



**LIGHT
HAWK™**

ALPOLIC® 350 BACKPLATES



SPEED
LIMIT
45



Korman Signs
INC.





CONTENTS

LightHawk ALPOLIC 350 Backplates 2

Backplate Models 4

Specifications 6

Warranties 8

FHWA Technical Summary 17

LIGHT HAWK™ ALPOLIC® 350 BACK PLATES

Product Overview

THE LATEST TECHNOLOGICAL ADVANCE IN SIGNAL BACK PLATES

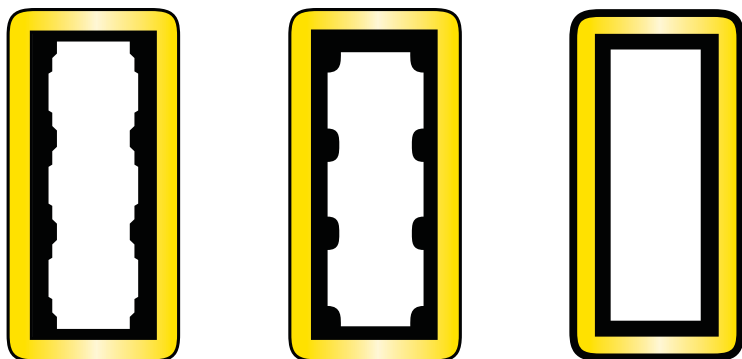
is here, the Korman Signs **LIGHTHAWK** Series. They are made from ALPOLIC 350, a proven lightweight aluminum composite material, and 3M™ Diamond Grade Cubed (DG3) state-of-the-art reflective sheeting to produce a twelve year finished product. No longer do you have to worry about fading, cracking, & peeling failures.

The comparisons to conventional signal plates are light years apart.



Multiple Configurations

The **LIGHTHAWK** ALPOLIC 350 Back Plates are furnished with a variety of reflective patterns, grades, and widths.



Give us a call at 1-800-296-6050

and use our 40+ years of manufacturing expertise to order, to request specifications, to request a sample, or to inquire further about this exciting new product!



[LIGHTWEIGHT]

Lighter than plastic or aluminum - 2mm thick at .57 lbs/sq ft



[STRENGTH]

Thicker and structurally stronger than conventional material



[VISIBILITY]

3M DG3 Sheeting is the brightest technology available from any angle



[DURABILITY]

Fluoropolymer finish & reflective sheeting provide 12 year expected life



[FABRICATION]

Any brand, size, fit, and shape via CNC machining operation



[SAFETY]

Fluorescent yellow yields ultimate intersection awareness day or night



[TESTING]

Wind tunnel and night time field demonstration



[ECONOMICS]

Very low net life cost investment



[SPECIFICATIONS]

Made to meet any DOT spec



Korman Signs
INC.

In a nut shell : The LightHawk is lighter and brighter



Night demos testing varying levels of reflective sheeting & layouts



Reflective back plates increase traffic signal visibility at intersections

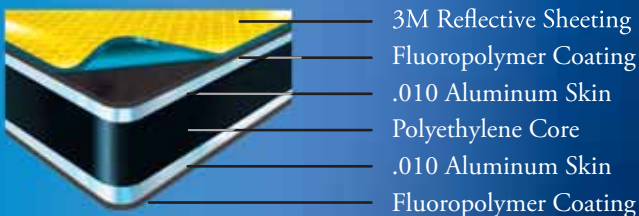


A number of studies have confirmed the safety value of reflectorized signal back plates. The **LIGHTHAWK** ALPOLIC 350 Back Plates are an innovative and more effective approach to fulfilling the goal of improving intersection safety and reducing accidents. The weight to structural strength ratio of the ALPOLIC 350 and the high performance of the 3M reflective sheeting is unmatched and

virtually prolongs the need of maintenance for the life of the signal light assembly itself. Additional features include the use of 3M VHB™ Tape for splicing which spread the stress load across the length of the joint. The **LIGHTHAWK** brand Back Plate is manufactured and made in the USA by Korman Signs, Inc. It can be fabricated to fit any signal head assembly using the latest CNC routing equipment shown below.

ALPOLIC 350

ALPOLIC® 350 is an aluminum/polyethylene/aluminum composite material that can be used in place of solid aluminum and other rigid sign substrates. The composite material is manufactured by laminating two skins of aluminum to both sides of an extruded thermoplastic core under tension and pressure. The resulting composite product is light, exceptionally flat, strong, rigid, and resistant to breakage. For backplate applications ALPOLIC 350 is coated with a black fluoropolymer finish on both sides presenting a suitable substrate for the acceptable adhesion of 3M reflective sheeting.



*Cross section of **LIGHTHAWK** ALPOLIC 350 Back Plate – A Hi-Tech Aluminum Composite Material Manufactured By Mitsubishi Plastics Composites America*



Diamond Grade Cubed - DG3

3M™ Diamond Grade™ DG³ Reflective Sheeting is the first-of-its-kind to meet the ASTM Type XI spec and is designed as an effective alternative for all types of conventional reflective sign sheeting being used currently.

This state-of-the-art, full cube prismatic reflective sheeting ensures optimal performance at all sight distances. The optical elements of the DG³ Sheeting Series return almost 60% of available light to road users - nearly twice the reflectivity when compared to conventional prismatic sheeting.

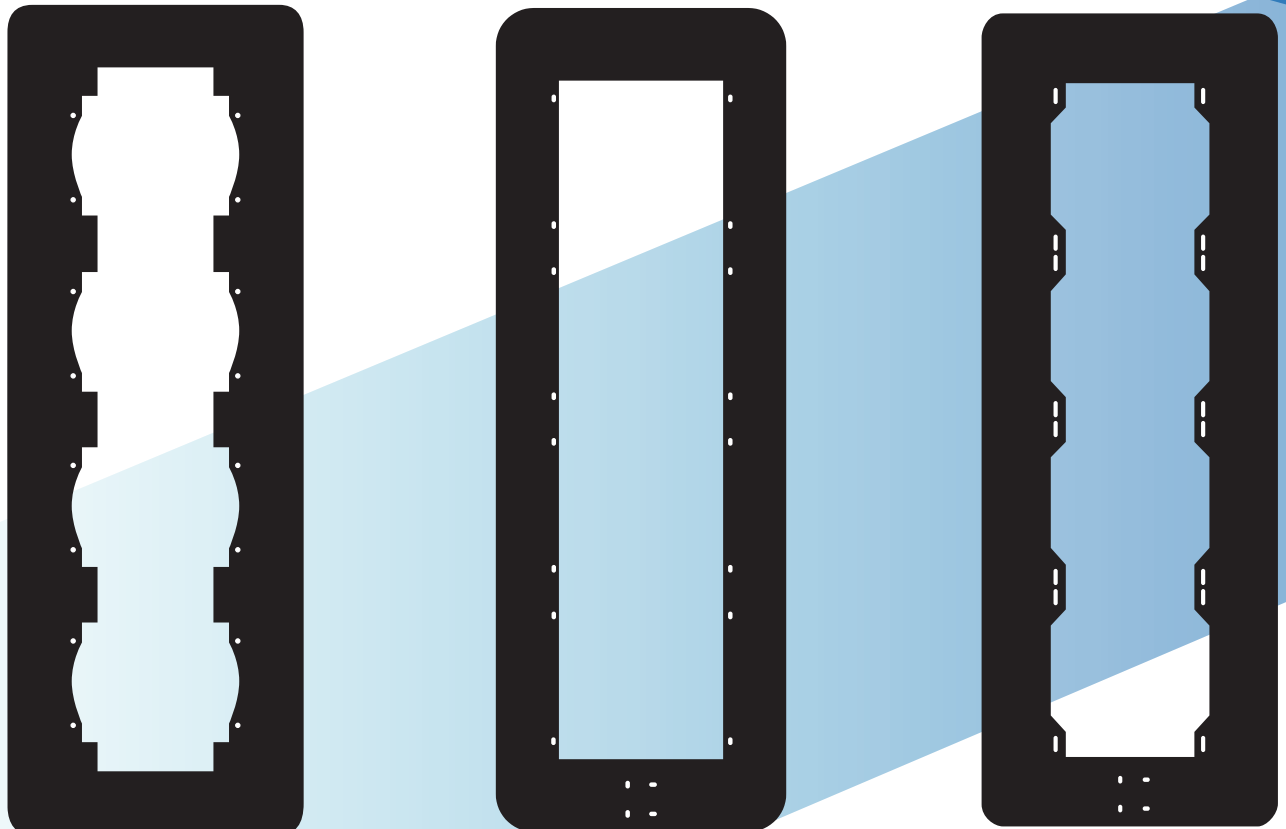
BACKPLATE MODELS

Additional models available based on signal manufacturer and light configuration - 3 section, 4 section, 5 section doghouse, in line, etc.

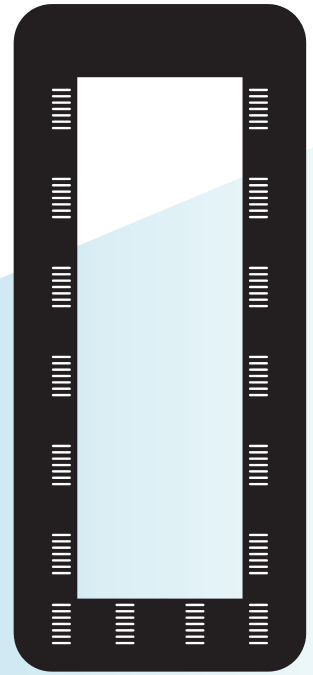
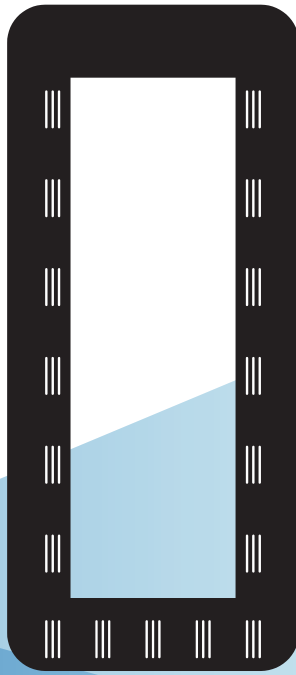
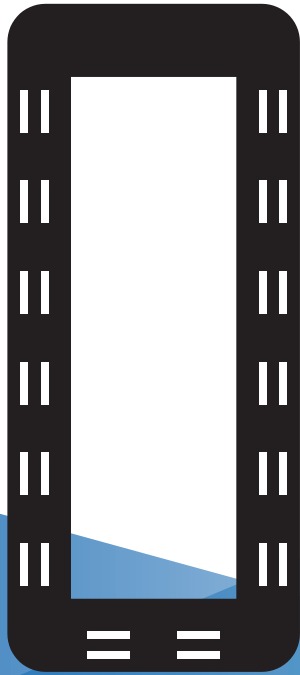
3 Section



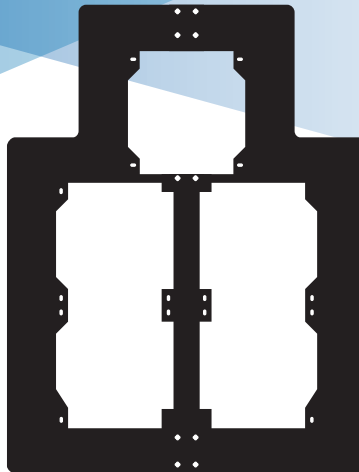
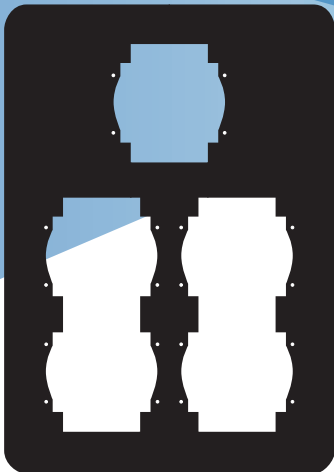
4 Section



Slotted or Louvered



5 Section



Louvered and Slotted Designs Available Upon Request

SPECIFICATION

Aluminum Composite Signal Back Plate

General

This specification covers the use of aluminum composite panels for permanent signal back plate applications as an alternative to conventional back plate substrates such as solid aluminum and plastic.

Technical

The composite sign material must be manufactured by bonding two skins of aluminum to an extruded polyethylene core utilizing a thermoset adhesive under tension and pressure in a continuous process. The polyethylene core must be pigmented with carbon black to prevent core edge deterioration from UV exposure. The resulting composite product should be light, exceptionally flat, strong, rigid, and resistant to breakage. It must fabricate similarly to aluminum and enable operations such as sawing, shearing, drilling, and punching. The exterior coating must be a fluoropolymer based paint that provides a surface quality that is suitable for the proper adhesion of reflective sheeting and expected life of 12 years. Documented evidence that the material is a suitable substrate by the reflective sheeting manufacturers must be provided. The interior of the aluminum skin must be coated with an epoxy chromate primer for added bonding strength with the polyethylene. The sign blank must be capable of being exposed to temperature ranges of -60° F to +170° F. The material must be available in a thickness of 2mm with the aluminum skin a minimum thickness of .010. The edges must be provided straight without displacement or projection of the core or skin.

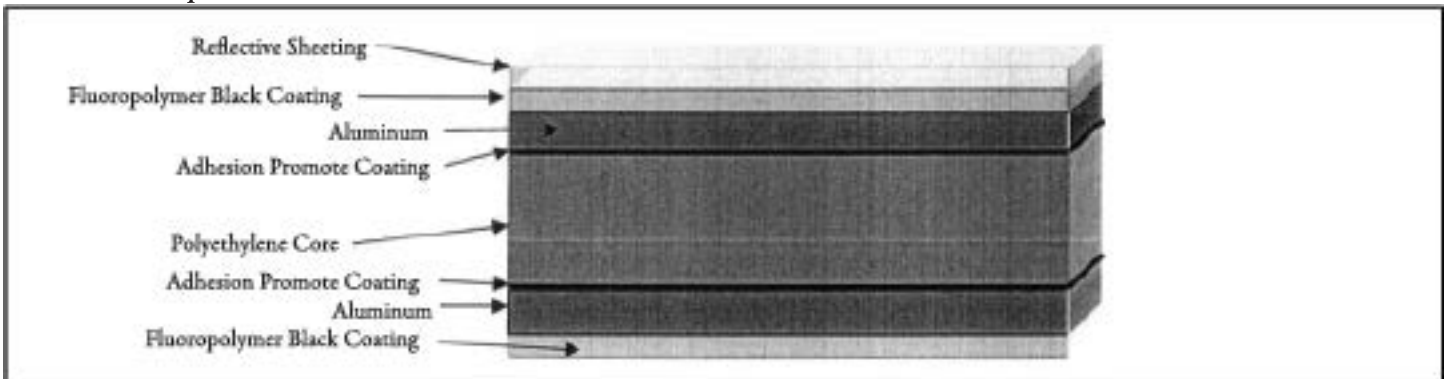
Minimum Properties

2mm

ASTM test procedures numbers are given in parentheses.

Aluminum Alloy	5052 H32
Aluminum Thickness– in.	.010
Sign Blank Thickness – in.	.079
Weight – lbs./sq. ft.	.57
Bow – Maximum % of length or width	0.5
C. of Expansion (D696) – in./in./°F	15x10 ⁶
Flexural Stiffness (C393) – psi	2.6x10 ⁸
Defonnation Temperature (D648) – °F	230
Avg. Tensile Strength (E8) -- psi	7487
Flexural Modulus (D790) – psi	4.22x10 ⁶
Punching Shear Resistance	
Average Load (D732) – lbs.	1258
Average Stress (D732) – psi	4766
Bond Integrity	
Vertical Pull (C297) – psi	1581
Drum Peel (D1781) – in.-lb./in.	62.5
Flatwise Shear (C273) – psi	1689
Durability years	12
Recyclability	100%

Aluminum Composite Construction



Wind Testing

This product shall have undergone documented wind testing with a minimum sustained velocity of 80 mph and gusts up to 108 mph. Video and digital image documentation and physical measurement of the substrate behavior under various wind loads must have been observed by an Independent Testing Agency. The back plate supplier may be required to provide the Test Date(s), the Name of the Facility, and the Name of the Independent Testing Agency.

Manufacturing Quality System

The aluminum composite manufacturing facility or facilities may be required to present documentation to show they are at least ISO 9001:2000 certified to produce the laminates specified herein.

Warranty

Warranty must be provided against defects, workmanship, and failures. See separate warranty documents.

Color Required

Standard dull black fluoropolymer coating both sides for meeting MUTCD back plate standard.

Packaging

Standard packaging for signal back plates to be 4-way skid or special wooden-reinforced box/skid. Standard packaging quantity depends on size of order. Bulk packaging per request. All packaging per industry standards.

Technical Support/Training

Supplier must provide personal factory support, and training within 24 hours for product matters that relate to fabrication and application.

Samples

Non-returnable samples may be required at no expense to evaluate prior to an award.

Reflective Sheeting Requirements

Customer to specify type, location, and size of reflective sheeting to be used on the signal back plate. 3 inch wide 3M Type XI #4081 Fluorescent Yellow reflective sheeting located around the perimeter on the edge without a border is recommended.

Slitting One Piece Back Plate

For Field Installation on existing assemblies customer may request a back plate to be pre punched and slit and furnished with a matching pre punched four inch x four inch scab plate with serrated flange bolt/nut fastening hardware. Using approved VHB tape is an alternate assuming two pieces 1.5 inches wide x 4 inches long are utilized to make the splice connection.

Fabrication Details

Customer to provide signal geometry, sample signal head, or name of signal head manufacturer to determine contour of the cavity to fit the rear of the signal heads, to match the necessary mounting hole or slot dimensions, and to present the minimum corner radii desired. It is understood the minimum space between the outer signal head edge and outer edge of back plate is a minimum of 5 inches. Back Plate to be provided in multiple pieces when necessary.

January 27, 2015

**METAL COMPOSITE PANEL WARRANTY
TRAFFIC SIGNAL BACK PLATE
TWELVE YEAR**

To: (“Customer”)

Korman Signs, Inc.
3029 Lincoln Avenue
Richmond VA 23228

From: Mitsubishi Plastics Composites America, Inc.

Project Name and Location: Location Description

Commencement Date of Warranty: Installation Date

Mitsubishi Chemical FP America Inc. (“MPCA”) hereby warrants to (“Customer”) that **2mm – TBL Black** purchased to be used solely as a back plate for traffic lights (the “Product”) to be supplied by MPCA, when used as a component of traffic control signs in the USA will not delaminate for the above stated period, beginning at the commencement date, with warranty period not to exceed twelve years plus one from date of shipment (or the life of the sheeting whichever is shorter) from the date of shipment by MPCA to Customer.

This warranty is applicable only to manufacturing defects caused by MPCA, and does not apply to any other causes, including but not limited to corrosive or aggressive atmospheres; damage during shipment, fabrication, installation or maintenance; exposure to flame; normal depreciation, wear and tear; acts of God; mechanical failure due to the Product’s interaction with other products or exposure to chemicals or abrasion; lack of prudent maintenance; acts of Customer, Customer’s contractors or customers, or any other third party; collisions; vandalism or malicious mischief; or other forces, conditions or circumstances unrelated to the quality of the Product at the date of shipment.

MPCA agrees to repair or replace, at its sole discretion, any Product as shall have been proven by written evidence by Customer to the satisfaction of MPCA not to be in compliance with the aforesaid warranty. The foregoing obligation of MPCA shall run for twelve (12) years beginning on the date of shipment by MPCA to Customer, and is expressly conditioned upon (i) receipt by MPCA of notification in writing from Customer of any claimed non-compliance with this warranty within thirty (30) days after such non-compliance first comes to the attention of Customer; (ii) full compliance by Customer and its employees, contractors and customers with all information, recommendations and instructions provided by MPCA whether on MPCA’s website, in Product-related literature and communications, and whether in written or oral form, with respect to handling, delivering, storing, processing, treating, installing and maintaining the Product; and (iii) full compliance by Customer and its employees, contractors and customers with normal practices of the design and construction industries and of the industry to which Customer belongs. Customer’s failure to satisfy any of the above three conditions shall be deemed a waiver by Customer of any right it may have to enforce this warranty.

If Customer makes a legitimate claims of non-compliance with this warranty MPCA will furnish Customer with replacement panels sufficient to restore the Product to its original effectiveness.

THIS WARRANTY AND REMEDY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WRITTEN OR ORAL, EXPRESSED OR IMPLIED AND INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM OR USAGE OF TRADE. IN NO EVENT SHALL MCFPA BE LIABLE FOR ANY INCIDENTAL OR CONSEQUENTIAL LOSSES OR DAMAGES (INCLUDING, BUT NOT LIMITED TO, ECONOMIC LOSS OR LOSS OF PROFITS) SUFFERED OR INCURRED BY CUSTOMER AS A RESULT OF OR IN CONNECTION WITH ANY BREACH OF THIS WARRANTY BY MCFPA EXCEPT IN THE CASE OF GROSS NEGLIGENCE OR WILLFULNESS OF MPCA.

All notices given under or pursuant to this warranty shall be in writing in English and sent by Registered or Certified Mail, postage prepaid, return receipt requested, or by reputable overnight courier service to:

Mitsubishi Plastics Composites America, Inc.
ALPOLIC Materials Division
Customer Service
401 Volvo Parkway
Chesapeake, VA 23320

Accepted By:
MITSUBISHI PLASTICS COMPOSITES AMERICA, INC.



Eiichi Sato
President/CEO

9 June 2016

FLUOROCARBON COATING WARRANTY
TRAFFIC SIGNAL BACK PLATE
TWELVE YEAR

To: (“Customer”)

Korman Signs, Inc.
3029 Lincoln Avenue
Richmond VA 23228

From: Mitsubishi Plastics Composites America, Inc.

Project Name and Location: Location Description

Commencement Date of Warranty: Installation Date

Mitsubishi Plastics Composites America, Inc. (MPCA) hereby warrants to the Customer that the Fluorocarbon-based coating **2mm – TBL Black** applied by MPCA to the aluminum materials purchased to be used solely as a back plate for traffic lights, by Customer from MPCA will not, for the above stated period, beginning at the commencement date, with warranty period not to exceed twelve (12) years plus one from date of shipment, under normal atmospheric conditions on the coated aluminum:

- A. Peel, check or crack except for such slight crazing or cracking as may occur on tightly roll-formed edges or brake bends at the time of forming pre-painted sheets, which is accepted as standard; or
- B. (1) Chalk in excess of a numerical rating of **8** measured in accordance with the standard procedures as outlined by the “Standard Methods of Evaluating Degree of Chalking of Exterior Paint” ASTM D4214-89; or
- (2) Fade or change in color in excess of **5** color difference units, using ASTM D2244-89 measured on the exposed painted surfaces which have been cleaned of external deposits and chalk and the corresponding values measured on the original or unexposed painted surfaces, it being understood that fading or color changes may not be uniform if the surface is not evenly exposed to the sun and elements;

and that gloss (60⁰ incident angle) loss will not exceed 40% when measure on exposed painted surfaces which have been cleaned of external deposits and the corresponding values measured on unexposed original painted surfaces. The gloss shall be measured using standard procedures as defined by “Standard Test Method for Specular Gloss”, ASTM D523-89.

This warranty is subject to the following conditions:

- A. Normal atmospheric conditions exclude corrosive or aggressive atmospheres such as those contaminated with chemical fumes, salt or other corrosive elements, including areas within 1500 feet of a body of salt water. MPCA requires a fresh water cleaning / maintenance program be in effect to prevent corrosion from accumulated deposits
- B. The warranty will not extend or cover:
 - (1) cracking or crazing as a result of metal fracture;
 - (2) damage to the coating occasioned by moisture or other contamination detrimental to the coating because of improper storage of the coated metal prior to installation;
 - (3) water damage due to condensation caused by improper packaging of the coated metal prior to installation;
 - (4) damages to the coated metal caused by handling, shipping, processing and/or installation; or
 - (5) damages to the coated metal caused by scratching or abrading after installation; or
 - (6) damages to the coated metal as a result of standing water in horizontal installations;
- C. The warranty will not be applicable to damage or failure which is caused by acts of God, falling objects, external forces, explosions, fire, riots, civil commotion's, acts of war, or other such similar or dissimilar occurrences beyond MPCA's control.
- D. Any change, modification or alteration of the exposed FEVE finish by chemical, electrical, mechanical, flame or any other means shall void this warranty.
- E. Customer shall maintain adequate records to establish identification of the coated material and dates of the installation of the coated metal. Customers shall demonstrate that the failure of the coated metal was due to a breach of the warranty stated herein.
- F. MPCA's exclusive liability under this warranty, or otherwise, will be limited to refinishing, repairing or replacing in situ, at MPCA's sole option, the defective coated metal. The warranty on any refinished, repaired or replaced coated metal supplied hereunder shall be for the remainder of the warranty period applicable to the originally coated metal. All warranty work will be performed by a company or contractor selected by MPCA. Color variance between replacement or repainted product and original shall not be indicative of a defect.
- G. Claims under the warranty must be made to MPCA in writing within thirty (30) days after discovery of the defective coating and MPCA must be given a reasonable opportunity to inspect the coated metal claimed to be defective.
- H. MPCA reserves the right to terminate this warranty at any time upon thirty (30) days advance written notice, except with respect to any coated metal which has already been shipped to Customer.

- I. All records and samples Customer is required to prepare and maintain under the terms of this warranty shall be retained by Customer for the warranty period applicable to the coated metal, and in the event of a claim hereunder, MPCA shall have the right to inspect such records and samples,
- J. All notices under or pursuant to this agreement shall be in writing in English and sent by registered or certified mail, postage prepaid, return receipt requested to:

Mitsubishi Plastics Composites America, Inc.
ALPOLIC Materials Division
Customer Service
401 Volvo Parkway
Chesapeake, VA 23320

ALL SUCH NOTICES DEPOSITED IN THE U.S. MAIL AS SET FORTH ABOVE SHALL BE
CONSIDERED SERVED WHEN SO DEPOSITED.

To terms or conditions other than those stated herein and no agreement or understanding, oral or written, in any way purporting to modify this warranty shall be binding on MPCA unless made in writing and signed by its authorized representatives.

Except as set forth herein, MPCA makes no other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular purpose, with respect to the product.

Accepted By:
MITSUBISHI PLASTICS COMPOSITES AMERICA, INC.



Eiichi Sato
President/CEO

9 June 2016



August 12, 2016

Korman Signs, Inc.
3029 Lincoln Avenue
Henrico, VA 23228-4295

RE: Limited Warranty for Application of 3M™ Reflective Sheeting for Borders on Alpolic Substrate for Traffic Signal Backplates

Dear Mr. Korman;

We are pleased to inform Korman Signs, Inc., of Henrico, VA ("Korman") that 3M will provide a limited warranty for the 3M™ Reflective Sheeting ("Sheeting") as outlined in Attachment A, when applied in accordance with the 3M requirements included in the respective product bulletin and with the additional requirements, terms and conditions described in Attachment A, for projects using the subject matter Sheeting on flame-treated Alpolic substrate with FEVE coating for border delineation of traffic signal backplates.

By signing below, Korman agrees to the terms and conditions of the warranty as outlined in Attachment A.

If there are questions, please do not hesitate to contact me, or your 3M representative.

Sincerely,

A handwritten signature in blue ink, appearing to read 'Fuat Aktan', is written over a horizontal line.

Date: August 12, 2016

Fuat Aktan
Division Quality and Regulatory Manager
3M Traffic Safety & Security Division

A handwritten signature in black ink, appearing to read 'Bill Korman', is written over a horizontal line.
Bill Korman
President
Korman Signs, Inc.

Date: 8/13/16

Attachments: Attachment A

Attachment A

Warranty – Diamond Grade (DG³) and Visual Impact Performance (VIP)

3M warrants that, in the United States, for a period of seven (7) years in states with high solar exposure¹ (“High Exposure States”), and for a period of ten (10) years² elsewhere, 3M™ Diamond Grade™ DG³ Reflective Sheeting 4081 Fluorescent Yellow and 4091 Yellow, and Diamond Grade™ VIP Reflective Sheeting 3981 Fluorescent Yellow and 3991 Yellow sold by 3M and applied by Korman for traffic signal backplate border applications will:

- (a) remain legible when viewed from a moving vehicle under normal day and night driving conditions by resisting excessive fading, discoloring, cracking, crazing, peeling, and blistering and,
- (b) after cleaning, retain 70% of the minimum values for coefficient of retroreflection (R_A) stated in ASTM D4956-16 Table 10 Type XI for DG³ and Table 9 Type IX for VIP and,
- (c) after cleaning, Fluorescent Yellow sheeting shall meet or exceed a daytime luminance (Y%) of 40.

The seven (7) year warranty period in High Exposure States, and the ten (10) year warranty period elsewhere in the United States are collectively referred to as “Warranty Period”.

Warranty – High Intensity Prismatic (HIP)

3M warrants that, in the United States, for a period of ten (10) years, 3M™ High Intensity Prismatic Reflective Sheeting 3931 Yellow sold by 3M and applied by Korman for traffic signal backplate border applications will:

- (a) remain legible when viewed from a moving vehicle under normal day and night driving conditions by resisting excessive fading, discoloring, cracking, crazing, peeling, and blistering and,
- (b) after cleaning, retain 70% of the minimum values for coefficient of retroreflection (R_A) stated in ASTM D4956-16 Table 5 Type IV for HIP.

Terms and Conditions

The above warranty (“3M Warranty”) is subject to the following terms and conditions:

- 3M approved substrates, or flame-treated Alpolic substrate with FEVE coating, as tested and recommended by 3M technical service (“Approved Substrate”) shall be used as the signal backplate onto which Sheeting is applied (together, “Finished Backplate”). The entire sheeting contact surface of the backplate shall be flame-treated,
- 3M Warranty applies only to signal backplate applications. Application of Sheeting on Alpolic substrate, flame-treated or otherwise, for any use other than signal backplates is outside of the scope of this 3M Warranty,
- Adhesion failures caused by the substrate or improper surface preparation are not the responsibility of 3M,
- Korman notifies 3M within two business days, in writing, of any engineering changes to the Approved Substrate, and understands that Sheeting applied to the modified substrate may not be covered under 3M Warranty,
- Korman has appropriate procedures and maintains data on flame-treating of the Approved Substrate, and agrees to furnish 3M with this data upon 3M’s request, in the case of a claim, or as a part of an audit to ensure process conformity. 3M Warranty will apply only to Approved Substrates for which such traceable flame treatment data are provided,
- All components involved in the 3M Warranty are being stored, applied, installed, and used only as 3M requires in its product bulletins and other 3M product information, and as noted herein,
- An Approved Substrate’s failure to meet the 3M Warranty must be solely the result of the Sheeting and not of (a) outside causes including improper storage, fabrication, handling, maintenance or

¹ States with high solar exposure: Alabama, Arizona, Florida, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, South Carolina and Texas.

² Twelve years for standard yellow.

installation; (b) non-vertical applications where the Approved Substrate face is more than +/- 10% from vertical; (c) use of any material or product not made by 3M or not included as a matched component to the respective sheeting; (d) use of application equipment not recommended by 3M; (e) failure of sign substrate; (f) loss of adhesion due to incompatible or improperly prepared substrate; (g) exposure to chemicals, abrasion and other mechanical damage; (h) snow burial or any other sign burial; (i) collisions, vandalism or malicious mischief; (j) or an act of God,

- 3M reserves the right to solely determine the method of replacement, and any replacement product will have the remainder of the original product's unexpired 3M Warranty,
- Warranty Period is measured from the signal head conspicuity plate manufacturing date ("Fabrication Date"). Claims made under this warranty will be honored only if the traffic signal backplate was dated upon completion of Fabrication Date using a permanent method (sticker, permanent marker or crayon, metal stamp, etc.), and 3M is notified of a 3M Warranty claim during any applicable Warranty Period and Korman provides the information reasonably required by 3M to verify if a 3M Warranty is applicable, and 3M is permitted to verify the cause of the failure,
- In the case of the standard warranty for Sheeting outlined in the respective product bulletin for signage applications being modified, 3M may change this 3M Warranty in accordance with the changes in the standard warranty for Sheeting.

Limited Remedy

If Sheeting, applied onto an Approved Substrate is proven not to have met the 3M Warranty, then a buyer's exclusive remedy, and 3M's sole obligation, at 3M's option, 3M will, at its expense:

- (a) for installations in the High Exposure States, restore the Finished Backplate's surface to its original effectiveness if this occurs within five (5) years after the Fabrication Date; or,
- (b) for installations in states other than High Exposure States, restore the Finished Backplate's surface to its original effectiveness if this occurs within seven (7) years after the Fabrication Date; or,
- (c) furnish only the necessary Sheeting quantity to restore the Finished Backplate's surface to its original effectiveness if this occurs during the remainder of the Warranty Period.

The replacement Finished Backplate will carry the unexpired Warranty Period of the Finished Backplate it replaces.

Disclaimer

THE 3M WARRANTY IS MADE IN LIEU OF ALL OTHER PREMIUM OR ADDITIONAL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR CONDITION OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE, OR ANY IMPLIED WARRANTY ARISING OUT OF A COURSE OF DEALING OR OF PERFORMANCE, CUSTOM OR USAGE OF TRADE.

Limitation of Liability

Except for the limited remedy stated above, and except where prohibited by law, 3M will not be liable for any loss or damage arising from the signs or any 3M product, whether direct, indirect, special, incidental or consequential damages (including but not limited to lost profits, business or revenue in any way), regardless of the legal theory asserted including warranty, contract, negligence or strict liability.

Term and Termination

The effective date of this 3M Warranty is the date of signature by Korman. The term of this 3M Warranty begins on the effective date and ends on December 31, 2018, or upon termination by either party, and can be renewed. Termination or expiration of the 3M Warranty does not invalidate the 3M Warranty of the Finished Backplates with Fabrication Dates during the Term. Either party may terminate this 3M Warranty agreement at any time during the term with a 90-day written notice to the other.

Intersection Proven Safety Countermeasure

Technical Summary: Backplates with Retroreflective Borders



U.S. Department of Transportation
Federal Highway Administration

<http://safety.fhwa.dot.gov>



Foreward

In 2012, the Federal Highway Administration, Office of Safety issued a "Guidance Memorandum on Promoting the Implementation of Proven Safety Countermeasures". This guidance took into consideration the latest safety research to advance a group of countermeasures proven highly effective at improving safety. The nine Proven Safety Countermeasures chosen for targeted implementation included Backplates with Retroreflective Borders, defined as "the addition of narrow strips of retroreflective tape or sheeting around the border of the backplates." This combination of traffic signal backplates and retroreflective borders serves to improve and enhance the visibility and conspicuity of the traffic signal indications, ultimately leading to fewer red light running related incidents.

As a means to further promote and advance Backplates with Retroreflective Borders, this Technical Summary and a companion Executive Summary have been prepared to assist transportation professionals with decisions pertaining to their implementation. This document provides a substantive overview of policy, procedural and construction issues. More information on this safety countermeasure can be found on the FHWA website at <http://safety.fhwa.dot.gov>.

This publication does not supersede any publication; and is a Final version.

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Contents

Easier to see, day or night.....	1
Low cost per unit, big safety benefit	1
Reduction in collision claims and injury/fatality crashes: a proven safety measure ...	1
Low cost, simple implementation	2
Multiple vendor options	2
Mature process	2
Case Study: City of Nashua, New Hampshire, Lessons Learned	3
Flexibility in design and materials	4
Backplate (variations: back plate, backboard)	4
Retroreflective backplate border	4
Numerous installation options	5
Ordering backplates directly from the distributor with retroreflective tape pre-applied	6
Ordering retroreflective tape (in the desired width) and backplates at the same time, but without pre-application	6
Ordering retroreflective tape (in the desired width) and applying it to existing backplates.....	6
Case Study: Kentucky's Evaluation of Retroreflective Borders on Traffic Signal Backplates	7
Case Study: Washington State's Success with local Implementation of Retroreflective Borders on Traffic Signal Backplates	8
Case Study: New Hampshire's Plan for the Future Implementation of Retroreflective Borders on Backplates	9
Case Study: Virginia's Systemic Plan to Implement Retroreflective Borders on Backplates.....	10
Endnotes	11

Easier to see, day or night

Traffic signal backplates—thin plates of material that surround traffic signal indication light arrays—are intended to improve the visibility of the signal by providing a consistent and controlled-contrast background. Attempts to further enhance the visibility and conspicuity of traffic signals, particularly during nighttime hours, have led to the addition of narrow strips of retroreflective tape or sheeting around the border of the backplates. This combination—called backplates with retroreflective borders—frames the signal indication, providing visual benefits during both daytime and nighttime conditions.

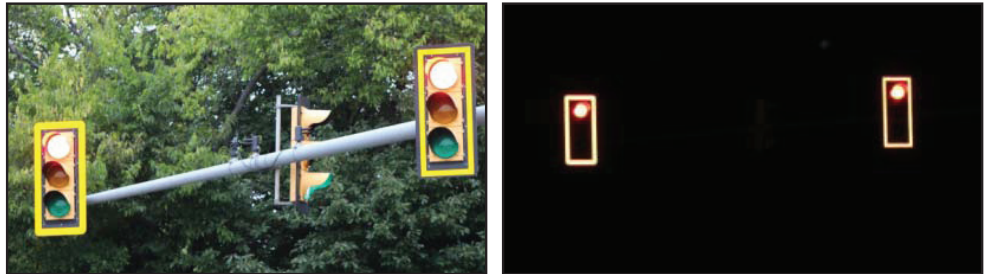


Exhibit 1: Retroreflective borders on backplates can provide a visual benefit during both daytime and nighttime conditions. (Source: VDOT)

Retroreflective borders also

enhance the visibility of traffic signals for aging and color vision impaired drivers enabling them to understand which signal indication is illuminated. Retroreflective borders may also alert drivers to signalized intersections during periods of power outages when the signals would otherwise be dark, and non-reflective signal heads and backplates would not be visible. FHWA cited the treatment as an “Aging Driver” Best Practice¹ and one of its nine Proven Safety Countermeasures;² the treatment was also added as an option in the 2009 Manual on Uniform Control Devices (MUTCD).³ As a result of successful implementation in varied localities, many U.S. State and local transportation agencies have adopted practices and policies concerning this countermeasure.

Low cost per unit, big safety benefit

Backplates with retroreflective borders is a safety treatment that does not require significant material or labor costs to install. Depending on the implementation method chosen, costs range from \$35 for adding reflective tape to existing backplates to \$56-110 for replacing the backplates with reflective material already incorporated.

Reduction in collision claims and injury/fatality crashes: a proven safety measure

The first study of retroreflective backplates was conducted in 1998 in British Columbia,

Included in the Manual of Uniform Traffic Control Devices (MUTCD)

MUTCD Section 4D.12 Visibility, Aiming, and Shielding of Signal Faces

A yellow retroreflective strip with a minimum width of 1 inch and a maximum width of 3 inches may be placed along the perimeter of the face of a signal backplate to project a rectangular appearance at night.

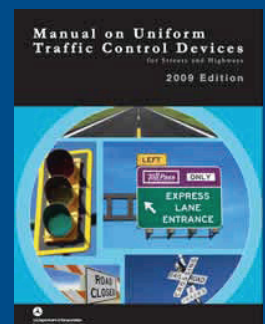




Exhibit 2: In June 2005, yellow retroreflective borders were added to existing backplates at three high-crash locations in Columbia, South Carolina. Simple before- and after-implementation comparisons showed crash reductions at the three sites ranged between 29 percent (total crashes) and 50 percent (late-night/early-morning crashes).⁵ (Source: FHWA)

Canada, with ten signalized intersections. What began as a small project turned into a sizable deployment and study, with robust statistical evaluations conducted after several years.

In a paper published in 2005, Sayed et al⁴ reported the results of a study testing the application of 75mm-wide retroreflective tape on backplates at 17 signalized intersections. The results showed the total modeled insurance claims were reduced by approximately 15 percent. This 15 percent reduction in all crash

types became the basis for the crash modification factor (CMF) of 0.85 as cited in the CMF Clearinghouse, and is referenced by a number of organizations and vendors with regard to the effectiveness of adding retroreflective borders to signals. This remains the most complete study to evaluate the effectiveness of retroreflective borders on backplates exclusively.

A closer look at those 17 locations suggests that retroreflective borders on backplates are effective across a broad range of installations. The roads in the study varied in characteristics, ranging from 30 to 55 mph posted speeds, with surrounding land uses that were urban and suburban (with industrial or commercial developments), some with lighting, and some with pedestrian facilities.

Low cost, simple implementation

The most effective means of implementing retroreflective backplates is to adopt them as a standard treatment for signalized intersections across a jurisdiction, so that the treatment will be consistently incorporated into all new construction and modernization projects.

Multiple vendor options

The list of State and local agencies using this proven countermeasure grew substantially in the last several years, leading many traffic control device vendors to offer them as a complete product. Agencies should work with their suppliers to determine availability.

Mature process

While retroreflective backplates are a low-cost, fairly simple modification, early adopters have learned to address a short list of possible implementation challenges, such as minimizing installation time, adjusting to the learning curve of integrating new practices and equipment, and physically accessing signal heads.

Michigan DOT and Highway Safety Improvement Program (HSIP) Funding

Beginning with FY15 HSIP projects, Michigan DOT now requires retroreflective border backplates for any traffic signal upgrade project, making it an HSIP standard.⁶

States have funded these projects in various ways. Some jurisdictions, such as the City of Nashua, New Hampshire, have used Congestion Mitigation and Air Quality (CMAQ) funding to install backplates with retroreflective borders as part of overall signal modernization. Other states, such as Washington, have largely funded installation retrofits through Highway Safety Improvement Program (HSIP) funding.



Exhibit 3: Signals with retroreflective backplates in the City of Nashua, New Hampshire. (Source: VHB)

CASE STUDY: City of Nashua, New Hampshire, LESSONS LEARNED

As part of a larger project to upgrade 68 intersections in its downtown core, the City of Nashua installed retroreflective borders on signal backplates to increase signal conspicuity and improve safety. Louvered, aluminum backplates with a 2-inch strip of yellow reflective tape were installed on approximately 400 signal heads at 41 of the 68 targeted intersections. The majority of these

were retrofits of existing signals. Officials cited the FHWA's Proven Countermeasures as a factor in their decision to include the retroreflective backplates as part of the signal upgrade.

The project, completed in 2014, was funded through the Federal participating Congestion Mitigation and Air Quality (CMAQ) program (with an 80/20 Federal/local ratio). Projected benefits include a 40 percent reduction in total crashes due to all of the measures implemented as part of the program, a 13 percent reduction in total crashes due to retroreflective backplates, better intersection levels of service, and improved air quality for the city. (Source: VHB)

Lessons learned during the project include:

- If the signal head isn't removed prior to installation of a backplate, it may be necessary to cut through the backplate to flex it around a signal head. Use a power saw to cut through the backplate, as tin snips can leave ragged and sloppy cuts that prevent the tape from adhering properly to the backplate.
- Providing a list of all signal configurations and manufacturers helps the installation team plan ahead for properly fitting backplates, which saves time in the field.
- Ultimately, the replacement backplates selected were manufactured to fit many types of signal heads. Replacing the backplates while the signal head remained in place was a fairly quick procedure, with an approximate installation time of 10-15 minutes per backplate.

Flexibility in design and materials

Backplates and borders come in various configurations:

Backplate (variations: back plate, backboard).

Generally, backplates are made up of a thin strip of material that extends outward from and parallel to a signal face on all sides of a signal housing to provide a background for improved visibility of the signal indications.

Backplates are typically made of aluminum or ABS plastic. Aluminum allows for color variation through painting, while ABS has a fixed set of colors selected during production. Aluminum is typically a better surface for adhering retroreflective sheeting, but multiple jurisdictions have applied tape to ABS with no notable degradation. Backplate width is driven by the size of signal faces and the respective material specifications for each jurisdiction.

Sometimes the backplate is louvered with a series of narrow openings framed at their longer edges with slanting, overlapping fins or slats. Designed to allow air to pass through and better disperse wind loads, louvered backplates are more commonly used in locations prone to high-wind conditions. Retroreflective tape placed over louvers defeats the purpose of the louvers and accelerates degradation of the tape. Application on these backplates may require use of a narrower-width tape. Some states require a border of at least a ½-inch between the tape and any louvers.

Retroreflective backplate border. A strip of yellow retroreflective sheeting placed along the perimeter edges of a backplate provides a “frame” for the signal face that is visible under both light and dark conditions. Retroreflective tape is coated with glass spheres or engineered microprisms to reflect light back to its source. Typically, it comes in rolls, and has an adhesive backing. Tape can be 1- to 3-inches in width; however, the 2-inch variety is most commonly used, per the specification of States such as Florida, Ohio, Indiana, and South Carolina.

Among the different types of retroreflective sheeting available, prismatic types are most



Exhibit 4: The retroreflective border provides a visual reference about the orientation of the signal, particularly during dark conditions. (Source: VHB)



Exhibit 5: Signals at a displaced left-turn (DLT) intersection in Fenton, Missouri, have backplates with and without retroreflective borders. (Source: FHWA)

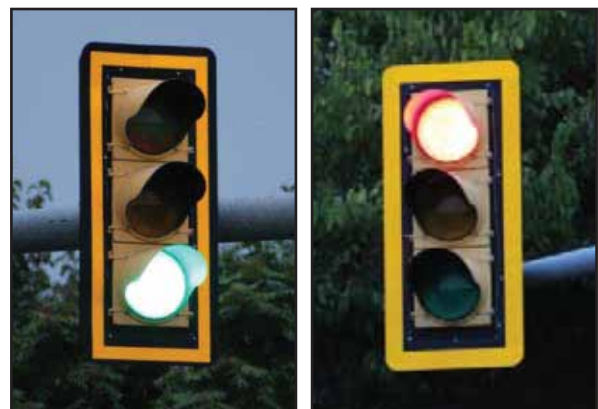


Exhibit 6: There may be variations in the type of retroreflective borders. The backplate on the left has a black border on the outside of the retroreflective border. On the backplate to the right, the retroreflective border extends to the edge of the backplate. (Source: VDOT)

often used. The most common is ASTM Type XI, but others, including ASTM Types I, III and IV, are also used. The choice of sheeting type is largely driven by State specifications, but may also be influenced by availability of the desired width in a convenient form.

Numerous installation options

Existing traffic signal hardware, available manpower, traffic conditions, and other factors influence the chosen method of installation. Backplates can be installed on the ground if the signal is new or removed, or while the signal/backplate is still hanging. Many agencies take the opportunity to install retroreflective borders on backplates when replacing or updating signal heads.

Exhibit 7: Retroreflective Borders on Backplates Installation Considerations

As part of its implementation of retroreflective borders on backplates, the Virginia Department of Transportation (VDOT) asked Regional Operations Maintenance Managers for ideas about installation methods and retrofitting existing signals. This table is adapted from information gathered by VDOT to evaluate various installation techniques, equipment costs, labor time, maintenance of traffic (MOT) costs, durability, warranty, and potential installation locations.

	Retrofit Existing Backplate		Replace Existing Backplate		Add New Backplate	
Installation	In air: Scrape clean, apply tape.	In air: Remove, treat, and reinstall backplate.	In air: Remove and replace backplate.	Ground: Remove signal head and add backplate.	In air: Add new backplate.	Ground: Remove signal head and add new backplate.
Equipment Cost	Low	Low	Low	Mid	High	High
Labor Time	Low	Mid	Mid	High	Mid	High
MOT Cost	Mid	Mid	Mid	High	Mid	High
Durability Concerns	Yes	Yes	Yes	No	No	No
Warranty Concerns	No	Void if backplate is cut.	Void if backplate is cut.	No	No	No
Implementation Locations	<ul style="list-style-type: none"> Older signal heads where new backplates do not fit. Recently installed signal heads with untreated backplates. 		<ul style="list-style-type: none"> Older signal heads where backplate fits. Recently installed signal heads with untreated backplates. 		<ul style="list-style-type: none"> Older or recently installed signal heads where new backplate fits. 	
Notes	No signal head brand inventory required.		Backplates are specific to signal head manufacturer (need inventory).		<ul style="list-style-type: none"> No signal head inventory required. May have to replace other equipment (cables, brackets, etc.). 	

Methods for placing retroreflective borders on backplates include:

Ordering backplates directly from the distributor with retroreflective tape pre-applied.

This option may be best for new and replacement signals. It represents the highest initial material cost, but saves the labor cost of local sign shops applying the tape. However, not all backplates will fit on existing signal heads. For example, the City of Nashua, New Hampshire—where approximately 400 signal heads were retrofitted with retroreflective borders on backplates—required a manufacturer-specific backplate for 15 percent of existing signal heads.

Ordering retroreflective tape (in the desired width) and backplates at the same time, but without pre-application. Utilizing agency sign shop personnel to apply the tape saves on the initial cost of the backplates and provides greater flexibility regarding matching the correct type of backplate to an existing signal head. Cost savings, however, may be offset by labor costs for tape application at the local sign shop.

Ordering retroreflective tape (in the desired width) and applying it to existing backplates. This is the least expensive option initially and may be particularly helpful in a jurisdiction with few backplates to treat or few signals overall. An agency may wish to remove the backplate, clean it thoroughly, and install the tape in the field, or install the tape to the backplate while the signal is hanging. Field installation can be affected by weather conditions.



Exhibit 8: Installation details for retroreflective borders on backplates. The photo to the left shows where the backplate was cut along the bottom to fit around the signal head. The backplate was fastened to the signal housing to the left and right of the cut. The photo to the right shows a detail of the applied tape. (Source: VHB)

Widely Implemented Safety Treatment

As of 2014, more than half of U.S. State highway agencies have a policy, specification, or standard for implementing backplates with retroreflective borders.

CASE STUDY: Kentucky's Evaluation of Retroreflective Borders on Traffic Signal Backplates

VISION: The Kentucky Transportation Cabinet (KYTC) sought low-cost safety improvements at urban, high-volume, signalized intersections and rural, high-speed intersections known for increased red-light running.⁷

CHARACTERISTICS: Thirty signalized intersections were chosen throughout Kentucky for their high volume of crashes from 2000 to 2007, high incidence of red-light-running behavior, and high-speed approaches (between 45 and 55 mph).

COST: The costs for implementing the countermeasure were approximately \$150 to \$180 per signal head, including materials and labor.

IMPLEMENTATION: Two types of retroreflective backplates were installed: black backplates with yellow retroreflective borders, and yellow retroreflective backplates. The retroreflective backplate and border were visible during the day, but conspicuity increased significantly at night and under limited visibility conditions.

RESULTS: A simple before-and-after study showed an aggregate crash reduction at the 30 intersections of 19.6 percent, a 44.4 percent reduction in angle crashes, and a 10 percent reduction in rear-end crashes. Urban and rural results were not differentiated; however, the aggregate reduction exceeded the CMF Clearinghouse's 15 percent expected crash reduction for adding retroreflective orders to signal backplates in urban areas.⁸

CURRENT PRACTICE: KYTC does not require retroreflective backplates;⁹ however, when retroreflective plates are installed, a 2-inch wide fluorescent yellow reflective tape is to be applied around the outer perimeter of the face of the backplate. Note that the reflective tape must comply with the latest ATSM Standard for Type IX, Fluorescent Yellow retroreflective sheeting.



Exhibit 9: Treatments were applied to signals on both span wire and mast arms. (Source: FHWA)



Exhibit 10: Treated signals at a Kentucky intersection. (Source: FHWA)

CASE STUDY: Washington State's Success with Local Implementation of Retroreflective Borders on Traffic Signal Backplates

VISION: The Washington State Department of Transportation (WSDOT) requires the use of backplates for all overhead-mounted displays for new, updated, or rebuilt signal faces. WSDOT has been working with local agencies to retrofit signals with retroreflective backplates, including adding retroreflective tape to existing backplates or adding backplates and tape. WSDOT has funded projects (many of them widespread) in more than 16 jurisdictions; however, many installations are also made directly by local agencies.



Exhibit 11: Mast-mounted signals with retroreflective borders. (Source: VHB)

CHARACTERISTICS: Many of the State's retroreflective backplate installations have been completed under the Quick Response Safety Program. Under this program, cities, counties, and Tribes could apply for grants for the construction phase of projects that met two goals: (1) to reduce fatal and serious injury collisions on local roads and streets and on State highways that serve as city arterials within any local jurisdiction; and (2) to get safety projects implemented quickly.

COST: The cost for implementing the countermeasure was approximately \$450 per intersection.

FUNDING: Funding for retrofitting existing backplates with retroreflective sheeting came through a variety of sources. HSIP funding has been the primary source for local agencies; however, other funding sources have covered installations, including those on the State highway system.

IMPLEMENTATION: Yellow retroreflective borders were added to existing signal backplates, framing the signal head. In some locations without existing backplates, backplates with a retroreflective border were installed. Washington State officials advise that the most common method of installation is to manually apply the tape to backplates.

CURRENT PRACTICE: Backplates are to have a 1-inch to 3-inch wide yellow strip of retroreflective, Type IV, prismatic sheeting around the perimeter to project a rectangular image at night.

CASE STUDY: New Hampshire's Plan for the Future Implementation of Retroreflective Borders on Backplates

VISION: To employ the FHWA proven safety countermeasure throughout the State.

IMPLEMENTATION: The New Hampshire Department of Transportation (NHDOT) reviewed the loading capabilities of their approximately 450 signals. Approximately 90 to 95 percent of the signals have backplates and are mounted on existing mast arms. Signal poles and foundations were designed for aluminum signal heads and backplates at specified distances along the arm. Based on the existing signal designs, NHDOT determined that adding retroreflective tape would be a negligible increase in loading on the mast arms, making a retrofit of signal backplates with retroreflective tape feasible.



Exhibit 12: Treated signals in Nashua, NH.
(Source: VHB)

Building on lessons learned in Nashua, NH, NHDOT plans to conduct a pilot program that includes 100 locations, which is almost 25 percent of the State-maintained signalized intersections. (See page 3 of this technical summary for more information on lessons learned.) The pilot will include a field evaluation of the signals to decide which of three methods (taping backplate, retrofitting signal with new backplate, or installing new signal head with backplate) should be proposed and to quantify that information. Upon completion of the pilot, lessons learned will be reviewed to determine the best installation method for the remaining 75 percent of the signalized intersections in New Hampshire.

MATERIALS AND METHODOLOGY: NHDOT conducted a review of signal heads and backplates to determine the types of signal heads in place and which backplates could be used. NHDOT also reviewed methods for installing new retroreflective borders on backplates, including vertical cuts and retaping. Vertical cuts on the sides of existing signal heads would allow NHDOT to avoid taking the signal head down. There was a concern that removing the signal heads may cause the brackets to crack. NHDOT also considered retaping across the face of the plate and the back of the plate. In reviewing the methods for applying tape, NHDOT found that the amount of pressure used when applying the tape is important. The tape also cannot be applied to backplates with flaking or peeling paint. In those instances, installers would need to determine whether to replace the backplate or the whole signal.

CURRENT PRACTICE: NHDOT is in the planning stages of the pilot project to implement retroreflective borders on backplates, but has also adopted a blanket policy that any new signal or modernization project will include 2-inch retroreflective backplates.

CASE STUDY: Virginia's Systemic Plan to Implement Retroreflective Borders on Backplates

VISION: Virginia Department of Transportation (VDOT) plans to implement retroreflective borders on backplates as a safety improvement that benefits all regions and districts.

FUNDING: The backplates will be funded through VDOT's Open Container funds.

IMPLEMENTATION: VDOT plans to begin systemic installations on VDOT-identified Corridors of Statewide Significance (CoSS), and to create a longer-term specification that can be used for isolated intersections in the future. Installations began in the fall of 2014.

MATERIALS AND METHODOLOGY: In order to determine the best method of applying the retroreflective borders on backplates, VDOT asked Regional Operations Maintenance Managers to contribute ideas on best methods and retrofit. VDOT also reviewed methods employed by other States and determined that many use 2-inch strips and prismatic sheeting while others use fluorescent yellow. VDOT's Materials Division is researching the size and type of strips that should be recommended. (For more information, see page 5 for Retroreflective Borders on Backplates Installation Considerations.)

CURRENT PRACTICE: VDOT is creating a standard for applying the retroreflective borders on backplates and determining the implementation priority of signalized intersections along VDOT's CoSS. Next steps include working with the regions to identify final deployment locations and possibly conducting a pilot study to determine the time necessary for a retrofit.

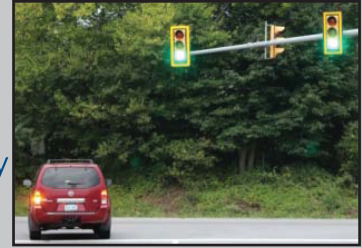


Exhibit 13: An intersection in Virginia with treated signals.
(Source: VDOT)

Endnotes

- ¹ FHWA, Handbook for Designing Roadways for the Aging Population, FHWA-SA-14-015, June 2014 (http://safety.fhwa.dot.gov/older_users/handbook/)
- ² FHWA, Office of Safety, Proven Safety Countermeasures web site. (<http://safety.fhwa.dot.gov/provencountermeasures/>)
- ³ FHWA, Manual on Uniform Traffic Control Devices (MUTCD), 2009 Edition. (http://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm)
- ⁴ Sayed, T., Leur, P., and Pump, J., "Safety Impact of Increased Traffic Signal Backboards Conspicuity." 2005 TRB 84th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#05-16, Washington, D.C., (2005)
- ⁵ FHWA, Retroreflective Borders on Traffic Signal Backplates—A South Carolina Success Story, FHWA-SA-09-011, December 2009. (<http://safety.fhwa.dot.gov/intersection/resources/casestudies/fhwasa09011/>)
- ⁶ Michigan Department of Transportation, Fiscal Year 2015 Federal Local Safety Program Call Letter, July 16, 2013. (http://www.michigan.gov/documents/mdot/MDOT_-_LAP_-_FY_2014_Safety_Program_Call_Letter_391978_7.pdf)
- ⁷ University of Kentucky, College of Engineering, Low-Cost Safety Measures at Signalized Intersections, Research Report KTC-08-11/SPR316-06-1F, May 2008. (http://uknowledge.uky.edu/cgi/viewcontent.cgi?article=1074&context=ktc_researchreports)
- ⁸ FHWA, Desktop Reference for Crash Reduction Factors, Report No.: FHWA-SA-08-011, September 2007. (<http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/>)
- ⁹ Kentucky Transportation Cabinet, Construction Standard and Supplemental Specifications, 2012. (<http://transportation.ky.gov/Construction/Standard%20and%20Supplemental%20Specifications/800%20Materials%2012.pdf>)

Additional references

Manual on Uniform Traffic Control Devices (2009 Edition), Part 4D Traffic Control Signal Features
(<http://mutcd.fhwa.dot.gov/pdfs/2009/part4.pdf>)

Florida Department of Transportation, Plan Preparation Manual, Chapter 7 Traffic & ITS Design (Section 7.4.17).
(<http://www.dot.state.fl.us/rddesign/PPMManual/2009/Volume1/zChap07.pdf>)

Senior Mobility Series: Article 4 - Marking the Way to Greater Safety, FHWA Public Roads Volume 70/No. 1
(<http://www.fhwa.dot.gov/publications/publicroads/06jul/08.cfm>)

Crash Modification Factor (CMF) Clearinghouse [quick search "retroreflective backplate"]
(<http://www.cmfclearinghouse.org/>)

Evaluating Impact on Safety of Improved Signal Visibility at Urban Signalized Intersections
(<http://pubsindex.trb.org/view.aspx?id=800943>)

Missouri DOT Engineering Policy Guide Traffic Control Signal Features
(http://epg.modot.org/index.php?title=902.5_Traffic_Control_Signal_Features_%28MUTCD_Chapter_4D%29)

Road Safety Performance Associated with Improved Traffic Signal Design and Increased Signal Conspicuity
(<http://mutcd.fhwa.dot.gov/texts/miska/miska02.htm#toc>)

Washington Department of Transportation Design Manual
(<http://www.wsdot.wa.gov/publications/manuals/fulltext/m22-01/m22-01.06revision.pdf>)

FOR MORE INFORMATION

Office of Safety: Jeffrey Shaw, jeffrey.shaw@dot.gov

Office of Operations: Bruce Friedman, bruce.friedman@dot.gov

FHWA Resource Center: Tim Taylor, timothy.taylor@dot.gov

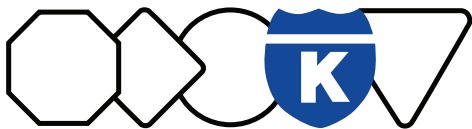
Visit FHWA's intersection safety Web site to download this and other technical outreach products highlighting proven intersection safety treatments from across the country:

<http://safety.fhwa.dot.gov/intersection>



U.S. Department of Transportation
Federal Highway Administration





Korman Signs INC.

*3029 Lincoln Avenue | Richmond, Virginia 23228
Phone 800-296-6050 | 804-262-6050 | Fax 804-261-1040
Email korman@kormansigns.com*

www.kormansigns.com