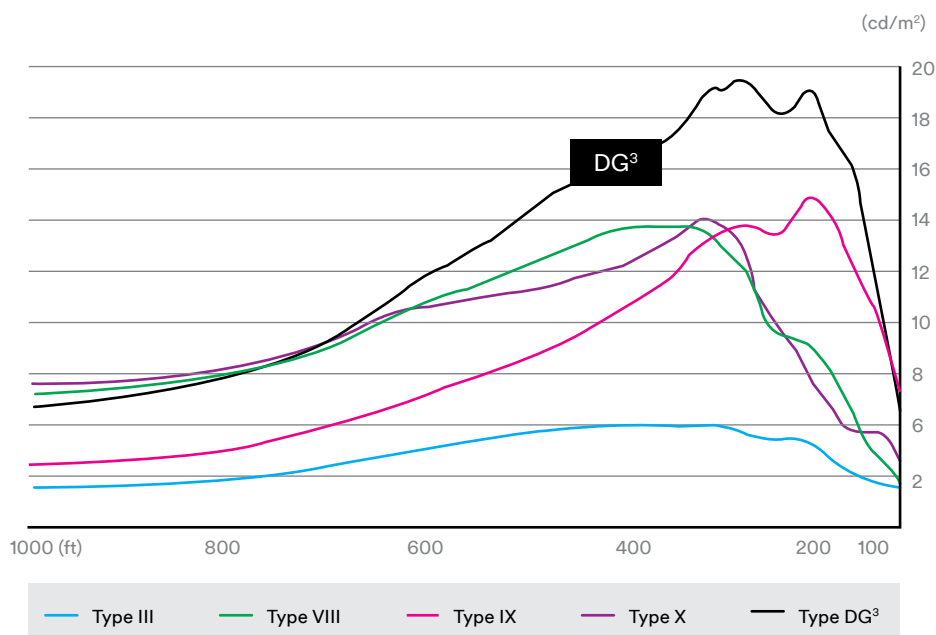
Diverse observation angles. Signs must accommodate the observation angles of all types of vehicles on the road. Retroreflective performance is critical to make signs visible for every driver.

Different sized vehicles create different observation angles between headlights and driver's eye level, requiring greater retroreflective performance from signs.



Twice the retroreflective efficiency increases visibility on the road

Luminance values increase appreciably with Diamond Grade DG³ technology to accommodate the wide range of observation angles from different sized vehicles, entrance angles for signs above and to the left or right.



Represents luminance values for a right shoulder-mounted sign viewed by a driver of an SUV-sized vehicle with VOA headlamps.

3M™ Diamond Grade™ DG³ Reflective Sheeting provides higher luminance values than all other sheeting types at the distance most critical to drivers – at 500 feet and closer. Compared with other microprismatic sheetings, the DG³ full cube solution is measurably – and visibly – superior.

The science of light

Light is measured to determine true performance in the driving environment.

Headlamps:

Intensity from the source is measured in candela (cd)



Illuminance describes how much light reaches a surface, measured in Lux

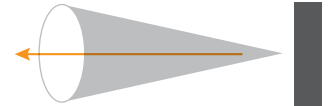


Observation angle:

Luminance is a measure of how bright a reflective surface appears (mostly governed by retroreflective at night and ordinary reflection during the day)



Retroreflective efficiency can be defined by total light returned into a "cone of retroreflection" and light reflected toward a point in the cone is measured in $\text{cd}/\text{m}^2/\text{lux}$



Older drivers:

The driver's eye process this light to perceive the surface's legibility



Designed to meet the needs of drivers



Now and years from now

- Exceeds MS 1216 : 2003, LLM T1/07, JKR ATJ 2E/87 (Pindaan 2011) JKR 21300-0033-12 and complied to Type XI of ASTM D4956-17 minimum retroreflectivity requirements
- State-of-the-art “full cube” technology
- 100 percent efficient optical elements
- Delivers optimal performance where and when drivers need it most

Drivers today need more help on the roadway

Several factors render much of today's installed signing less effective in providing the visual guidance drivers need. Visually / optically aimable (VOA) headlights, with their horizontal cut-offs, reduce the visibility of signs by as much as 53 percent (depending on sign location).¹ Diverse vehicle sizes – from cars to SUVs to semi-tractors – create vastly different observation angles. Changing demographics also play into the need for improved signage. Older drivers have slower response times and decreased visual acuity at night.²

Science supports better signage

A distinct correlation exists between sign brightness and a driver's ability to comprehend the sign's message.³ Comprehension directly relates to reaction time, which can mean the difference between safely navigating a certain roadway environment or being in an accident. One study found that where brighter, more visible signs were installed, crash numbers fell by 25 to 46 percent over three to six year period.⁴

Designed to meet the needs of all drivers now and years from now

3M™ Diamond Grade™ DG³ Reflective Sheeting incorporates "full cube" technology for optimal performance. Its optical elements are 100 percent efficient, returning almost 60 percent of available light – nearly double that of traditional prismatics. DG³ sheeting is designed as a replacement for all types of reflective sign sheetings in use today. It performs at all sight distances – including short and medium sight distances, and where signs are positioned in disadvantaged locations such as overhead or on the left shoulder.

Better for the environment

Not only is 3M™ Diamond Grade™ DG³ sheeting bright and durable, it's better for the environment. The manufacturing processes for prismatic sheeting reduce VOC emissions by 97 percent and energy consumption by 72 percent compared to standard engineer grade sheeting processes. Now that's a change for the better.



NIGHT



Available in standard and fluorescent colors for highly visible signs from day to dusk to dark

DAY



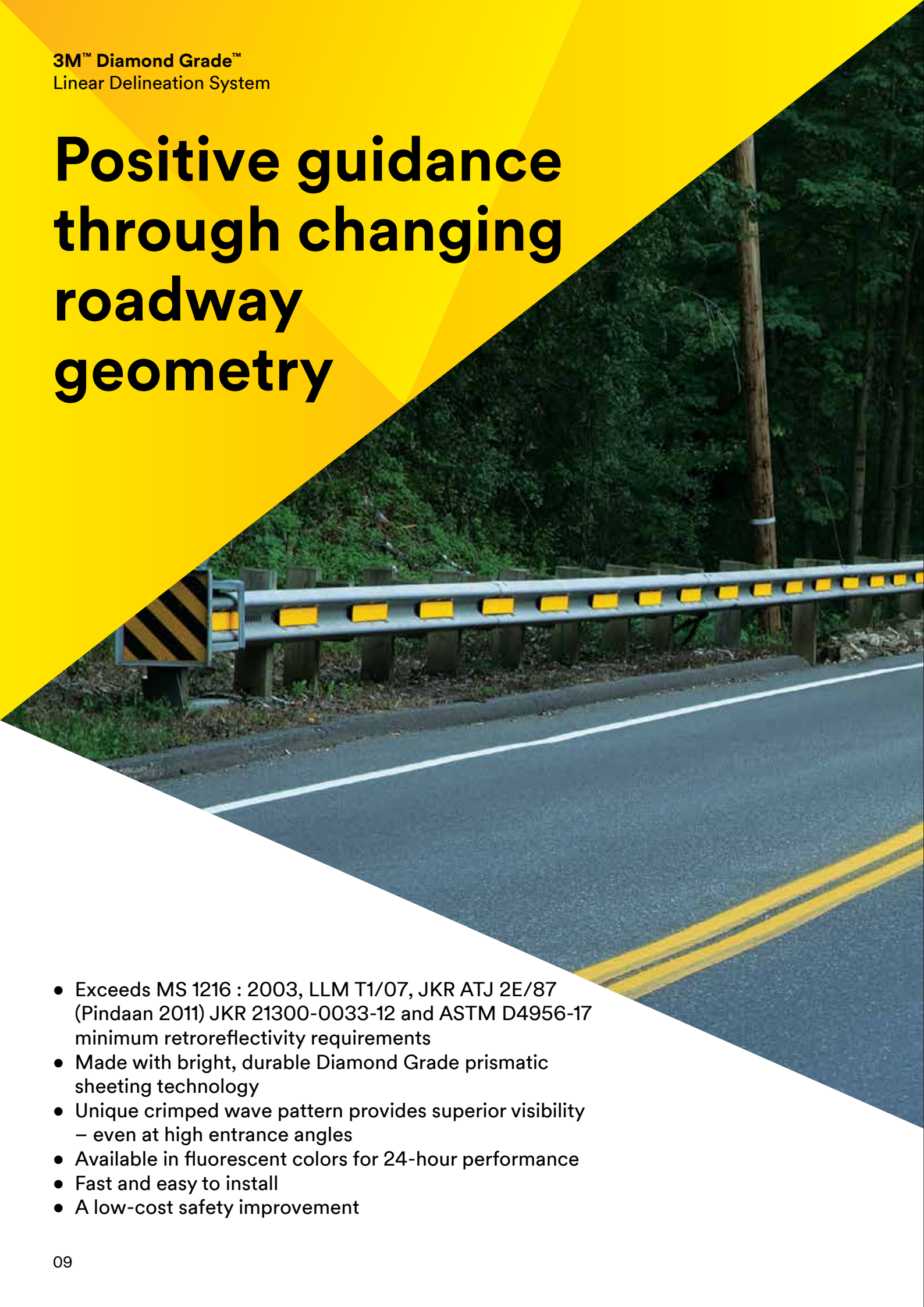
¹ Sivak, M., et al, University of Michigan Transportation Research Institute, UMTRI-2000-1.

² Transportation in an Aging Society, special report 218, FHWA, 1988.

³ Schieber, F., University of South Dakota, Heimstra Human Factors Laboratories, TRB-04-1951.

⁴ Ripley, D., Howard R. Green Company, ITE AB04H313.

Positive guidance through changing roadway geometry

- 
- Exceeds MS 1216 : 2003, LLM T1/07, JKR ATJ 2E/87 (Pindaan 2011) JKR 21300-0033-12 and ASTM D4956-17 minimum retroreflectivity requirements
 - Made with bright, durable Diamond Grade prismatic sheeting technology
 - Unique crimped wave pattern provides superior visibility – even at high entrance angles
 - Available in fluorescent colors for 24-hour performance
 - Fast and easy to install
 - A low-cost safety improvement

Providing positive guidance through changing roadway geometry

It is well known that changes in roadway geometry lead to increased crashes, resulting in escalating costs to agencies and society. Navigating changing roadways becomes even more difficult at night.

- Two-thirds of fatalities occur when vehicle leave the road
- Single vehicle run-off-the-road accidents continue to lead U.S. crash statistics
- In the U.S., the nighttime accident rate is three times that of the day rate

The 3M™ Diamond Grade™ Linear Delineation System provides clear visual guidance to help drivers through work zones and other challenging roadway conditions.

Proven technology for increased safety

3M's linear delineation system is designed to enhance driver safety where there is a need to call attention to a changed or changing condition, such as an abrupt roadway narrowing or curvature, or to provide guidance through a work zone. Common applications include:

- Curved roadways
- Tunnel approaches
- Entrance and exit ramps
- Bridges

Linear delineation system panels combine high performance 3M™ Diamond Grade™ Reflective Sheeting with a unique crimped design for optimal visibility and angularity. Panels are available in fluorescent colors that provide increased visibility from dawn to dusk, as well as at night.

Economical and durable

Linear delineation technology continues 3M's more than 75-years tradition of delivering traffic safety solutions with industry-leading service life. 3M's linear delineation system panels are economical and now even easier to install with 3M™ VHB™ Tape. High performance VHB tape is pre-applied to the panels for fast, easy application to metal guardrails, work zone barriers and median barriers. No special tools or messy adhesives are required.



3M linear delineation system panels are now available in a 1.5-inch version designed to fit into guardrail troughs and offers flexibility for application to concrete or other surfaces both on and off the roadway.

Size	Available Colors
4- and 6- inch panels	White
	Red
	Fluorescent Yellow
	Fluorescent Orange
1.5-inch panels	Fluorescent Yellow

All panels have a standard length of 34 inches.



NIGHT



DAY

3M™ Diamond Grade™

Aluminum Backed Flexible Prismatic

3M™ DG™ Aluminum Backed Flexible Prismatic



Features

- Flexible prismatic Sheeting
- Non-metallic reflective elements
- Conformable aluminum foil backing
- Ready-to-use screen printed '>' and '/' patterns
- Strong primer for application
- Vandal-proof edge sealing

Advantages

- Excellent day and night visibility
- Visible even from long distances and wide angles
- Directly applicable on uneven concrete / wood / metallic surfaces without any cracking
- No separate structure or substrate needed for installation
- Difficult to peel off, steal or vandalize
- Outdoor weatherability
- Easy to carry and install

Enhance visibility and positive guidance. Driving made easy and safe.

Aluminum-backed flexible prismatic (AFP)

Construction

- Made of non-metallic flexible prismatic retroreflective sheeting
- Uniform black-colored arrow / slant line pattern screen-printed on the top
- 50 micron thick Aluminum (Al) foil with Laminated at the back
- Pressure sensitive adhesive and a easily removable liner at the back of the Al-foil



Examples:

Roundabouts, Traffic Islands, Footpaths, Gap-in-medians, T Junctions, Hair-pin bends, Flyover / Metro pillar, Electric pole, High mast lights, Trees, Traffic booths, Street name signs, Underpasses, Parking lot pillars, Overhead road-crossing, Rail-Boom Barrier, Tunnels, Culvert & bridge walls, Toll-plaza bull nose, Milestones, Guide posts, Parking lot — pillars, ramps



Bright and durable



- Exceeds MS 1216 : 2003, LLM T1/07, JKR ATJ 2E/87 (Pindaan 2011) JKR 21300-0033-12 and complied to Type IV of ASTM D4956-17 minimum retroreflectivity requirements
- Excellent choice for JKR and MHA Minimum Retroreflectivity Compliance
- Meet multiple specifications
- Tougher top coat
- Vivid daytime colors
- Improved optical package



One product for several applications

3M™ High Intensity Prismatic Reflective Sheeting Series 3930 with pressure sensitive adhesive is designed for use on durable traffic control signs, work zone signs and delineators.

- Meets ASTM D4956 Type III and Type IV specifications.
- Tougher topcoat provides improved scuff, scratch and gouge resistance and increased durability for the demanding need of the work zone.
- Vivid daytime colors provide 24-hour performance with increased daytime visibility.
- The improved optical package increases nighttime visibility.

Better for the environment

Not only is 3M high intensity prismatic sheeting bright and durable, it's better for the environment. The manufacturing process for prismatic sheeting reduces VOC emissions by 97 percent and energy consumption by 72 percent compared to standard engineer grade sheeting processes. Now that's a change for the better.

Attention - getting visibility for safer work zones

3M™ Diamond Grade™ Flexible Work Zone Sheeting Series 3910

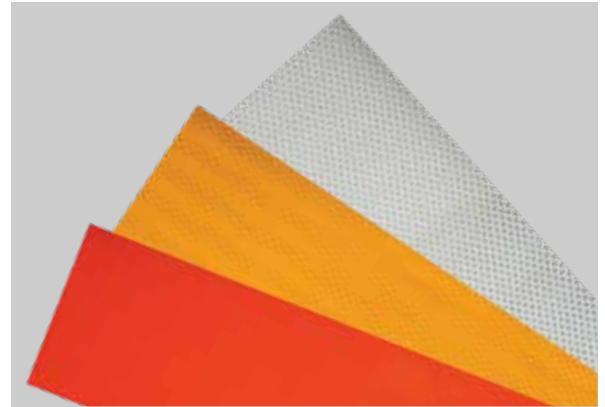
3M™ Flexible Prismatic Reflective Sheeting Series 3310M

- Exceeds MS 1216 : 2003, LLM T1/07, JKR ATJ 2E/87 (Pindaan 2011) JKR 21300-0033-12 and ASTM D4956-17 minimum retroreflectivity requirements
- Improve driving safety with 24-hour visibility
- Improve work zone safety with attention-getting brightness
- Maintain high conspicuity with long-lasting fluorescent color and brightness
- Maintain visibility in compromised conditions
- Withstand rough handling with durable, impact-and scratch-resistant material
- Apply to reboundable traffic control devices for an ideal, flexible solution
- Apply quickly and easily on reboundable devices
- Conforms to virtually any curved surface for a flexible solution

High performing reflective materials bring unmatched visibility to the work zone

Positive guidance is no accident in work zones

3M retroreflective technologies make temporary traffic control devices more visible and durable for a safer work zone environment. From the highest performing sheetings on the market today, to high-conspicuity fluorescent colors, to advanced wet reflective temporary pavement markings, 3M delivers a notable difference.



Series 3910



Unique “full cube” technology, used to make 3M™ Diamond Grade™ DG³ Reflective Sheeting, produces 100 percent efficient optical elements that are nearly twice as bright as conventional prismatic sheetings. Work zone conditions can easily compromise the positioning and visibility of traffic control devices. Better, brighter signs attract the driver’s attention sooner, for earlier comprehension and a more natural, timely driving reaction among other drivers and workers nearby.



Highly conspicuous fluorescent colors provide superior visibility day and night, dawn and dusk. Fluorescent orange material is recognized at greater distances and with a more accurate perception of color than non-fluorescent orange-colored products.¹ The high luminance and attention-getting visibility of prismatic technology helps temporary traffic control devices provide unambiguous, positive guidance even in compromised work zone conditions, and thus reduce the potential for incidents and accidents.



Wet reflective pavement markings actually work with water to remain highly visible in rain and wet road conditions. Removable tape and all weather paint products are simple to apply, and perform for a normal construction season. The bright continuous delineation emphasizes lane shifts yet installs and removes easily for fast changeovers.

¹ Evaluation of Fluorescent Orange Signs, Texas Transportation Institute, TDOT, TX-00/2962-S,2000

Work zone solution: visible, flexible, versatile

Unmatched flexibility helps deliver outstanding conspicuity

The dynamic nature of work zones creates special requirements, Traffic control devices must perform in less-than-optimal situations. 3M produces wide-angle asymmetric prismatic reflective material with orientation and rotation angles that provide attention-getting brightness even when control devices have been moved or misaligned. This highly flexible sheeting material conforms easily yet maintains visibility at high entrance angles for assured recognition and guidance in compromised conditions.

Durable, precoated with pressure sensitive adhesive, applies easily.



Also available in red / white-striped
barricade sheeting

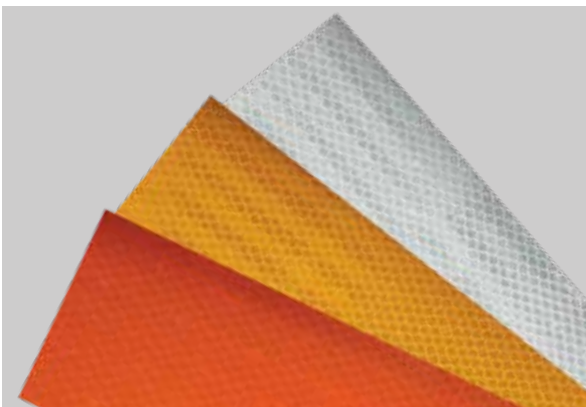
Super-thin film applies easily yet maintains superior performance

3M™ Flexible Prismatic Reflective Sheeting is ideal for reflectorizing any reboundable traffic control device such as drums, barricades and channelizes. Its impact-resistant coating improves durability. It applies quickly and easily because of the pre-coated pressure-sensitive adhesive.

The material is highly conformable and can be applied using a squeeze roller or by hand. Thin, flexible and durable, the sheeting delivers superior performance and brightness throughout its life.



Dedicated to traffic safety and the transportation industry, 3M has been an innovation leader for more than 75 years. 3M combines comprehensive systems and services with high performance materials to provide visibility and safety for life on the road.



Series 3310M



Protect your signs against graffiti

- Durable, transparent and easy to clean
- Stain / solvent resistant
- Resists damage from stickers
- Avoid sign replacement costs
- Backed by 3M's Matched Components System warranty



Take a stand against graffiti and give your signs a longer street life

Life on the streets can be rough. From paint and markers to eggs and stickers, we've all seen traffic signs that bear the marks of vandals. Defaced signs can present a serious safety threat to motorists and pedestrians. To your agency and the residents you represent, marked signs erode civic pride. And, because of clean-up and replacement costs, graffiti also erodes your budget.

3M™ Protective Overlay Film Series 1160

3M™ Protective Overlay Film Series 1160 is a premium product ideal for use with all sheetings – especially high performance sheetings, such as 3M™ Diamond Grade™ High Intensity Prismatic Reflective Sheeting. Series 1160 film combines the ultimate in durability and stain / solvent resistance. It also does a great job of resisting damaging stickers, a growing form of vandalism. Plus, because Series 1160 film is ultra-clear, it maintains the warranty and original performance of any 3M sheeting it protects.

3M™ Protective Overlay Film – your transparent, solvent-resistant graffiti barrier

3M protective overlay film can solve the growing urban graffiti problem by providing a protective layer that resists graffiti.

Protective overlay film acts as a barrier to block stains while allowing for safe, easy clean-up. It resists solvents to protect the sheeting and, since it's transparent, it maintains your signs' specified brightness.

Designate 3M™ Protective Overlay Film for all your graffiti needs

The easiest way to enhance safety and protect yourself against graffiti is to apply 3M protective overlay film on new signs before you install them.

- The treatment pays for itself in one cleanup!
- Clean signs ensure performance and increase motorist / pedestrian safety
- Improves the look of your community and boosts civic pride
- Adds value to your sign replacement program
- Quicker, easier, safer cleaning for your crews
- It's a critical part of your "graffiti abatement effort" (along with education, regular inspection, community involvement / awareness, enforcement, etc.)

Easy to clean

Cleanup is simple. Many stains can be efficiently removed from 3M protective overlay film with a simple detergent washing.

For tougher graffiti, several products designed specifically for graffiti removal work exceptionally well on Series 1160 overlay film.

Easy to apply

3M protective overlay film is quick and simple to apply using either motorized or hand squeeze roll applicators.

Color Card Reference Guide

3M™ Diamond Grade™ DG³ Reflective Sheeting



White 4090



Yellow 4091



Red 4092



Blue 4095



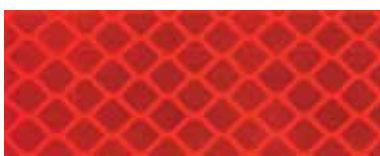
Green 4097



Fluorescent Yellow 4081



Fluorescent Yellow Green 4083



Fluorescent Orange 4084



White Translucent 4090T

3M™ High Intensity Prismatic Reflective Sheeting



White 3930



Yellow 3931



Red 3932



Orange 3934



Blue 3935

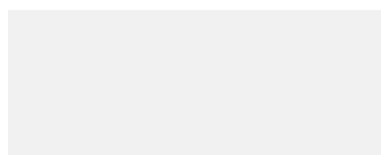


Green 3937



Brown 3939

3M™ Protective Overlay Film



Premium Series 1160

3M™ Diamond Grade™ DG³ Flexible Prismatic Reflective Sheeting



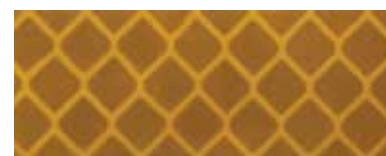
White 3910



Fluorescent Yellow 3911



Fluorescent Orange 3914



Aluminum Back Yellow

3M™ High Intensity Flexible Prismatic Reflective Sheeting



White 3310M



Yellow 3311M



Orange 3314M

Type XI Sheeting^A of ASTM D4956-16b

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow - Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	-4°	830	620	290	83	125	37	25	660	500	250
0.1° ^B	+30°	325	245	115	33	50	15	10	260	200	100
0.2°	-4°	580	435	200	58	87	26	17	460	350	175
0.2°	+30°	220	165	77	22	33	10	7.0	180	130	66
0.5°	-4°	420	315	150	42	63	19	13	340	250	125
0.5°	+30°	150	110	53	15	23	7.0	5.0	120	90	45
1.0°	-4°	120	90	42	12	18	5.0	4.0	96	72	36
1.0°	+30°	45	34	16	5.0	7.0	2.0	1.0	36	27	14

^A Minimum Coefficient of Retroreflection (R_s) cd/fc/ft² (cdlx⁻¹ m⁻²)^B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or orderType IV Sheeting^A of ASTM D4956-16b

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown	Fluorescent Yellow - Green	Fluorescent Yellow	Fluorescent Orange
0.1° ^B	-4°	500	380	200	70	90	42	25	400	300	150
0.1° ^B	+30°	240	175	94	32	42	20	12	185	140	70
0.2°	-4°	360	270	145	50	65	30	18	290	220	105
0.2°	+30°	170	135	68	25	30	14	8.5	135	100	50
0.5°	-4°	150	110	60	21	27	13	7.5	120	90	45
0.5°	+30°	72	54	28	10	13	6	3.5	55	40	22

^A Minimum Coefficient of Retroreflection (R_s) cd/fc/ft² (cdlx⁻¹ m⁻²)^B Values for 0.1° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order

ASTM D4956 - 16b

Table 11 Color Specification Limits (Daytime)^A

Color	1		2		3		4		5	
	x	y	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		
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472		
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404		
Green ^B	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771		
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346		
Blue ^B	0.140	0.035	0.244	0.210	0.190	0.255	0.065	0.216		
Purple	0.302	0.064	0.310	0.210	0.380	0.255	0.468	0.140		
Brown	0.430	0.340	0.610	0.390	0.550	0.450	0.430	0.390		
Fluorescent Yellow-Green	0.387	0.610	0.369	0.546	0.428	0.496	0.460	0.540		
Fluorescent Yellow	0.479	0.520	0.446	0.483	0.512	0.421	0.557	0.442		
Fluorescent Orange	0.583	0.416	0.535	0.400	0.595	0.351	0.645	0.355		
Fluorescent Pink	0.600	0.340	0.450	0.332	0.430	0.275	0.536	0.230	0.644	0.290

^A The four pairs (five pairs for fluorescent pink) of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant D65.

^B The saturation limit of green and blue may extend to the border of the CIE chromaticity locus for spectral colors.

ASTM D4956-16b

Table 13 Color Specification Limits (Nighttime)^A

Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.475	0.452	0.360	0.415	0.392	0.370	0.515	0.409
Yellow	0.513	0.487	0.500	0.470	0.545	0.425	0.572	0.425
Orange	0.595	0.405	0.565	0.405	0.613	0.355	0.643	0.355
Green	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Red	0.650	0.348	0.620	0.348	0.712	0.255	0.735	0.265
Blue	0.033	0.370	0.180	0.370	0.230	0.240	0.091	0.133
Purple	0.355	0.088	0.385	0.288	0.500	0.350	0.635	0.221
Brown	0.595	0.405	0.540	0.405	0.570	0.365	0.643	0.355
Fluorescent Yellow-Green	0.480	0.520	0.473	0.490	0.523	0.440	0.550	0.449
Fluorescent Yellow	0.554	0.445	0.526	0.437	0.569	0.394	0.610	0.390
Fluorescent Orange	0.625	0.375	0.589	0.376	0.636	0.330	0.669	0.331

^A The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with CIE Standard Illuminant A.



Transportation Safety Division

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