Reflective Conspicuity

TDOT Dump Truck and Light Duty Pickup Truck Reflective Striping Recommendations for the TDOT Occupational Health and Safety Division.

Tennessee Department of Transportation | July 2018

Table of Contents

Summary

Considering any previous recommendations from the TDOT Occupational Health and Safety Office and TDOT Equipment Committee, procurement regulations from the Central Procurement Office, and any applicable ASTM standards; an evaluation team was formed to access the performance of conspicuity tape markings on TDOT Dump Trucks and light Duty Pickup Trucks. The group consisting of Construction and Maintenance Operations employed in Region 2 (District 28) and Region 3 (District 39) evaluated the performance of reflective vehicle markings from two manufacturers: 3M and ORAFOL. The objective of the evaluation team was to analyze the reflective features and location of the conspicuity tape on a variety of different dump trucks and pickup trucks commonly used in the state's fleet. Material cost was not a consideration for the evaluation team and a cost analysis is expected to be performed by the TDOT Occupational Health and Safety Office. Upon testing and evaluating both 3M and ORAFOL products, the evaluation team recommends the following reflective conspicuity tape:

TDOT Pickup Truck

- 3M 12 inch Fluorescent Lime-Yellow / Black Chevron Conspicuity Tape.
- 3M Fluorescent Lime-Yellow / Black Conspicuity Tape (or scraps) to be installed on inside of all doors to face traffic when door is opened.
- 3M 2 inch and 4 inch Fluorescent Lime-Yellow Conspicuity Tape to be supplemented based on Regional and District needs.

TDOT Dump Truck

- 3M 6 inch Fluorescent Lime-Yellow / Black Chevron Conspicuity Tape to be used on tailgate. 3M 12 inch Fluorescent Lime-Yellow / Black Chevron Conspicuity Tape to be used on rear of V-Box Salt Spreader.
- 3M Fluorescent Lime-Yellow / Black Conspicuity Tape (or scraps) to be installed on inside of all doors to face traffic when door is opened.
- 3M 4 inch Fluorescent Lime-Yellow Conspicuity Tape to be used as additional marking on tailgate and rear of V-Box Salt Spreader.

Below is an image of the 3M chevron conspicuity that was provided for testing procedures.

It was discussed with 3M representatives that the 12.00” chevron conspicuity length be reduced from 96.00” (8 feet) to 72.00” (6 feet). The new length will be sufficient for all pickup tailgates while reducing waste and material cost.

Introduction

The Occupational Health and Safety Division is responsible for developing and implementing policies, specifications, and procedures to ensure the health and safety of people inspecting, maintaining, constructing, and traveling our transportation system. Reflectivity conspicuity was identified as a potential low-cost improvement to work in conjunction with the TDOT Warning Light Standardization Manual to obtain maximum visibility on the roadway system regardless of working conditions. An evaluation team was asked to examine multiple reflective conspicuity manufacturers on a variety of state vehicles and present their conclusions to OHS for final review.

This report combines input from manufacturer representatives and TDOT Operations employees and introduces requirements intended to:

- Identify reflective material that will provide low-cost and long-lasting visibility to enhance TDOT distinguishability on the roadway.
- Utilize conspicuity tape that provides statewide uniformity.
- Detect best practice reflective tape installation instructions for Garage and Operations employees.

The installation and evaluation detailed in this report provide recommendations based exclusively on the performance of the material provided by 3M and ORAFOL and recognize the above requirements. Before any conspicuity tape is to be purchased in bulk, it is imperative that TDOT Occupational Health and Safety create a purchasing plan for Regional or District procurement through local purchase or statewide contract.

Requirements and Guidelines

Minimal restrictive guidelines were discussed prior to the evaluation team installing and evaluating the 3M and ORAFOL products and there are no known Tennessee Code Annotated requirements for vehicle markings.

In an effort to maintain departmental consistency, the evaluation team was asked to only use Lime-Yellow Fluorescent reflective material similar to TDOT HELP vehicles.

Prior to installation, the evaluation team performed research for industry standards for reflective material and determined that the reflective conspicuity shall meet the requirements of ASTM D 4956-90 which provides basic information regarding retroreflective sheeting types and adhesive backing classes. Both the 3M and ORAFOL samples meet this requirement.

Installation

The initial installation of chevron conspicuity tape and additional 4 inch reflective tape was performed in the District 28 – Tullahoma Garage on April 25, 2018 and in the District 39 – Belfast Garage on June 29, 2018. Representatives from 3M were present including Seth Bleiler (Traffic Safety and Security Division) along with various District 28 and 39 personnel from both Operations and their respective Garages.

For testing purposes, 3M provided TDOT with (12) 12 inch chevron strips for pickup trucks and (12) 6 inch chevron strips for dump trucks. Orafol provided (5) 12 inch chevron strips. The installation for both the Chevron and reflectivity tape was performed in a controlled environment under ideal conditions per manufacturer recommendations of standard conditions of 72 ± 3º and 50 ± 5% relative humidity. For an objective opinion on the installation process, the first 6 chevron strips were installed by 3M representatives and the second set of chevron strips were installed by TDOT personnel. All twelve dump truck chevron strips and 4 inch reflective tape were installed by TDOT personnel. The (5) 12 inch Orafol chevron strips were installed by TDOT personnel. Orafol did not provide any installation instructions, so the procedure for the 3M was followed, Below is the process for installation of the 3M and Orafol products:

Installation Steps

(Installation pictures document the process for a Ford F-250. It is not possible to give specific installation instructions for each make/model/year pickup and dump truck in the state's fleet. Due to the variety of vehicles, the installation process is likely to vary depending on: warning light configuration, contours of the tailgate, emblems, badges, etc.).

- Follow application temperatures as recommended in appropriate 3M literature (typical installation: • Flat without rivets: 50–100 °F • Flat, curved or corrugated surfaces with rivets: 55–100 °F
- Wash vehicle prior to installation of adhesive conspicuity tape.
- Remove any vehicle hardware (tailgate handle, badges, emblems, etc.).

- Carefully clean the area using isopropyl alcohol. Use one paper towel moistened with alcohol to clean and one paper towel to dry the surface.

- Cut the 8' strips to (approximately) 1" longer than the width of the tailgate.

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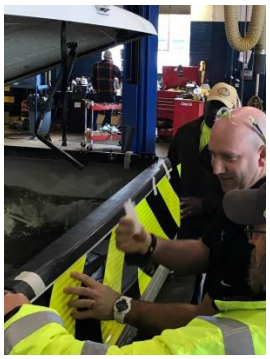
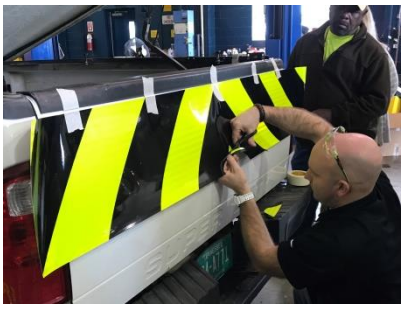
- Position the cut chevron strip on the tailgate using masking tape to hold in place.



- Cut around any existing emblems, badges, etc.
- In many cases, it is a good practice to remove vehicle badges or decals to facilitate easier and faster installations.

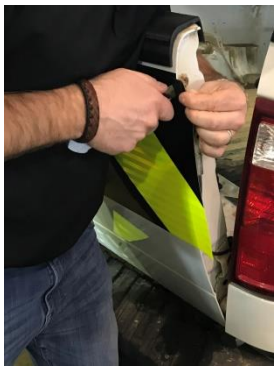


- Lift the adhesive tape and remove the backing of the conspicuity strip.

- Lower the adhesive tape into place (working from the “hinged” masking tape) and press conspicuity tape firmly against the surface of the vehicle while working to remove any bubbles.

- Remove all bubbles using 3M Hand Applicator.
- Use of a clean low friction sleeve such as a blue Monkey Strip (http://monkeystrips.com) will minimize scratching.

- Cut any remaining tape from the edges of the tailgate using scissors or a razor knife.



- Re-install vehicle hardware (tailgate handle, badges, emblems, etc.).

- Install conspicuity tape on inside of all doors to face traffic when door is opened.

Installation Conclusions

The installation for 12” Chevron Strips, 6” Chevron Strips, and 4” reflective tape were applied to a variety of vehicles shown below. The location of the conspicuity tape was determined based on ease of installation while ensuring to have maximum visibility on the rear of the vehicle.

Prior to installation of any reflective material, the TDOT Occupational Health and Safety Division shared that it was their office’s intent to have TDOT employees install the conspicuity tape to reduce costs. After following the 3M installation process for (14) chevron strips, it was determined that TDOT personnel can easily be responsible for applying the reflective material. The total time for the pickup trucks varied depending on the make and model, but averaged 23 minutes. The installation for dump truck conspicuity averaged 16 minutes for both the chevrons and 4 inch strips. It is the opinion of the evaluation team, that installation time can be decreased as the installer becomes more comfortable with the process.

Evaluation

Vehicles were tested for a period of eight weeks prior to a determination of a recommended material. During the testing period, TDOT Operations crews were involved with: Bonnaroo traffic control, Interstate-24 Traffic Incident Management, and daily operations including: 24-hour guardrail installation inspection, Maintenance Quality Assurance inspections, mowing/litter inspection, asphalt hauling, brush removal, etc.

A side by side evaluation of the 3M and Orafol products was conducted and yielded very little reflective variations. Performance evaluations are very subjective from operator-to-operator, but all agree that both products provided excellent long distance advanced warning. Most agree that the conspicuity tape provides better long distance advanced warning than emergency led lights during daytime use. Both products offer great reflective qualities during night time operations providing an additional layer of protection to the state's fleet when using in conjunction with warning lights. During the evaluation process, Operators were also requested to install 2" tape, 4" tape, or scraps wherever they saw fit to provide them with extra security. Below are a few examples:




*(The installation of additional tape is creative and possible warranted, but it is recommended that supervisors limit the amount of tape for financial and aesthetic purposes).

Again, side by side evaluation of the 3M and Orafol products was conducted and yielded very little reflective variations. Below is a comparison of the two products:

3M **Orafol**

During the evaluation period, it was discovered that the reflective sheeting technologies from 3M and Orafol differed. The specifications below might be better suited for the "Specifications Recommendations" section of this report, but is included in this chapter for the sake of comparison:

It is important to note that there are different technologies that provide retroflective properties for sheeting. One technology utilizes a metallic vaporcoat. This type of product can incur vaporcoat fade or corrosion over time, especially when exposed to salt or salt brine. Due to the presence of the metallic layer, vaporcoated products are considered conductive and may be prohibited for use in certain applications where conductivity could be considered a safety hazard. Vaporcoated products typically have a greyish appearance had have a lower measure of whiteness. The Orafol products installed on TDOT pickups uses a metallic vaporcoat material.

Total Internal Reflectors (TIR) are designed materials that do not utilize metallic layers and hence are not affected by vaporcoat fade or corrosion. TIR materials are not considered conductive and have a higher whiteness than many metalized reflective conspicuity products. The 3M products installed on TDOT pickups and dump trucks are manufactured using TIR construction.

Specification Recommendations

Through the evaluation of the 3M and Orafol products tested, the evaluation team noted certain specifications needed to ensure quality, warranty, and effectiveness. The recommended specifications include:

- All reflective sheeting to be fluorescent yellow-green printed with black ink to create a chevron pattern.

- The reflective sheeting is to be constructed using Total Internal Reflectors (TIR) for added durability to fading and corrosion during winter activities.

- The reflective sheeting should remain visible by resisting excessive fading, cracking, peeling, lifting, or discoloration for a period of seven (7) years from the date of initial application per manufacturer terms and conditions.

- The reflective marking shall consist of prismatic lenses formed in a durable transparent resin and backed with an aggressive pressure sensitive adhesive and protective liner.

- The coefficients of retroreflection shall not be less than the minimum values specified in Table I. Measurements are to be made in accordance with ASTM E-810 "Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting." At all entrance angles[1], values shall be measured at observation angles[2] of 0.2° and 0.5°.

  Entrance Angle - the angle formed by a light beam striking a surface at a point and a line perpendicular to the surface at the same point.

  Observation Angle - the angle formed by the light beam striking the reflective surface and the light beam returning to the observer (from 800 ft., a motorist normally views a marking at approximately a 0.2° observation angle).

TABLE I

Photometric Values

Observation Angle (°)	Entrance Angle (°)	cd/lux/m2
0.2	-4	400
0.2	+30	220
0.2	+45	65
0.2	+60	30
0.5	-4	100
0.5	+30	45
0.5	+45	30
0.5	+60	20

- The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing or dimensional change after two years unprotected outdoor exposure, facing the equator in South Florida and inclined 45° from the vertical. Following weathering exposure, panels shall be washed in a 5% HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retroreflection shall not be less than the values in Table III when measured per Section 2 and the color shall conform to the requirements of Table II paragraph 3.0. The sample shall:

- Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting or curling or more than 1/32 inch (0.08 cm) shrinkage or expansion.

- Be measured only at angles of 0.2° observation, -4° entrance. Where more than one panel of a color is measured, the coefficient of retroreflection shall be the average of all determinations.

TABLE II		
Minimum Coefficient of Retroreflection after 2 Year South Florida 45^0 Accelerated Outdoor Weathering (cd/lux/m^2)		
Observation Angle (°)	Entrance Angle (°)	cd/lx/m^2
0.2	-4	320

- Resistance to Heat

  The retroreflective markings, applied to a test panel and conditioned as in 1.0, shall be measured in accordance with paragraph 2.0 at 0.2° observation and -4° entrance angles at both 0° and 90° orientations and exposed to 170 ± 5°F (77 ± 3°C) for 24 hours in an air circulating oven. After heat exposure the marking shall retain a minimum of 70% of the specified original coefficient of retroreflection at both orientations when measured at room temperature.

- Resistance to Corrosion

  The retroreflective marking applied to a test panel and conditioned as in 1.0, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain a minimum of 80% of the specified original coefficient of retroreflection when measured as described in paragraph 2.0 after 1000 hours exposure to a 5% concentration salt spray at 95°F (35°C) when tested in accordance with ASTM B-117.