FHWA-NJ-2008-008

Testing and Evaluation of Graduated Driver License Marker

Summary Report

Submitted by

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In cooperation with

New Jersey
Department of Transportation
Bureau of Research
And
U.S. Department of Transportation
Federal Highway Administration

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16. Abstract

The objective of this project was to assist New Jersey Motor Vehicle Commission in determining the feasibility of a removable visual marker for Graduated Drivers License (GDL) drivers. The NJ Teen Driver Safety Study Commission issued a report to the Governor and Legislature in March of 2008 in response to concerns over the growing level of fatalities and teen driver injuries in New Jersey. One of the recommendations from the Commission's report identifies the need to mark vehicles operated by mostly teen Graduated Driver License (GDL) drivers to aid in enforcement of the GDL law.

Six technologies were identified to meet the requirement for a removable tag on the vehicle license plate. After review of documents and discussion with vendors two technologies were field tested, a hook-and-loop, or Velcro, fastener, and a magnetic fastener. Both had two pieces, a base which attached to the license plate with adhesive and a top piece with a reflective sticker. Based on the field test and further review of product specifications, the hook-and-loop fastener is recommended as the preferred technology for this application. A retroreflective sticker was tested as well. Both the durability and the visibility of the stickers tested was not satisfactory. A draft specification was prepared to help address these deficiencies when the stickers are put out to bid. A focus group was held to discuss enforcement strategies and it was agreed that no identified was required on the sticker, only a solid color. It is proposed that the successful vendor conduct a field test of the attachment devices and the stickers, prior to full deployment, using approximately 500-1000 devices.

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EXECUTIVE SUMMARY

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Six technologies were identified to meet the requirement for a removable tag on the vehicle license plate. After review of documents and discussion with vendors, two technologies were field tested; a hook-and-loop, or Velcro, fastener, and a magnetic fastener. Both had two pieces, a base which attached to the license plate with adhesive and a top piece with a reflective sticker. Approximately 30 tags were tested over the course of a week with a total of approximately 200 detachments and attachments.

Based on the field test and further review of product specifications, the hook-and-loop fastener is recommended as the preferred technology for this application. Retroflective stickers with GDL printed on their surface, were tested for both durability and visibility. Several problems with these stickers were identified and have been addressed in a draft specification prepared for this report and included in Appendix J. Based on input from a focus group held for the project, the sticker will be a solid lime-green color without the GDL lettering.

As a result of the findings, it is recommended that the successful vendor conduct a more extensive field test of both the attachment devices and the stickers, using approximately 500-1000 tags in a limited geographical area. The test should be similar to the durability and visibility tests conducted for this project, but should extend over several months. This will provide an opportunity to identify problems before full deployment of the program takes place.

BACKGROUND

The NJ Teen Driver Safety Study Commission issued a report to the Governor and Legislature in March of 2008 in response to concerns over the growing level of fatalities and teen driver injuries in New Jersey. The Commission report included a number of recommendations addressing these problems. Recommendation 1.2 from the Commission's report identifies the need to mark vehicles operated by mostly teen Graduated Driver License (GDL) drivers to aid in enforcement of the GDL law. GDL drivers hold either a driving permit or provisional license. The marker will assist law enforcement in identifying GDL holders who may be violating GDL restrictions such as nighttime curfew and too many passengers. This report was prepared as a result of a request by the New Jersey Motor Vehicle Commission (MVC) for a recommendation for a removable "marker" to be placed on the standard New Jersey license plate that should identify the specifications for the marker covering materials and the attaching system along with production cost estimates. More information on the background of this research report is included in Appendix A.

OBJECTIVES

The objective of this project was to assist New Jersey Motor Vehicle Commission in determining the feasibility of a removable visual marker for Graduated Drivers License (GDL) drivers and determine which, if any technologies are viable for this purpose.

INTRODUCTION

The objective of this project was to assist New Jersey Motor Vehicle Commission in determining the feasibility of a removable visual marker for Graduated Drivers License (GDL) drivers. The NJ Teen Driver Safety Study Commission issued a report to the Governor and Legislature in March of 2008 in response to concerns over the growing level of fatalities and teen driver injuries in New Jersey. One of the recommendations from the Commission's report identifies the need to mark vehicles operated by mostly teen Graduated Driver License (GDL) drivers to aid in enforcement of the GDL law. The marker will assist law enforcement in identifying GDL holders who may be violating GDL restrictions such as nighttime curfew and too many passengers. Additional background on the need for the project is documented in appendix A.

This report documents the results of the following tasks which were carried by the team of Cambridge Systematics and SI Engineering, with the support of the sponsoring New Jersey agencies:

1. Scan of international GDL marking efforts – While no U.S. States currently use a removable identifier for GDL drivers, there are some initiatives underway in other countries. These efforts were documented in the original report and have been updated as part of this effort.

2. Identify potential materials for consideration – A potential list of materials for use as a removable GDL sticker were identified in the NJ Teen Driver Safety Study Commission report. These options were researched and evaluated based on available data and discussions with vendors. A revised set of options were developed and evaluated with two options ultimately identified for field testing.

3. Develop a testing regime for the materials and conduct tests – A general testing scheme was developed and specific tests proposed and carried out as documented in this report.

4. Conduct a focus group with state law enforcement – A focus group was conducted with State Police representatives, NJDOT staff, and NJMVC staff to evaluate the project findings and discuss next steps toward implementation.

SUMMARY OF WORK PERFORMED

Scan Of International GDL Identification Efforts

A brief international scan was conducted to identify examples of the use of a license plate GDL identifier. While there are a number of jurisdictions around the globe that use GDL identifiers, none of them were found to be using an identifier that is affixed to the license plate. The typical identifier that is used is a display plate that is affixed to the vehicle operated by the novice driver. These plates are often in the form of a square plate that bears a sans serif letter. These plates may be magnetic, may have an adhesive backing, or may have suction cups that allow for attachment on to windshields. Examples of these display plates include those in Australia, which use the letter "L" for learner's permits and the letter "P" for probationary drivers. Other places that use display plates include the United Kingdom, Ireland, Hong Kong, Norway, Singapore, New Zealand, and the Canadian province of British Columbia, among others.

No other U.S. state currently is requiring the use of display plates or other identifiers for novice drivers. As a result, New Jersey is at the forefront of GDL identifier implementation in the United States and other states will be watching to see the results of these efforts.

Evaluation Of Materials For GDL Tag

Initial Identification of Materials

In order to meet the schedule for the *Testing/Evaluation of Graduated Driver License Vehicle Marker,* some elements of project tasks two (Identify potential materials for GDL marker) and three (Develop a testing regime for the materials and conduct tests) were combined and accelerated. The consultant team held discussions with suppliers and reviewed specifications to assess whether the materials identified in the scope of work could meet the criteria set for the GDL marker. Five technologies identified in Task 2 of the scope of work were reviewed, including:

1. Reusable adhesive backing;

2. Dual Lock (3M), Velcro or other hook-lock system;

3. Magnetically receptive material (with adhesive backing) mounted to plate with magnet-backed marker;

4. Incorporate license plate mounting screw with steel plate or magnetically receptive material; and

5. A clip that slides onto the side of the license plate.

Based on research conducted a sixth option was added:

6. An adhesive-backed holder (pocket) fixed on the license plate with a slide-in decal.

Technology Assessment

An assessment of all six technologies was conducted, based on review of specifications and discussions with vendors. A list of vendors contacted is included in appendix B of this report and detailed results of this technology assessment are included in appendix C. Based on the analysis three technologies were selected for further evaluation.

Summary Table

The table below summarizes the initial findings regarding the various technologies. Four of the six criteria identified in the scope of work are listed in the table. Two of the criteria, background color of the tag and environmental impacts, do not vary significantly between options. Information on these characteristics was taken primarily from specifications. Specific characteristics which constitute fatal flaws are marked in the table with an (F). A scoring system also is incorporated in which each alternative is assigned a score of 1 to 5 on each criterion, with 1 as the lowest score and 5 as the highest. A fatal flaw automatically draws a score of 1. Table 1 supports the recommendation summary provided below.

Table 1. Initial Assessment of Technologies

Alternative	Size/Location	Visibility	Durability	Attachment Properties
1 – Reusable Adhesive Backing. Score =11	OK (5)	OK (4)	(F) Not intended for frequent reuse. Hard to keep both surfaces clean. (1)	(F) Difficult to remove and reattach. Quick deterioration likely with frequent removal. No assurance on amount of usage. (1)
2 – Hook-and-Loop Fasteners. Score = 18	OK (5)	OK (5)	OK – Specs indicate up to 1,000 attachments. (4)	OK if attached properly. May be an issue in applying adequate pressure. (4)
3a – Magnetically Receptive material mounted to plate – flexible magnets. Score = 13	Size of mount needed to secure bracket unknown, Multiple vendors may be needed with possible impact on quality and cost. (4)	(F) Unknown – may be subject to movement. (3)	Unknown. (3)	(F) Unknown – Performance subject to vibration, temperature changes, dirt, and moisture. (3)

Table 1. Initial Assessment of Technologies (continued)

Alternative	Size/Location	Visibility	Durability	Attachment Properties
3b – Magnetically Receptive material mounted to plate – rigid magnets. Score =15	Size of mount needed to secure bracket unknown Multiple vendors may be needed with possible impact on quality and cost (4)	OK (5)	Unknown. (3)	Unknown – Material tends to be corrosive, magnet may be too strong. (3)
4 – Magnetically Receptive material with plate mounting screws. Score =11	Mounting plate must match screw holes – could obscure part of plate. Multiple vendors may be needed with possible impact on quality (2)	Probably OK. (4)	Unknown. (3)	Requires base to go across entire plate. Screw holes must be precise. Washers may be needed. (2)
5 – Clip that slides on to the side of the license plate. Score =7	Clip may not fit in right location – may obscure part of plate (2)	Tag may be subject to movement or be obscured by clip. (3)	(F) Holder susceptible to movement. (1)	(F) Recessed plates have no room in back or on sides for clip. (1)
6 – Adhesive-backed holder with bracket/pocket and slide-in tag. Score =13	Probably OK although bracket will be larger than tag (4)	Tag may be obscured by bracket if not inserted properly – also may be obscured by dirt. (3)	Tag may peel while being slid into bracket. (3)	Bracket subject to dirt/snow/ice buildup making it difficult to slide tag. (3)

(F) – Considered fatal flaw.

Recommendation Summary

The assessment documented above provided three options that were worthy of further evaluation.

Option 2. Hook-and-Loop Fasteners (Score =18)

Option 3. Magnetically Receptive Material Mounted to Plate with Magnet-Backed Marker (Scores =13 and 15)

Option 6. Decal Slides which Slides-in an Adhesive-Backed Holder (Pocket) Fixed on the License Plate (Score =13)

Materials were obtained for field testing of options 2 and 3. Option 6 had to be dropped from the testing phase, since no existing product could be located, and the project schedule did not allow for customized product development.

Testing And Evaluation

Three general methods were available for evaluation of GDL tag options. These included:

- Use of specifications, existing test results, and discussions with suppliers;
- Field tests; and
- Laboratory tests.

Relatively long lead times are required to schedule and conduct laboratory tests. This created a challenge within the tight schedule specified for the project. A field test was arranged as soon as initial screening was complete and test materials could be obtained from vendors. Several laboratories were contacted but a decision on laboratory testing was deferred until field test results could be evaluated. A set of initial testing and evaluation strategies are documented in appendix D.

Field Test

A field test was designed by the consultant team and conducted by New Jersey State employees from October 8-15, 2008. Participants were supplied with two basic technologies, hook-and-loop (Velcro) fasteners and magnetic fasteners with two variations on each technology:

- Hook-and-loop fastener with clear base;
- Hook-and-loop fastener with black base;
- Magnet – flexible; and
- Magnet – rigid.

All four types of tags are attached to the license plate with an adhesive base. Hook-and-loop fasteners differed only in the color of the Velcro surfaces. This difference has relevance with regard to the visibility of the tag. Since the New Jersey plate has a light color, a black surface may provide a greater contrast with the plate, thus making it easier for enforcement personnel to spot. The flexible magnet was similar to a “refrigerator magnet” and could be easily bent, while the rigid magnet was heavier and less flexible.

In addition to the durability and attachment properties of the tags, the field test provided an opportunity to test the durability of the stickers. The lime green sticker originally specified for the project was not readily available. Ten stock colors were offered for testing and two were selected, a yellow and light green color. These colors were considered to be closest to the lime green. Various colors proposed for testing are shown in appendix E.

Personnel involved in the field test were provided with a set of instructions and asked to detach and reattach the tags with each use of their car. They also were asked to take the vehicle through a mechanical carwash at least once during the test period. Some of the participants conducted independent testing, including placing the tags in warm water and freezing them. These tests provided useful information on potential problems with the tags. Specific instructions for the field test are included in appendix F and a sample field test sheet is shown in appendix G.

Summary of Field Test Results

Twenty-nine tags were tested over a week period in October 2008 as shown in Table 2.

Table 2. Summary of Field Test Activities

Type of Tag	Number of Tags Tested	Total Number of Detachments and Attachments	Number of Times Tags were Exposed to Wet Conditions or Car Wash
Hook-and-Loop Clear Base	10	67	10
Hook-and-Loop Black Base	9	64	11
Flexible Magnet	7	49	7
Rigid Magnet	3	26	3
Total	29	206	31

The attachment and detachment properties of the tags were generally acceptable, although it was clear that the hook-and-loop fasteners would probably work more effectively in the long run. A detailed summary of problems experienced with hook-and-loop fasteners, magnetic fasteners, and stickers is included in appendix H. The problems found are summarized as follows:

Problems common to both Velcro fasteners and magnetic fasteners:

- Attachment between the base and GDL tag was weakened when surfaces were covered with dirt.
- In several cases, license plate frame did not allow room to place tag on license plate. Tag started to detach when placed partly on frame and partly on plate.
- It is difficult to get fingers in position to detach sticker from base. It was noted that the sticker should be slightly larger than the base so users can get their fingers underneath to remove.

Problems for Velcro fasteners only:

- Tended to stick and were difficult to detach.

Problems for magnetic fasteners only:

- Magnet easily broke in half after being frozen;
- Magnet could be broken in half after being twisted 20 times;
- Magnet could be torn in half after being bent back and forth 10 times; and
- GDL sticker could be pushed off base with fingers. Likely to move when subject to vibration from rough roads.

Problems with sticker:

- Some stickers peeled off when soaked in water;
- Lettering on some stickers faded when placed in warm soapy water; and
- Some stickers cracked down the middle when tags were bent back and forth.

Both types of magnets could be pushed off center with a modest amount of pressure, while the hook-and-loop fasteners were not subject to this type of movement. Attachment properties of both types of fasteners are impacted by dirt and may require cleaning periodically in order to work effectively.

Figures 1 and 2 illustrate problems that occurred with the GDL stickers. Figure 1 shows cracking that occurred during normal use while Figure 2 shows a tag that peeled after being placed in warm water.

Figure 1. Cracked Tag

Figure 2. Peeled Tag

Additional tests conducted with returned tags showed that stickers tend to crack down the middle on both magnets and hook and loop fasteners when the bases are bent or stressed. Since both require some amount of force to remove, this cracking is likely to occur over time if the tag is removed regularly. Eventually it will begin to peel.

There is clearly a significant difference in durability between the fasteners themselves. The hook and loop fasteners cannot easily be damaged or torn by hand, even when they are severely bent and twisted. Both types of magnets, however, crack in half relatively easily after being twisted 10 to 20 times. Once they are bent multiple times they are relatively easy to tear in half.

While sliding was not a major problem during the field test, the magnets have a greater tendency to slide than the hook and loop fasteners. Based on the field test it appears that the hook and loop fasteners should be specified for the GDL tag. The fasteners are specified for up to 1,000 attachments and detachments, which should be adequate for the period required. A draft specification for both hook and loop fasteners and stickers is provided in appendix J. However, it is likely that multiple tags will have to be supplied to users for the following reasons:

- Dirt, ice, and snow will interfere with the operation of the fasteners, no matter what technology is used. It is not realistic to expect all users to clean the base adequately.

- Any removable tag is likely to be lost. One of test participants suggested supplying a Velcro base for a keychain that could used to store a tag that is removed from the vehicle. This idea should be pursued but multiple tags will have to be supplied to users, or replacements made easily available, since losses are inevitable.

Visibility Testing

A visibility road test was conducted for both the green and yellow stickers during the focus group session held on October 25, 2008. The test involved three vehicles, one with a sticker on each of the front and rear license plates and two vehicles passing and following the subject vehicle. Each of the two passing/following vehicles had three focus group participants, including the drivers. The passing vehicles were instructed to identify the visibility of the marker both through the windshield and in the rearview mirror as they passed.

Based on this test, neither color sticker met the requirements of the New Jersey State Police for enforcement purposes. Both colors were easily visible when approaching a test vehicle from the rear. When passing in the opposite direction, however, visibility was poor. Tags on the front plate could not easily be seen at 25 miles per hour beyond 125 feet and tags on the back plate were nearly impossible to see in the rearview mirror. The yellow stickers did not contrast well with the license plate; the green stickers did slightly better but were not adequate. A brighter, more reflective color is needed; a brighter green may be effective. In addition, the focus group participants suggested that it was unnecessary that 'GDL' be printed on the marker if it reduced the marker's visibility.

Focus Group Results

This section includes a summary of the results of the Focus Group conducted on October 24, 2008 with representatives of NJ DOT, MVC, DHTS, NJSP, and several local police departments. The agenda for the focus group can be found in Appendix J.

Understanding and Enforcing GDL

- Understanding and enforcement of GDL laws and restrictions has greatly increased in the last three years. Two areas of concern are the specifics of passenger restrictions (who is allowed?) and provisional license periods. A roll call video would be the most appropriate way to clarify the rules for enforcement. However, the issues here really are the lack of understanding on the part of parents, more than law enforcement or young drivers.

- Another concern expressed regarding enforcement of GDL is the issue of having "just cause" to pull over a driver, particularly in the case where a non-GDL driver is mistakenly pulled over but found to have broken another law (i.e., DUI, murder, etc.). The feeling is these other charges would not hold up in court. As much as possible, the GDL marker mandate should explicitly make it a primary infraction such that the presence of the marker along with another GDL infraction (i.e., too many passengers, driving after hours) provides the justification to stop the driver.

Road Test

- The markers tested, as they are now, do not work. The size is ok, but visibility needs to be improved with a more visible color. Also, the "GDL" letters only reduce visibility and are not necessary as it will be known what the marker in that location on the license plate signifies.

- Placement should be on both the front and back plates.

Distribution

- Distribution should be strategic but should also make the markers widely available so that young drivers can easily get them when they first get their provisional licenses, but also when they need additional or replacement markers (i.e., lost, new car, etc.).

- Which outlets are used depends on funding. If the cost of markers is covered so that they are provided for free, they could be distributed through law enforcement offices, schools, insurance agents, etc. If the markers must be purchased, they should be distributed through select private vendors.

Will the Markers Help?

- Although they will not solve all the issues, the markers will provide law enforcement with one more tool to help identify GDL drivers and thus will help them enforce the law; and

- The markers will also increase driver compliance with GDL laws as they know the marker will draw increased attention from enforcement.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this project was to assist New Jersey Motor Vehicle Commission in determining the feasibility of a removable visual marker for Graduated Drivers License (GDL) drivers. Six technologies were identified to meet the requirement for a removable tag on the vehicle license plate. After review of documents and discussion with vendors, two technologies were field tested, a hook-and-loop, or Velcro, fastener, and a magnetic fastener. Both had two pieces, a base which attached to the license plate with adhesive and a top piece with a reflective sticker.

Based on the field test and further review of product specifications, the hook-and-loop fastener is recommended as the preferred technology for this application. This recommendation is made for the following reasons:

- While both technologies performed adequately in a limited field test, the hook-and-loop fasteners were returned in better condition and appeared to be significantly more durable than the magnets. Magnets could be easily broken after being twisted and bent, while hook-and-loop fasteners are very difficult to damage.

- Hook-and-loop fasteners are an established product that has been tested for applications that are similar, if not identical, to this one. Documentation is available to provide confidence that these fasteners will work effectively. Test results are available for peeling, shear, and tensile strength and specifications show that the material is resistant to most chemicals, dust, moisture, and UV rays. Similar documentation is not available for the magnetic fasteners.

- Hook-and-loop fasteners provide the option for a single vendor to provide everything that is needed for the application. This is not the case with other technologies.

A proposed functional specification for this application is provided in appendix J.

While hook-and-loop fasteners appear to be the most feasible technology several problems were identified during the research and test phases that need to be resolved:

- The GDL stickers that were tested did not perform as well as the fasteners and had a tendency to crack. The draft specification has been tightened to address this but more contact is needed with vendors to assure that frequent attachment and detachment does not destroy the sticker.

- The green and yellow stickers used during the field test were not readable by a vehicle passing in the opposite direction. A brighter color that stands out more from the license plate will be required.

- Tags are likely to be lost or misplaced on a regular basis, which will add to the difficulty of enforcement. It is recommended that multiple tags be provided to each GDL driver and that a Velcro attachment for a keychain be provided as well.

- Before implementing the program statewide, it is highly recommended that the successful vendor conduct a more extensive field test with approximately 500 -1,000 tags. This test should be conducted in a limited geographic area so it can be easily monitored by DOT, MVC, DHTS, and NJSP. Tags should be distributed and used by a sample of GDL drivers for 2-4 months before placing the full order for a statewide program. This test will help to identify any potential problems with performance, durability and visibility that did not surface in the shorter test conducted for this project. It will also help to determine how frequently tags are lost and provide a better idea of how the distribution system should work.

APPENDIX A – PROJECT BACKGROUND

The NJ Teen Driver Safety Study Commission issued a report to the Governor and Legislature in March of 2008 in response to concerns over the growing level of fatalities and teen driver injuries in New Jersey. The Commission report included a number of recommendations addressing these problems. Recommendation 1.2 from the Commission's report identifies the need to mark vehicles operated by mostly teen Graduated Driver License (GDL) drivers to aid in enforcement of the GDL law. GDL drivers hold either a driving permit or provisional license. The marker will assist law enforcement in identifying GDL holders who may be violating GDL restrictions such as nighttime curfew and too many passengers.

Legislation supporting the marker recommendation (Assembly Bill No. 3069) was introduced June 23, 2008. While the bill provides certain specifications for the marker, there is an opportunity at this time to develop a marker that best meets the needs of drivers, law enforcement, and legislature. A meeting of interested parties to discuss the marker was held at Motor Vehicle Commission Headquarters on August 5, 2008. At this meeting, it was determined that the marker would be placed on the standard New Jersey license plate. It also was determined that the plate marker needed to be tested so that the legislature could endorse specific requirements for the marker in the coming months. No other U.S. States have a legal requirement to identify GDL drivers by a marker on a vehicle.

The typical user of the marker and attachment system will be household members, including parents and novice GDL drivers. Household and other vehicles may be operated by GDL and basic license holders. The marker will be affixed/displayed when the vehicle is operated by GDL holder and removed when operated by basic license holder. GDL drivers who fail to display markers can be cited for a violation. Law enforcement officials will be authorized to stop a vehicle with a marker if a GDL violation is observed such as the number of passengers or hour of operation.

The New Jersey Motor Vehicle Commission (MVC) requested a recommendation for a removable "marker" to be placed on the standard New Jersey license plate that should identify the specifications for the marker covering materials and the attaching system along with production cost estimates. This report will provide detailed recommended specifications for the marker that can be incorporated into existing GDL legislation.

APPENDIX B – LIST OF CONTACTS

Material Options:

Avery Dennison Inc.
Phone: (626) 304-2000

Global Traffic Technologies, LLC
Phone: (800) 258-4610

3M
Phone: (800) 362-3550
(800) 555-1380
(301) 829-7198 (Chris DeColli, Professional Services Sales Manager)
(800) 213-2351 (Frank Lukaszewicz, North-East Sales Division)
(651) 736-5382 (Pamela, Technical Division)

Eneflux Armtek Magnetics, Inc.
Phone: (800) 227-6835
(516) 349-0222 (Chris)

Magnetic Component Engineering, Inc.
Phone: (800) 989-5656

Master Magnetics, Inc.
Phone: (303) 688-3966

Arnold Magnetic Technologies Corporation
(800) 543-4426

Mark IV IVHS, Inc.
Tel: (905) 624-3025 x 1202
Fax: (905) 624-4572
http://www.ivhs.com

Laboratory Inquiries:

Bruce Bryant (NJ State Prison)
Phone: (856) 459-7720

ASTM
Phone: (610) 832-9585

Institute of Transportation Engineers
(202) 289-0222

New Jersey Institute of Technology, Newark, NJ
Lab Director: Allyn Luke
(973) 596-2449

APPENDIX C – INITIAL SCREENING OF GDL ATTACHMENT TECHNOLOGIES

Through these discussions and review the following pros and cons were identified for each of the six technologies:

Option 1. Reusable Adhesive Backing

Pros:

+ Easy to apply (pressure sensitive adhesive) and remove after use.
+ Thin adhesive material that does not project out much from the plate thus will not be subjected to higher shear.
+ Initial application provides good performance on peeling.
+ Provides good bond to any materials.
+ A single supplier can (3M) can produce the whole assembled product.

Cons:

– Adhesive has low weather resistance.
– There is no assurance from the manufacturer's side about the number of usages.
– Whenever detached from the surface, it comes in contact with dust and moisture which lowers the performance.
– When removed from the plate, it will become driver's responsibility to protect the adhesive backing with some liner material until the next use to avoid exposure of adhesive surface.
– At the time of reapplication to the plate, one has to clean the surface on license plate from dust and moisture.
– With environmental exposure, dirt, and moisture, strong car wash chemicals and extreme weather changes, surface looses the cohesiveness of the adhesive and results to lower life.

Option 2. Hook-and-Loop Fasteners

Pros:

+ Fast and convenient to apply.
+ Satisfies durability requirements for number of usages and life cycle.
+ Higher results for peeling, shear, and tensile tests.
+ Resistant to most chemicals, dust, moisture, and UV rays.
+ As a supplier, 3M can produce the whole assembled product.

Cons:

- May need to provide more than one base in case a GDL holder needs to use marker in more than one vehicle.

Option 3. Magnetically Receptive Material Mounted to Plate with Magnet-Backed Marker

Based on market study two main types were identified which could be used in this application:

1. Flexible Magnets

Pros:

+ Can be Bent, Coiled, and Shaped.
+ Available with Pressure Sensitive Adhesive.
+ Corrosion-Resistant.

Cons:

- Lower Magnetic Strength, decal may fall off while using.
- Magnet manufacturers provide no assurance for re-usages, as the performance varies with the cleanliness of the surface while reapplication and contact with moisture.
- Low Temperature Resistance, during the temperature drop the magnetic strength decreases.
- Noncorrosive receptive, magnetic material, adhesives and retroreflective materials to be assembled to complete the product may be supplied from different vendors (minimum 2 (two) vendors).
- May not be a cost-effective solution.
- May need to provide more than one receptive base, in case a GDL holder needs to use marker in more than one vehicle.

2. Neodymium Material (Rigid Magnets)

Pros:

+ Very high resistance to demagnetization.
+ High energy, compare to size.
+ Good in ambient temperature.

Cons:

- Bond between base and decal may prove stronger than needed for this application.
- Material is corrosive and should be coated for long-term maximum energy output.
- Low working temperature for heat applications.
- Noncorrosive receptive, magnetic material, adhesives, and retroreflective materials to be assembled to complete the product may have to be supplied from different vendors.
- May not be a cost-effective solution.
- May need to provide more than one receptive base in case a GDL holder needs to use marker in more than one vehicle.

Option 4. Magnetically Receptive Material Mounted using Plate Mounting Screws with Magnet-Backed Marker

The pros and cons remain the same as option 3, here the method of mounting the plate changes.

Pros:

+ Provides assured bond between plate and receptive material.
+ Convenient removal of the assembly at the end of the requirements.

Cons:

- Receptive material should be long enough to go across the entire plate, so that the license plate mounting screws can be used for holding.
- In case of Neodymium material, magnetization is too strong and may bend the receptive material at the time of removal. Material should be thick enough to remain immovable.
- Involves material cost to meet the length and thickness requirements.
- May need to design and provide washers also.

Option 5. A Clip that Slides Onto the Side of the License Plate

Pros:

+ Provides assured bond between plate and decal.
+ Easy to apply the assembly at the end of the requirement.
+ Same decal can be used in multiple vehicles, no need for a base.
+ A cost-effective solution.

Cons:

- In some vehicles, it is observed that the plates are located in the depressed portion of the trunk/bumper, where there would be no room to slide in the clip.
- Requires room on the back side of the plate also.
- Chances of dislocation from the specified location over the period of time.
- Most of the license plates have frame around the edge of the plate, making it difficult to apply the clip.

Option 6. Decal slides which Slides-in an Adhesive-Backed Holder (Pocket) Fixed on the License Plate

Pros:

+ Assured positioning, as the decal will slide in from the top; rest two sides and bottom will hold it.
+ A single vendor can supply the whole assembly (3M).
+ Infinite attaching and detaching (sliding-in and sliding-out).

Cons:

- While sliding the decal, chance of peeling off retro reflective sheeting.
- Dust and dirt may deposit in the trails and the base, which may be tough to clean.
- Holder should be large enough allowing visibility in the display window.
- May need to provide more than one holder (pocket) in case if a GDL holder needs to use marker in more than one vehicle.
- Decal may slide-out from holder when subjected to heavy flow of water/wind such as car wash, Front license plate will be often subjected to these situations.

Summary of Review

Several of the options appear to have fatal flaws that preclude them further analysis and testing. These include:

Option 1. Reusable Adhesive Backing

Based on vendor discussions, reusable adhesive does not appear to have the durability required for this application. Frequent removal and reapplication will result in rapid deterioration of the adhesive surface, especially when the plate is wet or dirty. This option places responsibility on the user for keeping the surface protected and making sure that the plate is clean for each application. It is not realistic to expect most users to do this.

Option 4. Magnetically Receptive Material Mounted using Plate Mounting Screws with Magnet-Backed Marker

While options 3, 4, and 6 do not appear to have immediate fatal flaws testing materials are not readily available for these options. The consultant team is continuing to pursue manufacturers to determine whether these materials can be obtained. Options 3 and 4 are similar in that they use magnetically receptive tags; they differ only in the way the backing is applied to the license plate. The real goal of options 3 and 4 is to test the feasibility of a magnetic tag. Since it will be easier to obtain the adhesive backing proposed under option 3, we recommend that option 4 be dropped and option 3 be pursued.

Option 5. A Clip that Slides Onto the Side of the License Plate

In some vehicles, it is observed that the plates are located in the depressed portion of the trunk/bumper, where there would be no room to slide in the clip. Room is required on the back side of the plate also. A priority is to avoid using more than one technology.

APPENDIX D – INITIAL PROPOSAL FOR TESTING AND EVALUATION STRATEGIES

	Testing Strategy	Specific Steps
Size and Location	• Field test.	• Obtain sticker samples. • Apply to license plates. • Observe whether sticker is proper size and fits in preferred location.
Background Color	• Review specifications and manufacturer test results.	
Visibility	• Field test.	• Establish visibility requirement – NJSP. • Place stickers on vehicles. • Static observation of distance visibility during daytime and nighttime conditions. • Follow vehicles at various distances and conditions and record observations. • Follow moving vehicles to determine sight distance. Conduct tests during daytime and nighttime conditions and if possible during rainy/wet weather. Test on both freeway and arterial roadways. Estimate of sight distance is adequate.
Durability	• Review specifications adequate to determine durability of sticker.	
	• Field Test.	• Place on vehicles and conduct qualitative assessment of attachment device after test period.
	• Laboratory tests.	• Conduct laboratory test for vibration and moisture/dirt exposure.
Attachment	• Review specifications for attachment properties.	• Specifications should be adequate for hook-and-loop fasteners. May not be for other technologies.
	• Laboratory tests for attachment properties.	• Shear and peel tests conducted in laboratory.
	• Field test.	• Observe attachment after each use and document movement. Subject to car wash and various types of weather as schedule allows.
Environment	• Specifications adequate to determine environmental impacts.	

APPENDIX E – COLORS CONSIDERED FOR GDL STICKER

Colors Used During Field Test

APPENDIX F – SAMPLE FIELD TEST INSTRUCTIONS AND OBSERVATION SHEET

NJDOT GDL Marker – Field Test Instructions

Hook-and-Loop (Velcro-Type) Fasteners:

- Hook-and-loop fasteners come in two pieces. One is a base that attaches to the plate; the other contains the GDL sticker.
- Initial attachment:
  - The marker should be attached in the upper right hand corner of the plate. It should not obscure any of the lettering or numbering on the plate.
  - The area of the plate where the sticker will be attached should be thoroughly cleaned and dried before attachment.
  - The base of the tag has an adhesive surface on one side and a fastener (Velcro - type surface on the other). Peel the cover off the adhesive surface and press the base on to the license plate. Make sure base is aligned properly and press down with fingers.
  - GDL marker will have a sticker on one side and fastener (Velcro-type) surface on the other. Attach fastener surface to base. Make sure tag is centered on the base and press down evenly across tag with fingers. Apply pressure evenly across tag but do not use excessive pressure.
- Detach and reattach GDL tag after each trip – leave base on license plate.
- Observe tag condition and fill out form after each attachment/reattachment, noting weather conditions, attachment conditions and any peeling of sticker off the tag.
- Take vehicle through car wash at least once during test period.
- Attach tag here.

APPENDIX G – SAMPLE FIELD TEST SHEET

Date	Weather/Conditions	Primary Type of Road on Trip	Attachment
	D = Dry **W =** Wet **H =** Heavy rain/t-storm **C =** Car wash	**F =** Fwy or turnpike **A =** Major arterial **S =** Local street **M =** Mix	**OK =**No problem **S =** Sliding side to side or up and down **L =** Loose **C =** Difficult to detach/sticking **PL** = Base sticker peeling from license plate **PT** = GDL sticker peeling **O =** Other (describe)

APPENDIX H – DETAILED SUMMARIES OF FIELD TEST

Problems Identified with Hook-and-Loop Fasteners

Type	Date	Weather and Conditions **D =** Dry **W =** Wet **H=** Heavy rain/t-storm **C =** Car wash	Primary Type of Road on Trip **F =** Fwy or turnpike **A=** Major arterial **S =** Local street **M =** Mix	Attachment **OK =**No problem **S =** Sliding side to side or up and down **L =** Loose **C =** Difficult to detach/sticking **PL=** Base sticker peeling from license plate **PT =** GDL sticker peeling **O =** Other (describe)
Dual Lock Clear	10/11/2008	D	A	Placed GDL tag in a cup of warm soap water. Tag deteriorated. Able to peal face of tag off. Tag fell in dirt, got stepped on. Velcro filled with dirt, could not stick. Washed and would able to stick once dirt removed.
Dual Lock Black	10/8/2008	D	A	Installed without cleaning. Tag was one 1/2 plate and 1/2 frame.
Dual Lock Black	10/10/2008	D	A	Could not attach on plate due to wrap around plate frame. Tag was on 1/2 plate and 1/2 frame. Came off when attempted to remove Velcro front.
Dual Lock Black	10/11/2008	D		Placed GDL tag in a cup of warm soap water. Tag deteriorated. GDL letters rubbed off.
Dual Lock Clear				It would be a good idea if we could attach the tag to a keychain with Velcro (So it won't get lost). The sticker remained in good condition through the test period and was actually difficult to remove today.
Dual Lock Black	10/8/2008	D	A	Installed without cleaning. Tag was 1/2 plate and 1/2 frame.
Dual Lock Black	10/9/2008			Able to remove/replace no problem.
Dual Lock Black	10/10/2008	D	A	Tag was on 1/2 plate and 1/2 frame. Tag and backing came off.
Dual Lock Black	10/11/2008	D	A	Placed GDL tag in a cup of warm soap water. Tag deteriorated. Able to peal face of tag off. See Attached. Tag fell in dirt, got stepped on. Velcro filled with dirt, could not stick. Washed and would able to stick once dirt removed.
Dual Lock Black	10/8/2008	D	S	C

Type	Date	Weather and Conditions **D =** Dry **W =** Wet **H=** Heavy rain/t-storm **C =** Car wash	Primary Type of Road on Trip **F =** Fwy or turnpike **A=** Major arterial **S =** Local street **M =** Mix	Attachment **OK =**No problem **S =** Sliding side to side or up and down **L =** Loose **C =** Difficult to detach/sticking **PL=** Base sticker peeling from license plate **PT =** GDL sticker peeling **O =** Other (describe)
Dual Lock Black	10/9/2008	D	S	C
Dual Lock Black	10/14/2008	D	S	Removed base from plate (very difficult).
Dual Lock Black	8-Oct	D	S	Had questions about application of decal.
Dual Lock Clear	10/13/2008	D	F/M	Sticker Split down middle.
Dual Lock Clear	10/14/2008	D	F/M	Sticker Split down middle.
Dual Lock Clear	10/15/2008	D	M/F	Sticker Split down middle.
Dual Lock Clear	10/15/2008	D	F/M	To car wash – decal stayed on vehicle.
Dual Lock Clear	10/15/2008	D	S	Ok except for split middle of decal.

Problems Identified with Magnetic Fasteners

Type	Date	Weather/Conditions **D =** Dry **W =** Wet **H=** Heavy rain/t-storm **C =** Car wash	Primary Type of Road on Trip **F =** Fwy or turnpike **A=** Major arterial **S =** Local street **M =** Mix	Attachment **OK =** No problem **S =** Sliding side to side or up and down **L =** Loose **C =** Difficult to detach/sticking **PL=** Base sticker peeling from license plate **PT** = GDL sticker peeling **O =** Other (describe)
Magnet Flexible	10/9/2008	W	M	Lost part on way to car. Perhaps a magnetic holder on keychain since there is nowhere to place a removable piece.
Magnet Flexible	10/10/2008	D	M Interstate @ 70 + mph	S to the right. Hitting protruding bolt.
Magnet Flexible				Placed in Freezer and bent it – broke in half.
Magnet Rigid	10/11/2008	D	A	Placed GDL tag in a cup of warm soap water. No issues. Tag fell in dirt, got stepped on. Did not filled with dirt, could stick.
Magnet Rigid	10/12/2008	D	A	Twisted tag about 20 times. It broke in half. Was able to use in bits. Able to remove/replace no problem.
Magnet Rigid	10/13/2008	D	A	Able to remove/replace no problem. (Bits and Pieces)
Magnet Rigid	10/14/2008	D	A	Able to remove/replace no problem. (Bits and Pieces)
Magnet Rigid	10/15/2008	D	A	Able to remove/replace no problem. (Bits and Pieces)
Magnet Flexible	10/11/2008	D	M	L+S Cleaned and seemed OK
Magnet Flexible	10/11/2008	D	S	S
Magnet Flexible	10/15/2008	D	M	S, L

Problems with GDL Stickers

Type	Date	Weather/Conditions **D =** Dry **W =** Wet **H=** Heavy rain/t-storm **C =** Car wash	Primary Type of Road on Trip **F =** Fwy or turnpike **A=** Major arterial **S =** Local street **M =** Mix	Attachment **OK =**No problem **S =** Sliding side to side or up and down **L =** Loose **C =** Difficult to detach/sticking **PL=** Base sticker peeling from license plate **PT =** GDL sticker peeling **O =** Other (describe)
Dual Lock Clear	10/11/2008	D	A	Placed GDL tag in a cup of warm soap water. Tag deteriorated. Able to peal face of tag off. Tag fell in dirt, got stepped on. Velcro filled with dirt, could not stick. Washed and would able to stick once dirt removed.
Dual Lock Black	10/11/2008	D		Placed GDL tag in a cup of warm soap water. Tag deteriorated. GDL letters rubbed off.
Dual Lock Black	10/11/2008	D	A	Placed GDL tag in a cup of warm soap water. Tag deteriorated. Able to peal face of tag off. See Attached. Tag fell in dirt, got stepped on. Velcro filled with dirt, could not stick. Washed and would able to stick once dirt removed.
Dual Lock Black	10/8/2008	D	S	Had questions about application of decal.
Dual Lock Clear	10/13/2008	D	F/M	Sticker Split down middle.
Dual Lock Clear	10/14/2008	D	F/M	Sticker Split down middle.
Dual Lock Clear	10/15/2008	D	M/F	Sticker Split down middle.
Dual Lock Clear	10/15/2008	D	S	OK except for split middle of decal.

APPENDIX I – FOCUS GROUP AGENDA

AGENDA
NEW JERSEY GRADUATED DRIVER LICENSE MARKER FOCUS GROUP
OCTOBER 24, 2008

1:00 – 1:15 pm **Welcome and Introductions**

- Bernardo Kleiner, Cambridge Systematics

1:15-1:30 pm **Background and Overview**

- Pam Fisher, New Jersey Division of Highway Traffic Safety

1:30-1:45 pm **Presentation of Sample Markers**

- Hugh Louch, Cambridge Systematics

1:45-2:15 pm **Question and Answer Session**

- Bernardo Kleiner and Participants

  - *Do law enforcement officers in New Jersey know the provisions in New Jersey's GDL law?*
  - *If no, what can be done to improve this situation (training, tip card, roll call video, etc.)?*
  - *Are officers reluctant to stop and cite an underage person? If yes, why?*
  - *Will this program encourage officers to stop and cite more novice drivers for GDL violations? If yes, why? If no, why?*

2:15-3:00 pm **Road Test/Distribution Plan**

- Participants

3:00-3:45 pm **Report Out and Question and Answer Session**

- Bernardo Kleiner & Participant Volunteers

  Following their presentations, the following questions will be asked:

  - *Which location is the best for the marker in terms of visibility (front license plate or rear license plate)?*
  - *Should the color be changed?*
  - *What other changes should be made to make it easier for the officer to know if the driver is operating under GDL restrictions?*
  - *What driver actions would prompt an officer to look more closely at a vehicle?*

- *Will the program work in terms of the following:*
  - ◊ *Additional citations for GDL violations?*
  - ◊ *Improve novice driver behavior?*
  - ◊ *Reduce young driver fatalities and serious injuries?*
  - ◊ *If no, why will the program not work and how can it be improved?*

3:45-4:00 pm **Conclusion and Wrap Up**

- Pam Fisher

APPENDIX J – DRAFT FUNCTIONAL SPECIFICATION

Specifications for GDL Retroreflective Sheeting

1.1 DEFINITIONS[1]

1.1.1 RETRO-REFLECTIVE SHEETING

Retro-reflective sheeting or reflective sheeting shall be shall be silver - white, or colored, flexible, weather resistant material, and shall have a smooth, uniform retro-reflective outer surface.

A preassembled thin film that consists of a continuous layer of small retro-reflective elements close to the transparent surface.

For this application the sheeting shall conform to the following:

Retro-reflective sheeting shall consist of spherical lens elements adhered to a synthetic resin and enclosed by flexible, transparent sheeting having a smooth, flat outer surface. It shall conform to the reflectance requirements of Table 1.

1.1.2 RETRO-REFLECTION

Retro-reflection is defined as the reflection in which radiation is returned in directions close to the direction from which it came; this property being maintained over wide variations of the direction of the incident radiation.

1.1.3 RETRO-REFLECTIVE ELEMENT

One optical unit which by refraction or reflection or both, produces the phenomenon of retro-reflection.

1.1.4 ENTRANCE ANGLE

An entrance angle is the angle between the reference axis of the retro-reflector and the axis of the incident light (illumination axis).

1.1.5 OBSERVATION ANGLE

An observation angle is the angle between the observation axis and the axis of the incident light.

1.2 GENERAL CHARACTERISTICS

Specifications for the manufacture of retro-reflective stickers required for the GDL identifier are presented herein. There shall be a retro-reflective solid color sticker pasted on each identifier. The retro-reflective sticker shall be made of weather-resistant reflective sheeting having a smooth flat outer surface consisting of lens elements enclosed within a transparent plastic. The sheeting shall have pre-coated pressure-sensitive adhesive on the back side, protected by a

[1] *"Request for Proposal 07-X-39093 For: Sheeting, Reflective for DOT / DOC",* the State of New Jersey Department of Treasury, Division of Purchase and Property, January 12, 2007

removable liner, for convenient and durable attachment to the back of identifier's separable portion.

The reflective sheeting shall be free from ragged edges, cracks and blisters, and shall be readily cut without cracking or flaking. All sheets shall be free of foreign matter.

The pre-coated adhesive on all stickers shall be of a pressure-sensitive type which shall permit the sticker to be applied to the flexible decal and adhere with a uniform bond over the entire contact surface and must not curl, wrinkle, fade, discolor, delaminate, or change dimensions after environmental exposure over the service period of 24 months and 1000 attachments and detachments. The adhesive shall withstand drying oven temperatures of one hundred fifty degrees Fahrenheit (150°F) to at least three hundred fifty degrees Fahrenheit (350°F) without melting or running and shall not exude from edges of sheeting to cause stacked sheets or processed stickers to stick together during manufacture and distribution.

Stickers applied in accordance with instructions shall not blister, lift, or delaminate when subjected to gasoline, kerosene, diesel oils, water, steam, and cleaning detergents normally encountered in cleaning and washing service, nor shall stickers fade, disintegrate, or come off from extended exposure within a period of five years.

The dimensions of each sticker shall be one and one-half inches in width and one inch in height.

1.3 SCOPE OF WORK[2]

As stated herein, the terms reflective sheeting and retro-reflective sheeting are synonyms. Retro-reflective sheeting shall conform to ASTM D 4956 based upon results obtained.

1.3.1. General Requirements

a. Retro reflectance. All retro-reflective sheeting shall have the minimum coefficient of retro-reflection (Ra) in conformance with ASTM D 4956.

b. Color. The color of the retro-reflective sheeting, except for fluorescent colors shall conform to the color requirements of ASTM D 4956.

c. Fluorescent Colors. The daytime fluorescent color of retro-reflective sheeting shall be determined according to ASTM E 991.

In addition, the color shall be equally distinguished in daylight and at night under artificial headlight illumination. The color shall have a consistent chromaticity across all signs of the same color. Noticeable deviation from the shades that would affect the required performance shall be a cause for rejection of any sheeting or completed sign at any time before acceptance.

d. Product Performance Requirements. The performance requirements shall be such that there is no loss of retro-reflectivity; no loss of colorfastness; no cracking; and no other conditions inherent to the sheeting including inks and overlay film that causes it to be incapable of performing as required.

[2] *"Request for Proposal 07-X-39093 For: Sheeting, Reflective for DOT / DOC",* the State of New Jersey Department of Treasury, Division of Purchase and Property, January 12, 2007

1.4 SAMPLING AND TESTING[3]

The material will be tested on all of the following points, in conformance with ASTM designation D4956-01A, Section 7 - test methods.
Reflective sheeting shall conform to ASTM D4956 4.2.9

1.4.1. Photometry
1.4.2. Color
1.4.3. Adhesive
1.4.4. Film
1.4.5. Durability
1.4.6. General characteristics and packaging

1.4.1. Photometry

1.4.1.1. RETRO REFLECTANCE
Retro-reflective sheeting shall meet the minimum specific intensity per unit area (SIA) requirements of Table 1. The (SIA) shall be expressed as candela per foot-candle per square foot of sheeting. The measurements shall be conducted in accordance with the federal test method standard 370, photometric measurements of retro-reflective materials and retro-reflective devices of ASTM E810 standard test method for coefficient of retro reflectance.

1.4.1.2. RAINFALL PERFORMANCE
The SIA values of the retro-reflective sheeting totally wet by rain shall not be less than 90 percent of the values shown in Table 1. The measurements shall be conducted in accordance with AASHTO M 268.

1.4.1.3. SPECULAR GLOSS
The retro-reflective sheeting shall have an 85 degree specular gloss of not less than 40 when tested in accordance with ASTM D 523.

1.4.1.4. SHRINKAGE
Following the liner removal, the retro-reflective sheeting specimen shall not shrink in any direction more than 1/32 inch in ten minutes and 1/8 inch in 24 hours. The test shall be conducted on a 9 by 9-inch conditioned (72 degrees F 50 percent relative humidity for 24 hours) specimen with the liner, according to ASSHTO M268.

[3] *"Request for Proposal 07-X-39093 For: Sheeting, Reflective for DOT / DOC",* the State of New Jersey Department of Treasury, Division of Purchase and Property, January 12, 2007

Table 1 RETRO REFLECTANCE REQUIREMENTS MINIMUM SIA (SPECIFIC INTENSITY PER UNIT AREA), CD/F-C/FT

Color	Silver/ White	Yellow	Orange	Green	Red	Blue	Brown
Observation Angles, Degrees	0.2-0.5	0.2-0.5	0.2-.05	0.2-0.5	0.2-0.5	0.2-0.5	0.2-0.5
Entrance Angle							
-4 Degrees	70-30	50-25	25-13.5	9-4.5	14.5-7.5	4-2	0.6-0.25
15 Degrees	45-22	35-18	14-8	6-3.2	9.5-5	2.8-1.3	0.6-0.25
30 Degrees	30-15	22-13	5-4	3.5-2.2	6-3	1.7-0.8	0.3-0.2
45 Degrees	7.5-5	7.5-4	1-0.8	1-1	2-1	0.5-0.2	0.3-0.2

1.4.2. Color

The color of the retro-reflective sheeting shall be Lime Green & as per the MUTCD Section 2a-11. Colors shall conform to the AASHTO manual for signing and pavement marking of the national system of interstate and defense highways. Colors shall be visually determined according to ASTM D 1535 by comparison with the FHWA Interstate Highway Color Tolerance Charts using the Munsell notations. When directed by the engineer, the manufacturer shall provide results of the instrumental test using color coordinates as described in AASHTO-M-268.

In addition, the color shall be equally distinguishable in daylight and at night under artificial headlight lumination. The color shall have a consistent chromaticity across all signs of the same color. Noticeable deviation from the shades that would affect the required performance shall be a cause for rejection of any sheeting or completed sign at any time before acceptance.

1.4.3. Adhesive

The retro-reflective sheeting shall be pre-coated with a pressure sensitive adhesive backing shall be applied to properly prepared surfaces without the necessity of additional adhesive coats on the retro-reflective sheeting or application surface.

The protective liner attached to the adhesive shall be easily removed by peeling, without soaking in water or other solutions, and shall not break, tear, or remove adhesive from the backing. The liner shall be easily removed following accelerated storage for four (4) hours at 160 degrees F under a pressure of 2.5 pounds per square inch. The specimens shall be tested according to AASHTO M 268, Section 7.7.

Additionally, retro-reflective sheeting shall show no sign of cracking or de-lamination when subjected to the impact resistance test described in AASHTO M 268.

1.4.4. Film

No specifications available

1.4.5. Durability

1.4.5.1. ACCELERATED WEATHERING

When processed and applied in accordance with the recommended procedures, the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discoloration, cracking, scaling, crazing, blistering, edge lifting, curling or dimensional change. The sheeting shall be certified by the manufacturer to retain not less than the 65 percent of the minimum coefficient of retro-reflection specified in Table 1 at 1000 hours, when exposed to xenon arc weatherometer in accordance with ASTM G 23, Type E or EH weatherometer with the humidifier off.

1.4.5.2. COLORFASTNESS

One of the accelerated weathered specimens shall be tested for colorfastness. The specimen shall be wetted with a mild detergent and water solution and then compared with a similarly tested unexposed specimen under natural sky (north sky) daylight or artificial light having a color temperature of 7,500 K. The colorfastness shall be evaluated as follows:

Excellent: No appreciable change in color.
Good : Perceptible but no appreciable change in color.
Fair : Appreciable change in color.

Appreciable change in color is defined as the change that is immediately noticeable in comparison with the exposed specimen. The retro-reflective sheeting to be used must have either a "good" or an "excellent" rating.

1.4.5.3. FLEXIBILITY

The retroreflective sheeting shall have sufficient strength and flexibility so that it can be handled, processed, and applied according to the recommendations of the sheeting manufacturer without appreciable stretching, tearing, or other damage.

When tested in according to FED-STD-141C NOT 2, Methods 6224 and 6115, the retro-reflective sheeting, with the liner removed, shall have a tensile strength of not less than 5 pounds per inch of width. Elongation shall not be less than ten percent. The machine speed shall be 1 foot per minute.

Following liner removal, the retro-reflective sheeting shall be sufficiently flexible to show no cracking when slowly bent in a time of one second around a 1/8-inch mandrel with the adhesive contacting the mandrel.

The retro-reflective sheeting for cones, drums, and delineator guide post shall conform to the above except that after being conditioned for 24 hours at 53 degrees F, the sheeting shall be sufficiently flexible to show no cracking when slowly bent in one second's time around a 1/8 inch mandrel with adhesive contacting the mandrel.

1.4.5.4. SHRINKAGE

Following the liner removal, the retro-reflective sheeting specimen shall not shrink in any direction more than 1/32 inch in ten minutes and 1/8 inch in 24 hours. The test shall be

conducted on a 9 by 9-inch conditioned (72 degrees F 50 percent relative humidity for 24 hours) specimen with the liner, according to ASSHTO M268.

1.4.6. General characteristics and packaging

The sticker shall be manufactured in manner that insures that it shall not become brittle, flaky, discolored, or acquire a powdery surface for a period of at least five years and that permits the stacking of at least five stickers.

The adhesive protective liner may have a scalloped scoreline or a straight scoreline at or near the center of each sticker for easy removal.

The sticker under normal service use shall adhere to the back of identifier's separable portion and, when stacked up to five stickers high, shall adhere to the liner to which it is applied for a minimum of five years.

Specifications for Reclosable Fastener

(A) The fastener should consist of continuous polyolefin strips with polyolefin stems having a mushroom shaped top. The mushroom head should allow the fasteners to easily slide over each other allowing positioning of parts before they are snapped together creating a firm fastening attachment.

(B) The type of this fastener should refer approximately 250 stems per square inch. Peeling the pieces apart to disengage should be simple to do by hand.

(C) Corners of the fastener should be rounded, it can reduce the possibility of edge lifting or catching that may cause the fastener to be torn from the substrate, while improving the overall appearance.

(D) Solvent Resistance: The polypropylene backing, stems with mushroom top should resist attack by most common solvents and alkaline solutions. Tests should be conducted by the manufacturer to evaluate the solvents and exposure time expected for the actual application.

(E) Environmental Effects: Temperatures between -20°F (-29°C) and 200°F (93°C) should have minimal affect on closure strength.

(F) Water (Humidity) Resistance: Closure strength should not be affected by prolonged exposure to water or humidity. Once bonded the adhesive should have high resistance to moisture under typical use conditions.

(G) Car Washing and Cleaning: The adhesive present on these fastener products may make them should be suitable to car washing liquids and chemicals.

(H) Attachment Technique: The fastener should have pressure-sensitive adhesive on the backing. The pressure-sensitive adhesive should bond to the substrate on contact and parts can be handled immediately. Adhesive bond strength should increase with time, pressure, and temperature.

(I) Fastener should have conformable acrylic foam adhesive, providing good contact with substrates. The adhesive should be protected with a silicone treated liner allowing easy removal from the adhesive.

(J) The acrylic form adhesive should be well suited for applications exposed to high temperatures, and humidity.