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Evaluation of concrete median barrier delineation under poor visibility conditions

Kari A. French
West Virginia University

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**Evaluation of Concrete Median Barrier Delineation Under Poor
Visibility Conditions**

Kari A. French

**Thesis submitted to the
College of Engineering and Mineral Resources at
West Virginia University
In partial fulfillment of the requirements for the degree of**

**Master of Science
In
Civil and Environmental Engineering**

**David Martinelli, Ph.D., Chair
Darrell Dean, Ph.D.
Michael H. Dufalla, P.E.**

**Department of Civil and Environmental Engineering
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ABSTRACT

Evaluation of Concrete Median Barrier Delineation Under Poor Visibility Conditions

Kari A. French

A nationwide survey, durability test, and visibility test were conducted for concrete median barrier delineation. PENNDOT was encountering with delineators becoming detached due to harsh conditions in the roadside areas, as well as visibility problems in spot locations prone to fog. From the results of the research it was recommended that in areas prone to poor visibility conditions, PENNDOT consider decreasing the longitudinal spacing and providing delineation lower on the barrier than shown in the standards. With respect to the durability, in instances where the “peel-n-stick” delineators are comparable in price to obtaining the delineator and adhesive separately, that special consideration should be given to the “peel-n-stick” delineators. Their installation time was found to be less, and their durability was perfect over the one year period monitored. They should also be given special consideration in instances where traveler delay due to the traffic control set up to install the delineators is critical. Finally, the literature review revealed that the ultimate solution to delineation under poor visibility conditions is light-emitting delineation and should be considered as a long term solution.

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Chapter 1 Introduction

1.1 Introduction

Concrete median barrier delineators are reflective or light-emitting devices that are placed in series on a median barrier divider between opposing directions of traffic. The specific type of median barrier addressed in this research is the safety-shaped, also known as the F-shaped or “jersey” barrier. Delineation of these barriers is of interest to the Pennsylvania Department of Transportation (PENNDOT) because:

- (1) Due to durability problems caused by vandalism and the affects of adverse environmental conditions in the roadside area where they are mounted, this delineation causes a significant maintenance problem for the Department.
- (2) During poor visibility conditions, particularly fog and snow, there is a perceived increase in the frequency of side-swipe collisions with the barrier.
- (3) In response to the above-mentioned problems, different entities within PENNDOT have tried various delineation designs, without any scientific feedback on the effectiveness of the strategies.

In order to adequately evaluate the effectiveness of concrete median barrier delineation, particularly under poor visibility conditions, background information regarding this issue was required. A comprehensive literature review was conducted in order to understand delineation, the principles of retroreflectivity and visibility, and the effects of poor atmospheric conditions on visibility and the driving task. This review also focused on the deterioration and damage

incurred by the delineator due to its location in the roadside environment, which is generally very close to the traveling lanes. Finally, current research and issues in the area were identified.

In addition, a survey of standards and specifications for concrete median barrier delineation from other states was conducted. A survey was also conducted of PENNDOT personnel to determine strategies that they have tried in the past.

1.2 Summary of Results and Proposed Field Tests

There is an opportunity for updating the PENNDOT standard for concrete median barrier delineation to make it more effective in areas prone to poor visibility conditions. Field experiments that are proposed to this end and are as follows:

1. Test the effect of delineator configuration on driving performance under poor visibility conditions for barrier that is close to the traveling lane, as measured by driving performance indicated by speed.

Test Overview: Four 1500-foot to 1800-foot long test sections will be established on SR 40 just west of the crest of Summit Mountain near Uniontown, Pennsylvania. Two of the sections will be in the upgrade direction and the other two will be in the opposing lanes in the downgrade direction. Speed data will be collected at each test section under good visibility conditions to validate the suitability of the test sections and provide a baseline for driving performance in the area. During Phase I of the configuration testing, the following configurations will be tested:

- Delineator on top and side near the top – Current PENNDOT standard
- Delineator on top and side near the bottom

During Phase II of the configuration testing, the following configurations will be tested:

- Delineator on top and one on the side (either top or bottom, to be determined as a result of the Phase I testing)
- Delineator on top and three on the side

Speed measuring traffic counters will be placed in each section. Speed comparisons will be made. For each section, a test of statistical significance will be conducted between speed data collected (1) in the adjacent sections, (2) between the two configurations, and (3) between the speed data collected under poor visibility conditions and good visibility conditions.

2. Test the effect of delineator spacing on driving performance under poor visibility conditions for barrier that is close to the traveling lane, as measured by speed.

Test Overview: One of the above-mentioned delineator configurations will be selected to test the influence of spacing on driver performance. In both the upgrade and downgrade direction, one of the test sections will have the delineators spaced at the standard rate and the other will have spacing that is half the standard rate. Speed data

will be used as in (1) to determine the effect on driving performance. A test of statistical significance will be conducted between speed data in the two sections.

3. Measure the rate of delineator installation and survival for two mounting techniques: typical adhesives and adhesive used with Sun Labs adhesive.

Test Overview: The following three delineator applications will be tested to determine their installation and survival rate: (1) typical adhesive commonly used at PENNDOT, (2) a different, yet similar adhesive to the first type, (3) adhesive used with Sun Labs products having a butyl pad backing. Three test sections will be established, each section using a different application type. For each section, the rate of mounting and survival after one year will be measured. These will be used to perform a benefit-cost study of each application type. Each test section will contain approximately 17 delineators. Delineators will be mounted on the top and on the side near the bottom.

The outcomes of the testing will determine whether updates to the current standard should be proposed.

Chapter 2 Literature Review

2.1 Principles of Delineation and Traffic Control Devices

In this section, first some general principles of traffic control devices are reviewed and related to the specific function of delineation, particularly concrete median barrier delineation. Second, some of the documented principles and requirements specific to delineation are identified.

2.1.1 The General Principles of Traffic Control Devices

Delineators, in the most general sense, are traffic control devices. The purpose of traffic control devices is addressed in the Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2000),

The purpose of traffic control devices, as well as the principles for their use, is to promote highway safety and efficiency by providing for the orderly movement of all road users on streets and highways throughout the nation.

Traffic control devices notify road users of regulations and provide warning and guidance needed for the safe, uniform, and efficient operation of all elements of the traffic stream.

The primary purpose of delineators is to provide guidance information to assist the driver in following the roadway alignment. According to the Roadway Delineation Practices Handbook (Migletz, Fish and Graham, 1994), “delineation” is:

“any method of defining the roadway operating area for the driver...(and) is defined as one, or a combination of devices (excluding guide signs), that regulate, warn, or provide tracking information and guidance to the driver.”

The guidance provided by delineators is useful to the driver in particularly difficult driving circumstances, such as night-time driving, in adverse weather, and locations where the alignment might be confusing or unexpected. However, it is also useful and typically used for more general purposes, regardless of whether special circumstances exist. In the case of concrete median barrier delineation, it also marks the location of the median barrier, which can assist the driver in avoiding collisions with it. Because it is color coded to match the adjacent pavement marking it also provides some regulatory information.

According to MUTCD (FHWA, 2000), there are five fundamental requirements for traffic control devices to be effective. As traffic control devices, these are generally applicable to delineators and specifically concrete median barrier delineation. The requirements are as follows:

1. Fulfill a need.
2. Command attention.
3. Convey a clear, simple meaning.
4. Command respect of road users.
5. Give adequate time for response.

All of these requirements are important to concrete median barrier delineation. Relative to the first requirement, if there is no need for the delineation, then it is wasteful to place and maintain the devices in the field. Unlike other traffic control devices, where their unneeded use leads to violation and disrespect of that particular device and all devices in general, unneeded delineators are likely to be simply ignored by the driver and become a maintenance burden for the Department of Transportation.

Relative to the second requirement, the key to commanding attention is proper size and placement. The delineator must have an appropriate amount of reflective (or other means of emitting light) area to catch the drivers' attention. Furthermore, it must be located in the drivers' cone of vision. Finally, since concrete median barrier delineators are primarily reflectors mounted on the barrier for use during nighttime driving, they must also be located in cone of light emitted by the headlight. Note that as will be discussed later, the attention commanded by delineators is different than that commanded by other devices, such as signs, in that delineators convey information on a more subliminal level.

The third requirement can have implications for the layout of delineators at a fixed point along the highway. There are several known configurations of concrete median barrier delineation either currently or previously in use. For example, a reflector may or may not be placed on top of the barrier. Zero, one, two, or even three or more reflectors can be placed on the sides of the barrier. The configuration of a series of delineators along a route may be uniform, alternating, or varying in some other way. In the case of concrete median barrier delineation, the delineation must convey the alignment of the roadway, and also to a certain extent, it must convey the location of the barrier to allow the driver to identify it.

The concept of commanding respect is generally tied to other traffic control devices, most typically warning signs. For example, setting up work zone traffic control devices when there is no work being performed degrades driver respect for work zone traffic control the next time it is encountered. One problem caused by the lack of respect for concrete median barrier delineation is vandalism of top-mounted reflectors.

Adequate time for response to concrete median barrier delineation is directly tied to spacing of the delineators, and indirectly tied to the configuration, type, and size of the delineators. This is particularly important during adverse environmental conditions, when the driver may be depending solely on the delineation for guidance information. If the spacing is too large, the driver may lose sight of the delineation for a period of time, causing them to deviate from the proper driving path. The spacing required is a direct function of the visibility of the delineators. The greater the visibility of the delineation, the larger the spacing that can be accommodated.

The Policy on Geometric Design of Highways and Streets (AASHTO, 2001) also briefly addresses the needs for delineation. In the discussion on “Signing and Marking”, AASHTO identifies delineators as a “marking”, noting:

“Where removal (of physical obstructions near the roadway) is impractical, such objects should be adequately marked by painting or by use of other high-visibility material...Post-mounted delineators are (a) type of marking device used to guide traffic, particularly at night. Reflector units are installed at certain heights and spacings to delineate the roadway where alignment changes may be confusing and not clearly defined.”

This discussion reinforces the role of delineators in guiding traffic. Although the MUTCD is hesitant to accept the role of delineation in marking a hazard, the AASHTO publication does mention this function.

Furthermore, delineators are classified as a specific type of traffic control device in the MUTCD (FHWA, 2000), namely a “marking.” According to the MUTCD (FHWA, 2000), the function of a marking is to provide “guidance and information for the road user ... while allowing minimal diversion of attention from the roadway.”

Again, this is a reinforcement of the role of the delineator in guiding traffic. It also raises an important point to be made about the way in which delineators must accomplish this function. Its role is generally supplementary. It must provide information to aid the driver without becoming a primary focus.

2.1.2 Principles Specific to Delineators

The MUTCD (FHWA, 2000) also has a specific section devoted to delineation. This section provides more specific guidance on the function and application of delineation. The key points relevant to concrete median barrier delineation:

- Delineators are retroreflective devices, primarily used as an aid in nighttime driving and during adverse weather. It was noted that the 1988 version of the MUTCD did not mention aiding drivers during adverse weather. This was newly added for the 2000 edition.
- They are mounted above the roadway surface and along the side of the roadway in a series to

indicate roadway alignment, and as such are considered guidance devices rather than warning devices.

- An important advantage of delineators is that they remain visible when the roadway is wet or snow-covered. (FHWA, 1988) This clause was removed between the 1988 and 2000 editions of the MUTCD.

Six key requirements of delineators relevant to concrete median barrier delineation were also noted (FHWA, 2000):

1. Delineators shall consist of reflector units capable of clearly reflecting light under normal atmospheric conditions from a distance of 1000 feet when illuminated by the upper beam of standard automobile lights.
2. Reflective elements for delineators shall have a minimum dimension of 3 inches
3. The color of delineators shall, in all cases, conform to the color of edgelines.
4. The top of the highest retroreflector is 4 feet above the near roadway edge.
5. They should be in line with a roadside barrier that is 8 feet or less outside the outer edge of the shoulder.
6. The closest delineator spacing recommended for any condition (curvature, facility type, etc.) was 20 feet, corresponding to a 50-foot radius curve.

The MUTCD (FHWA, 2000) also provides general delineation requirements for horizontal curves, freeways and expressways and their interchanges and truck escape ramps.

Delineators should be spaced 200 to 530 feet apart on mainline tangent sections, 100 feet apart on ramp tangent sections, and 20 to 90 feet in curved sections, depending on the curvature.

There was no guidance specific to either (1) concrete barrier delineation or (2) delineation during adverse weather conditions.

2.2 Key Components of Delineation

In this section, some of the key principles related to delineation design are presented. Section 2.2.1 presents definitions of some of the key variables in delineation design. Sections 2.2.2 and 2.2.3 present the important principles of retroreflectivity and visibility as they relate to delineation. Section 2.2.4 discusses the driving task, and in particular the portions relying on delineation. Section 2.2.5 concludes this section with an investigation of the environmental conditions present in the roadside area that have an impact on delineator performance and life.

2.2.1 Elements of Delineation Design

This purpose of this subsection is to briefly define the key variables in delineation design and layout.

Size - This is the size of the delineator, which may or may not be the size of the reflective area if it does not cover the entire delineator.

Spacing- The distance between delineators, measured longitudinally along the roadway.

Reflective Area - The area containing the retroreflective sheeting or element.

Configuration - How delineators are positioned on a transverse cross-section of the barrier.

Delineators are typically positioned either on the top only, side only, or both top and side. There can be several rows on the side.

Mounting - How the delineators are fixed to the barrier, usually through bolting or gluing.

2.2.2 Retroreflection

Except for the few delineators that emit light, delineators function by reflecting light from vehicle headlamps back to the driver. Thus, the reflectivity properties of delineators are crucial to their operations. Delineators, like most traffic control devices that use reflected light for nighttime visibility, are retroreflective. Retroreflection is defined as the ability of a surface to reflect incoming, or incident, light predominately in the direction of the source (Migletz, Fish and Graham, 1994). In the context of driving, this means that the light from the vehicle headlamps is redirected back towards the vehicle, thus making the delineator visible to the driver.

Retroreflection is unlike the reflection of light off a mirrored surface, which directs light at an angle that is equal and opposite to the direction of its source. The perfect retroreflector reflects light in the exact reverse direction of the light incident upon it, which in highway applications would be directly back at the headlamps. Thus, drivers would not be able to see a perfect retroreflector because none of the light would be directed towards their eye. In highway use, however, retroreflectors are not perfect. Some of the light is absorbed by the reflector, and the remainder of the light is scattered in all directions predominately in the direction of the source, in

this case the headlamps. In this way, some of the reflected light reaches the eye of the driver.

Figure I shows different types of reflection and Figure II shows the comparison of a perfect retroreflector to actual roadway retroreflector.

Figure I – Different Types of Reflection, (Migletz, Fish and Graham, 1994)

Figure II – Comparison of Perfect Retroreflectors to Roadway Retroreflector, (Migletz, Fish and Graham, 1994)

In this section, some of the principles related to retroreflectivity are explained, and the general classes of retroreflective sheeting are presented. Please note that the most common and significant retroreflective traffic control device is the sign. As such, much of the material presented in this section was detailed in work related to signs. However, with a few exceptions, the principles are transferable from one to other.

An understanding of the principles of retroreflectivity begins with an understanding of the terms and units of measurement related to light and retroreflectivity. Light, from vehicles headlamps, is measured in terms of candlepower (cp), or the metric candela (cd). Illuminance, measured in foot-candles (fc) or metric lux (lx) is a measure of the amount of light falling onto a surface. Once the light is reflected from the surface to the driver it is termed luminance. This is what the driver actually sees. Luminance is measured in candelas per square foot (cd/ft^2) or square meter (cd/m^2). Reflectivity is measured as the coefficient of retroreflected luminance, RL, which is defined as the ratio of the luminance of a surface to the normal illuminance on the

surface (Migletz, Fish and Graham, 1994). This is basically the amount of light leaving the retroreflective material per the amount of light striking it from the source. It is given the English units of candelas per foot-candle per square foot ($\text{cd}/\text{fc}/\text{ft}^2$) or the metric equivalent of candelas per lux per square meter ($\text{cd}/\text{lx}/\text{m}^2$).

The ability of a retroreflective material to direct light back to its source is also described by another property, its angularity. In the case of delineators, angularity is defined by the angle at which light is directed towards the delineator (known as the entrance angle) and the angle at which light is returned to the driver (known as the observation angle.) In terms related to the driving population, these are the angles at which the light from the headlight strikes the delineator perpendicular to its surface, entrance angle (ϕ), and the angle between the incoming light and the reflected light as it is seen by the motorist on its return from the delineator, observation angle (θ). The observation angle is a function of the difference in elevation between the driver's eye and the headlamp, while the entrance angle is a function of the horizontal distance between the delineator and the vehicle. See Figure III. A small change in the observation angle can have a large impact on the amount of light reflected back to the driver.

Figure III – Observation and Entrance Angles, (Migletz, Fish and Graham, 1994)

Retroreflective delineator materials return a spreading cone of light over a range of observation angles. As a vehicle approaches a delineator, the observation angle increases, thus narrowing the cone of light reflected to the driver. The light at the center of the cone is most intense and gradually dissipates as the distance from the source is increased. This spreading of the cone is what allows motorists at varying observation angles to see the retroreflected light.

Retroreflection for delineators is most commonly accomplished through the use of retroreflective sheeting. Most retroreflective sheeting is composed of either glass beads with a reflecting surface behind them or prismatic reflectors. Prismatic retroreflection is the result of internal reflection, as light enters it is reflected off the first surface to the rear surface which then reflects the light to the last surface and then back to the source. Figure IV shows a typical delineator with prismatic retroreflective sheeting. Figure V shows how prismatic retroreflectors reflect light.

Figure IV – Typical Delineator with Prismatic Sheeting

Figure V – How Prismatic Retroreflectors Reflect Light, (Migletz, Fish and Graham, 1994)

According to the ASTM Standards Specifications for Retroreflective Sheeting for Traffic Control, D 4956-95 there are six categories of retroreflective sheeting material that apply to delineators:

- Type I: A medium-intensity retroreflective sheeting referred to as "engineering grade" and typically enclosed lens glass-bead sheeting.
- Type II: A medium-high-intensity retroreflective sheeting sometimes referred to as "super-engineering grade" and typically enclosed lens glass-bead sheeting.
- Type III: A high-intensity retroreflective sheeting that is typically encapsulated glass-bead or prismatic retroreflective material.
- Type IV: A high-intensity retroreflective sheeting that is typically and unmetallized microprismatic retroreflective element material.

- Type V: A super-high-intensity retroreflective sheeting that is typically an abrasion-resistant metallized microprismatic retroreflective element material.
- Type VI: An elastomeric-high-intensity retroreflective sheeting without adhesives. This sheeting is typically a vinyl microprismatic retroreflective material.

PENNDOT also has two additional categories of retroreflective sheeting. They are the following types:

- Type VII: A super-high-intensity retroreflective sheeting sometimes referred to as "Diamond Grade" and typically a resin-filled prismatic retroreflective material.
- Type VIII: A fluorescent high-intensity retroreflective sheeting that is typically encapsulated glass-bead unmetallized microprismatic or resin-filled prismatic retroreflective material.

Since this research will not deal with reflective sheeting, this topic will not be covered in depth. However, a few facts about the sheeting, which may be pertinent, include:

- In general, the sheeting types are generally more reflective and more expensive as grade increases. For example, Type IV is seven times as bright as and four times the cost of Type I sheeting. (Moeur, 1999) Diamond Grade sheeting can be up to 14 times as bright as and five times the cost of Type I sheeting. (Moeur, 1999). The service life also increases slightly, from approximately seven years for Type I to ten years for Types IV and VI (Moeur, 1999). All grades can be and generally are used for signs. However, Types V and VI have special applications and Type VIII is an emerging issue given the recently approved applications of fluorescent-colored signs.

- PENNDOT currently specifies Type V sheeting for delineators. The typical use of Type V sheeting is in delineators and raised pavement markers, although it can also be used in signs (Moeur, 1999). Its service life is approximately 5 ½ years (Moeur, 1999). The 5 ½ year service life is not typically an important consideration, as other aspects of the delineator life cycle, such as vandalism or falling off the barrier typically dictate their service life. However, if these elements become neutralized, the service life of the reflective material would become an issue.
- Prismatic retroreflectors, which includes Type V, generally appear brighter than glass bead retroreflectors because prismatic retroreflectors gather and return light in a narrower beam (Wright, 1996).
- Microprismatic sheeting contains many units of “minute corner-cubed prisms per square inch that are embossed into a clear and durable sheeting material” according to the Traffic Engineering Handbook. (ITE, 1992)
- The properties of the retroreflective sheeting do not remain constant with time. There are many ways in which the sheeting can degrade and reduce the amount of light that is returned to the driver. The amount of exposure to solar radiation, high temperatures, abrasion from debris, and other forces of nature significantly reduce the service life of a delineator. The original quality of the sheeting has also been cited as a cause of degradation. These effects will be discussed in more detail in Section 1.2.5.

2.2.3 Visibility

In this section, some of theoretical aspects of visibility are reviewed, particularly as it relates to traffic control devices and adverse environmental conditions. The section concludes with some pertinent research findings related to visibility, delineation, and adverse environmental conditions that were found during the literature review.

Visibility Criteria

The criteria that determine the visibility of delineators are luminance, contrast, conspicuity and the prevailing weather and atmospheric conditions. Each will be discussed below.

As previously mentioned, luminance is the amount of light reflected from a surface, in this case, a delineator. The overall amount of delineator luminance is important, and a major contributor to whether the delineator can be comfortably seen. However, the distribution of luminances in the driver field of vision is of crucial importance for visibility.

There are many ways to define relative luminances, the most common procedure is to specify the ratio of two luminances that exist side by side. This ratio is known as contrast.

Contrast, in the context of delineation, is provided in the equation below:

$$C = \frac{L_D - L_B}{L_B}$$

where:

C = Contrast

L_D = Luminance of the delineator

L_B = Background luminance

Contrast determines how clearly an object stands out from its background and is therefore a better measure of a delineator's visibility than luminance. In general, the greater the contrast, the better the visibility. Note that contrast, and hence delineator visibility, can be negatively affected not only by a decrease in the luminance from the delineator, but also from an increase in the background luminance. As will be seen, in many cases this is the reason for visibility problems.

The concept of contrast can also be related to median barrier / road surface visibility. Because these are often constructed from the same or similar material having similar colors, the contrast between the median barrier and the road surface can be low. This situation exists during the daytime as well as the night, although the need for contrast decreases under daytime conditions.

Conspicuity is defined as the likelihood that a driver will notice a certain target at a given distance (Migletz, Fish and Graham, 1994). Unlike luminance and contrast, conspicuity is not easily determined and is dependent upon many factors, some of which are very unpredictable.

Generally speaking, however, it is probably the best measure of visibility. The factors that affect how conspicuous a traffic control device will appear to the driver are given below (McGee and Mace, 1987):

- Eccentricity
- Degree of expectation
- Visual complexity of the background area
- Size

Before a discussion of these items, note that the concept of conspicuity is not applied to delineators like other traffic control devices, such as signs. Part of function of delineation is to indicate the roadway alignment without being a distraction. The information provided by delineators should be accepted and processed on a more subliminal level than, for example, a stop sign, which requires specific driver decisions and responses. In short, delineators should clearly appear in the driver field of vision without attracting too much attention.

Eccentricity is a measure of how far away the driver's line of sight can be in order for the delineator to remain detectable. For near guidance information, it is logical to assume that the further the delineation is from the line of sight, the less likely it is that the delineator will be detected. However, since the field of vision converges towards the center, a certain amount of eccentricity is tolerable for far guidance purposes. As will be seen, some states have warrants for placing delineation on concrete median barrier that is based on the distance from the barrier to the traveling lane.

Driver expectancy is an important factor in determining how conspicuous a traffic control device will appear. If the driver is seeking the device, it will appear much more conspicuous. However, given the steady and repeating nature of delineation, the concept of expectancy is not applied like it might be for single device, such as a stop sign. Expectancy is important in delineation in that drivers following the path marked by it build up an expectance relative to its path. They expect that following the delineation path coincides with following the road. Missing delineators or other inappropriate changes in delineation design, particularly in curves, could cause problems.

Visual complexity is not easily understood or measured. However, it can have an extreme effect on the conspicuity of some traffic control devices. In situations where there is high complexity the traffic control device must compete with the distractions and visual clutter of its surroundings. Concrete median barrier delineators generally have only the median barrier and oncoming traffic for competition. While the median barrier provides a good background, oncoming traffic, particularly their headlamps, can have a significant affect on conspicuity.

The size of a delineator affects how much it stands out from its surroundings. A larger delineator will have more reflective area and will better compete with background clutter. However, it is interesting to note that in fog visibility research, it was determined that the visibility of a luminous source--an automobile tail light--was dependent on the intensity of the light and not size. (Institute of Transportation and Traffic Engineering, 1969) In contrast, in research on pavement markings, it was determined that a wider pavement marking of less brightness was as visible as a narrower marking of greater brightness (Hoffman and Firth, 1985).

Neither of these was concerned strictly with delineators, so neither is definitive on the topic. This is an issue worth pursuing specifically as it relates to the size of delineators under poor visibility conditions.

There is no numerical measure for conspicuity. Assessing it involves a qualitative evaluation of the above-mentioned factors. The most pertinent point related to conspicuity of delineators is that it can be controlled by adjusting the above-mentioned factors. However, it must be remembered that more conspicuity will not always lead to a better driving condition.

Visibility Under Adverse Environmental Conditions

It is well known that climate and weather conditions can contribute to the ineffectiveness of delineation because of degradation of visibility. Specific conditions that could have an adverse effect on the visibility of delineation are rain, snow, fog and particulate matter.

Rain

Rain can have a great impact on the visibility of a delineator. In general, rain reduces the driver's ability to see the surroundings, particularly if it accumulates on the windshield at a rate faster than it can be removed. At night, the combination of glare from oncoming headlights reflecting off the film of water on the road surface increases background luminance levels and erodes delineator contrast. Also retroreflectivity is lost due the film of water directly on the delineator and the dispersement of light as it comes in contact with the droplets of airborne

water. As the light beam hits the water particles, the light is dispersed and refracted, therefore shifting the light rays from the delineator in different directions. Very few light rays are reflected back to the driver. In addition, water lying on the delineator can affect the angle at which light enters and exits the delineator, which is a key to retroreflection. The increase in background luminance, coupled with the decrease in the delineator luminance, decreases the contrast of and the ability to see the delineator. As will be seen, the reduction in visibility during snow and fog conditions is also caused by the reduction in contrast. However, it is more dramatic in these situations.

Rain does not have a great impact on the durability of delineators. However, they are subject to splashing from wet highways, which may cover them with dirt or degrade their retroreflectivity. This will be discussed in Section 1.2.5.

Snow

The effect of snow on visibility is two-fold. First, all types of markings, concrete median barrier delineators included, can become snow-covered and thus not visible. The most susceptible marking to snow cover is the pavement marking. However, depending on the size and shape of the delineator and the intensity of the snowfall, delineators mounted on concrete median barrier can also become snow-covered. It would seem that the further the delineator sticks out from barrier, the less likely it would be to become covered by accumulating snow. However, this is not necessarily so, as snow can accumulate on vertical surfaces (delineator) without the need to build up from a horizontal surface (barrier).

Second, snow affects driver visibility. Visibility is most affected by the reflection of head lamp light off the snowflakes back towards the driver. This increases the background luminance relative to the delineator. As with rain, the increase in background luminance, coupled with the dramatic decrease in the delineator luminance, greatly decreases contrast of and the ability to see the delineator. The effect of an intense snowfall is more likely to effect visibility than an intense rain. Snowplowing activity and deicing salts also have a detrimental effect on the delineator. This will be discussed in Section 2.2.5

Generally speaking, rain and snow conditions both obliterate other markings providing guidance information faster than delineators. Pavement markings for example, can be obliterated in a matter of seconds under these conditions. During these times, delineators take on added importance in providing guidance information. There are times when the only traffic control device providing guidance information are delineators.

Fog

Fog also greatly reduces a driver's visibility. Fog is a ground level cloud composed of water droplets varying in diameter from 2 to 50 microns with concentrations between 20 and 500 droplets per cubic centimeter of air. Fog becomes denser in areas of high particulate matter, commonly referred to as smog.(FHWA, 1990) Research performed in the late 1970s indicated that driver performance is not seriously degraded until visibility drops below 600 feet in daylight. (Heiss, 1976).

As with rain, the light from the head lamps is reflected, refracted, and generally dispersed, making the amount of reflected light reaching the driver minimal. At the same time, because the water droplets are smaller and more concentrated, the dispersed light in the fog, particularly the light reflected back to the driver, greatly increases the background luminance relative to clear conditions. As with snow conditions, the increased background luminance coupled with reduced delineator luminance drastically reduces the delineator contrast making it difficult and many times impossible to see.

Particulate Matter

Particulate matter, such as dust or smoke, can be significant problems in different parts of the country, where dust or sand storms occur. Only limited research was found on this topic, but one source did document occurrences of zero (0) visibility during a dust storm. (Blackledge and Burritt, 1977) It is likely that these airborne particles differ from water droplets in their ability to reflect, refract, and disperse light. It is more likely that visibility problems under these conditions are caused by a masking of the roadway environment, with minor contributions from light dispersion. However, this statement is highly dependent on the constituency of the particulate matter and atmospheric conditions.

Particulate matter also has a damaging effect on the delineators, as they are subject to abrasion from the airborne particles. This will be discussed later Section 1.2.5.

Pertinent Research Findings

The following are miscellaneous findings related to visibility of delineators that were found during the literature review.

Driver Visibility Findings From by the Roadway Delineation Practices Handbook (Migletz, Fish and Graham, 1994):

- Drivers 65 and older may require four times as much light to see as well as a 39-year-old.
- Older drivers adopt less flexible searching strategies.
- Driver perception-reaction time continually increases with age.
- Recommendations were made to double the value of luminance contrast to account for older or impaired drivers.
- Two (2) seconds of preview time is required for short-range guidance and a minimum of three (3) seconds is required for long-range guidance. At 40 km/h (25 mi/h), delineation must be visible at least 34 m (110 ft) ahead; at 90 km/h (55 mi/h), delineation must be seen at least 76 m (250 ft) ahead.
- Optimal contrast levels and, therefore, the required reflectivity to allow for processing at a higher level must account for conditions (such as fog, rain, dew, glare) that could alter a minimum contrast achieved in clear, dry weather.

Driver Visibility Findings From Other Sources:

- There was evidence that after 11 months raised pavement markers (RPMs) retained operational effectiveness with respect to near delineation but that their effectiveness as a far delineator was degraded (Krammes and Tyer, 1991).

Note: RPMs are delineators much like concrete median barrier delineators. However, RPMs are subject to wear from traffic, whereas concrete median barrier delineators are not.

- New prismatic RPMs in clear weather had a threshold visibility distance of 243 m (790 ft) when dry and 198 m (660 ft) when wet. New prismatic RPMs in fog had a threshold visibility distance of 109.8 m (360 ft) when dry and 100.6 m (330 ft) when wet (Blaauw and Padmos, 1982).

Note: To a certain extent, this demonstrates visibility reduction of delineators under rain conditions.

- Traffic-worn RPMs in clear weather had a threshold visibility distance of 131.5 m (430 ft) when dry and 140.3 m (460 ft) when wet. Worn corner-cube RPMs in fog had a threshold visibility distance of 70.2 m (230 ft) when dry and 109.8 m (60 ft) when wet (Blaauw and Padmos, 1982).

Note: While not subject to wear directly from traffic, delineators are subject to the abrasive effects of airborne road debris such as anti-skid material for winter maintenance.

2.2.4 Driving Task

It has been stated that the primary function of delineation is providing guidance information. This section reviews a popular conceptual framework of the driving task, and focuses on information gathered and processed at the guidance level.

The information gathered and processed in driving a motor vehicle may be grouped into three levels (Allen, Lunenfield, and Alexander, 1971):

- Control
- Guidance
- Navigation

Control is related to the physical operation of the vehicle. Tasks such as steering and speed control fall into this category. The consequence of inability to execute at this level can lead to a crash. Guidance is a higher level of the driving task, as it combines the elements of controlling the vehicle to follow the appropriate path. For example, the ability to steer and control speed are applied to follow the road alignment, change lanes when necessary, select headways, execute desired turns, etc. Errors at this level can also lead to crashes. The highest level of the driving task is navigation. Navigation is related to planning and executing a trip. It involves knowing the route between the origin and the selected destination, and the ability to follow the appropriate path(s) through the highway network to successfully complete the trip. Driver errors at this level generally only lead to the driver losing their way and becoming lost. The basic relationship

between these levels is that the lower the level, the more critical it is to safe vehicle operation. This has a direct relationship on driver information processing. In cases where the driver is overloaded with information, the driver will process the information from the lower level in lieu of a higher level. A classic example is navigation information placed amidst confusing or difficult geometric conditions. The information needed to control or guide the vehicle will take precedence over the navigation information, and the navigation information may be missed, causing the driver to miss a route needed to reach the destination.

This review is specifically interested in the guidance level since this is the level at which delineation contributes information to the driver. The following is a more detailed explanation of the guidance level.

Guidance level of driver performance refers to the driver's task of selecting a safe speed and path on the highway. While performance at the control level is overt action, performance at the guidance level is a decision process. The driver must evaluate the immediate situation, make appropriate speed and path decisions, and translate these decisions into control actions needed to survive in the traffic stream. Activities include decisions to relating lane positioning, overtaking, and passing...(Alexander and Lunenfield, 1975)

The role of markings and delineators was specifically addressed relative to the guidance level in the Users Guide to Positive Guidance (Post, Alexander and Lunenfield, 1981).

Markings and delineators...provide messages to the driver, which are often redundant or coded. Some messages are redundant in that they give the same information but in a different form than given by the highway itself.... Coding is an important aspect of... their color... and position. Whether markings are redundant, coded or carry discrete information not carried elsewhere, they are an extremely important class of information carrier.

Delineation contributes information to this level primarily in the area of path selection. The delineation marks the alignment of the road, albeit by marking a parallel path. As such, consistency in delineation is important since changes in delineation can be perceived by the driver as a change in the path that must be followed. Inconsistency can lead to crashes. In addition, since control level information will take precedence over guidance information, a steady, consistent stream of delineation will insure that the information is present when the driver needs it and is mentally capable to process it. Lastly, providing clear, concise guidance information contributes to better information processing at the navigation level, since less of the drivers capacity will need to be contributed to the lower levels of information processing.

2.2.5 Environmental Considerations

As previously mentioned overall climate and environmental conditions in the intermediate roadside area have a great impact on the physical condition and life of a delineator. Passersby can also cause damage. Snow, particularly plowed snow, vandalism, abrasives, sunlight, and temperature extremes all negatively impact the physical condition of delineators. Rain is one of the few environmental conditions that improve the physical condition of delineators. Each of these effects is described below.

Snow

Although the actual snow itself does not do much damage to the delineator, snowfall indirectly affects the life of a delineator. With the event of significant snowfall comes the responsibility of keeping the roadway clear for vehicles. A few ways in which the roads are kept clear are de-icing materials, anti-skid materials and snowplowing, or some combination. The anti-skid material, in its nature, is required to be very abrasive to provide traction for traveling vehicles. This abrasive material has a deteriorating effect as it is thrown or splashed onto the delineator from passing vehicles. Likewise, the de-icing material is made from chemicals that are known to deteriorate delineators. These de-icing materials often mix with snow on the road and create slush that is splashed onto the delineators, placed near the bottom of the barrier, by passing vehicles. This is a major concern for PENNDOT, as it was voiced as one of the primary reasons for poor visibility. Similarly, as snowplows are clearing the roadway, delineators can be impacted by either the plow blade or plowed snow, either of which can break the delineator or knock it off of the barrier.

Vandalism

Occasionally damage done to the delineators can be caused by vandalism, particularly to the large (12" high) top-mounted delineators. The delineators attract attention from passersby and are easily knocked off the barrier simply by contacting them in some way at the prevailing traveling speed. At 80-foot spacing (the maximum spacing in Pennsylvania) and 45 mph, 50 of

these delineators can be knocked off the barrier in one minute. It is unknown if this can be prevented through use of smaller delineators. However, it is logical that smaller delineators could be less attention grabbing and a smaller target, while still achieving the same effect on driving.

Blowing Dust

Dust and particulate matter accumulates on and along side of the road. As this dust gets blown around by the draft from passing cars and wind, it can come in contact with the delineator, causing an abrasive effect. Over time this dust and particulate matter can erode the surface of the delineator, reducing the effectiveness and life of the delineator. This problem is significant enough that special abrasive resistive Type V sheeting has been developed.

Rain

Generally speaking rain does not have an adverse effect on delineators, which are known to be cleaned by the rain. However, when it rains, there is a tendency for mud puddles to form on the side of the road. As traveling vehicles drive over these puddles, the dirt is thrown onto the delineator, and over time can have an abrasive effect on the delineator. California, for example, specifies that delineators be placed outside a “splash zone.”

Sunlight

Ultraviolet rays from the sun have an impact on the effectiveness of a delineator. Prolonged exposure to the sun results in color fading of the delineator and overall deterioration.

Extreme Temperatures

Temperature is also an issue when it comes to the life of a delineator. The thermoplastic material that delineators are made from is created to withstand specific temperature extremes. This is why the material used for these delineators vary in certain regions. For example, a thermoplastic delineator formulated for the southwestern U.S. would not be appropriate for the northeast and vice versa. Also, in colder climates, delineators have had problems with the freeze-thaw cycle. This freezing and thawing effect causes early failure by weakening the delineators bond to the barrier.

2.3 Current Issues and Research in Concrete Median Barrier Delineation

Other than this project, there is currently not much attention being devoted to delineators in the transportation research community. Major research in traffic control devices is currently being focused on the use of fluorescent colors, older drivers, minimum in-service retroreflectivity

guidelines and special ITS-based needs. However, research has been performed in the past on delineators and similar devices. The following discussion highlights some of the results.

Sun Labs in Uniontown, Pennsylvania, recently conducted research on an improved flexible hinge between delineator base and mounting area for the retroreflective sheeting (T-shaped delineators, with the base as the cross-member and retroreflective sheeting mounted on the stem). According to Sun Labs, this hinge was more flexible than other hinges under extreme cold conditions, making it less susceptible to plowed snow and vandalism. They, as well as numerous other companies, have also developed delineators that emit light. Cost and battery life are known issues with these devices.

Another research report documented a preliminary field evaluation using ultraviolet headlights in conjunction with fluorescent pavement markers. It was found that visibility was increased 47% over the standard delineators and headlights. While the usage of fluorescent materials is on the increase in the United States, it is uncertain if the usage of ultraviolet headlights is on the increase or will ever be significant enough to guide the design of delineation.

2.4 State of Practice Survey of Concrete Median Barrier Delineation

For this purposes of this study, the state-of-the-practice can be defined as the way concrete median barrier delineation is currently being implemented. The duty of delineating median barrier typically falls at the state level, as such, it was desired to review the standards, specifications, and other practices of state DOT officials relative to this topic. In this section, the

standards, specifications, and practices of PENNDOT and other states are reviewed to define the state of the practice in concrete median barrier delineation. A thorough review was conducted for Pennsylvania, as the first section is devoted entirely to it. The second section deals with what was found for the remainder of the states.

2.4.1 Current PENNDOT Standards and Practices

The current PENNDOT standard for concrete median barrier delineation is number TC-7604, page 2 of 4 (adopted 12/15/99). The standard is shown in Figure VI. In short, the median barrier has two retroreflective units at each location, one on top of the barrier and one on the side placed 26" above the roadway surface. Both delineators must have Type V (ASTM) retroreflective sheeting. The reflective area of the delineator on the side has a vertical dimension of at least 3" but not more than 4.5". The horizontal dimension is at least 3.5" but not more than 4". There are three varieties of acceptable top-mounted retroreflective units. They are labeled Type P, R, and S in the standard. Type P and R are flat rectangular delineators, both of which have horizontal dimensions of 3". They differ in that the reflective area of Type P is 5" in height, while Type R is 4". In addition, the reflective area of the Type P reflector is 3" removed from the top of the barrier. The reflective area for the Type R delineator is only 0.5" removed from the barrier top. The Type R delineator is unique in that the vertical portion of the delineator (portion with the reflective sheet) is connected to the base portion via a flexible hinge. This is because delineators are subject to horizontal forces that bend them parallel to the barrier. These forces come from a variety of sources, primarily vandals, plowed snow, and wind.

The Type S delineator is much larger than the Types P and R, and it is not flat. It is paddle- shaped and requires a separate base to secure it to the barrier top. The reflective sheeting measures 3" horizontally by 12" vertically. The bottom of the reflective sheeting is 2.5" removed from the top of the barrier.

In the notes section of the standard, a maximum horizontal spacing of 80 feet for tangent sections and 40 feet for curve sections with a radius less than 1000 feet is specified. The means of securing the delineator to the barrier, as documented in the specifications (Pub. 408), is epoxy or manufacturer-approved adhesive.

The standards for concrete median barrier delineators have changed numerous times in the past. Two types of delineators that were installed under previous standards that are no longer installed are as follows:

- Circular reflector mounted on a square bracket - also referred to as a “center-mount”
- Trapezoidal-shaped reflector for use on the sides of barriers. This type of delineator had severe durability problems

These delineators are shown in Figure VII - Previous Standard Delineators.

NOTE 3: SIDE MOUNTED DELINEATORS SHALL BE LOCATED 26 INCHES FROM THE PAVEMENT TO THE CENTER OF THE DELINEATOR.

Figure VI – PENNDOT's Standard Drawing for Concrete Median Barrier Delineation (TC-7604)

Figure VII – PENNDOT's Previous Standard Delineators

Various PENNDOT District and County Maintenance personnel have also tried different methods of delineation in response to particular durability, maintenance, or reflective problems that were encountered. A survey of each District Traffic Unit was conducted to determine these special applications. A few county maintenance personnel were also contacted at the referral of the respective District Traffic Unit. The following is a synopsis of the discussions that took place.

First, it was noted through these discussions that maintenance of concrete median barrier delineation is a significant problem that is being faced statewide. Almost all Districts reported that maintaining the delineators is a major effort that often times they cannot keep up with. Broken delineators and their tendency to fall off of the barrier were the most cited reasons for the maintenance problems. These two reasons point to the delineator durability and method of mounting as areas where improvements should be considered.

A few Districts reported using raised pavement markers (RPMs) in place of the standard delineators. This was to counteract the durability problem. RPMs are designed to be much tougher than delineators because they are subject to traffic loads. The RPMs that are used for mountable islands were used because they are smaller and lighter than other types of RPMs. The larger RPMs, while providing more reflective area, were also heavier and much less likely to stay glued to the barrier. The RPMs, with their prismatic retroreflective design, are generally more effective at reflecting light than delineators, which use microprismatic sheeting. This partially compensates for the smaller reflective area.

A few of the Districts also reported staggering the top and side-mounted delineators so that they did not align vertically, as shown in the standard. The spacing between the top and side delineators was kept at the standard distance of 80 feet. However, since they were staggered, a delineator was encountered by the driver at half of the standard distance (every 40 feet).

Some of the Districts also reported adding side-mounted delineators in response to specific circumstances. One District halved the spacing between delineators in problem areas. Another District placed a second row of side-mounted delineators on the high (6 foot) median barrier. The first row was placed at the standard height of 26 inches. The second row was placed

at the midpoint between the first row and the top of the barrier. Another District reported using three rows of delineators. They were using RPMs in place of the standard delineators and wanted to compensate for the difference of reflective area between the standard delineator and a single RPM. The arrangement of the three rows of delineators is shown in Figure VIII. In their observation of this arrangement under traffic, they noted that drivers tended not to shy away from the barrier to the normal extent because the bottom row of delineators more clearly locates the bottom of the barrier to the driver. This is because the bottom row is placed on the widest portion of barrier, which is at the bottom. The arrangement shown in Figure VIII is currently used for all concrete median barrier applications in the District where it originated.

Three approaches were taken to counteract the problem of delineators falling off the barrier. One District reported using different adhesives, including a Tite Bond Concrete Adhesive that they believe works better than the normal epoxy and/or “Liquid Nails” that most Districts reported using. One county maintenance office reported using a heavier dosage of the typical epoxy to glue the delineators onto the barrier. He noted that they coat the barrier with epoxy, then put an approximately 1/2" thick layer of epoxy on the delineator, and push the delineator on until the epoxy seeps out through the holes in the plate. They then mash the epoxy that seeps out through the holes to form an anchor. They have had good success with this approach. A second county maintenance office reported attaching the top-mounted delineators with lag bolts. Holes were drilled in the top of the barrier (or bridge parapet) using an electric powered hammer drill or “hilti drill”. The hole was approximately 1.5" deep. An anchor was then place in the hole, and delineator attached with a lag bolt and flat washer. The manager of

this operation reported that a crew of three persons--one drilling and two attaching the delineators--could place up to approximately 14 delineators in an hour.

Finally, during the discussions a few ideas came up which have not actually been put into practice, but should be mentioned for future consideration. The usage of “inlaid” delineators and reflective tape in lieu of delineators were mentioned to counteract the damage caused by forces such as vandalism and plowed snow. Two districts were interested in solar-powered light-emitting delineators for areas with poor visibility conditions. One person had a specific type in mind and a second indicated that he knew of a company that made a “blinking” variety, but that PENNDOT requires the device to burn steady. Lastly, for temporary work zone barrier, an upside-down U-shaped bracket that fits over the top of the barrier that reflectors could be mounted to was mentioned as a way of quickly mounting and dismounting reflectors for temporary situations.

Figure VIII – Three Side Row Delineation Configuration

2.4.2 Delineator Standards from Other States

A survey of other states was conducted to determine their standards and specifications for concrete median barrier delineation. The survey was conducted by telephone, as each state was asked to send their standards and specifications for these devices. Many states have these documents posted on a web site. In these cases, there was no need to contact them by phone.

Standards and/or specifications were reviewed for the following states. They are grouped by geographic area to demonstrate geographic coverage. See Appendix A for complete details.

Northeast

Connecticut

Delaware (Specs Only)

Maryland

New Jersey

New York

Rhode Island

West Virginia

Vermont

South

Alabama

Florida

Kentucky

Midwest

Indiana

Illinois

Michigan

Minnesota (specs only)

Missouri

North Dakota (specs only)

Ohio

South Dakota

West

Alaska

Arizona

California

Georgia

Colorado

Oklahoma

Montana

Nevada

Oregon

Utah

Standards for concrete median barrier delineation could not be found for the following states. In most cases, the standards for either delineation and/or concrete median barrier were located, but no mention was made, nor drawing shown, of delineation on concrete median barriers.

Alaska

Arizona

Georgia

Michigan

Oregon

Rhode Island

South Dakota

Idaho They will be developing a new standard for concrete median barrier delineators in the near future. Preliminarily, they are planning on specifying a device that connects to the pins in the median barrier.

Vermont It is believed that they do not use concrete median barrier in permanent situations. For temporary situations, the median barrier delineators are placed at a height of

21" at 20 foot intervals. The delineators must have at least 9 in² of reflective surface, and they are placed on the sides only.

Alabama According to an Alabama DOT official, they do not have statewide standards for these devices. In general they are mounted at 40 foot spacing, with delineators similar to PENNDOT Type R on top and the previously used trapezoidal delineator on the side. The delineators are not mounted on the top and side, but instead either one or the other is used.

The review of the standards will follow a format whereby states having significant differences from the PENNDOT standards will be listed. The standards and specifications referenced in this review can be found in the Appendix. The states being compared are: Ohio, Connecticut, West Virginia, Nevada, California, Illinois, Utah, Kentucky, Oklahoma, Colorado, New York, Florida, Indiana, Montana, Maryland, New Jersey, and Missouri. In addition, the specifications were available for Delaware, Minnesota, and North Dakota. The specifications typically only provide reflective sheet and size information. Note that exclusion of a state from one of following lists does not necessarily imply anything, as in many cases the information could not be determined from the standards provided.

States that bolt delineators to the barrier in lieu of adhesive

Missouri 1/4" by 1 1/4" hole drilled for an aluminum or galvanized fastener

Utah attached with a "metal hit anchor" - detail shown in Appendix A

Connecticut	attached with 2 - 10 mm anchor bolts
New York	attached with a 10 mm expansion bolt
Ohio	connect delineation to bridge parapets with 2 - 3/8" x 3" double wedge anchor bolts

States that do not have delineators on the side of the barrier (top only)

New York	
Connecticut	
West Virginia	
Nevada	
California	
Utah	
Kentucky	unless the two sides of the barrier are separated into two walls
Colorado	
Oklahoma	only if a glare screen is in place
Montana	

States using different delineator shapes (e.g., circular center-mount, trapezoidal, etc)

Missouri	Similar to center-mount PENNDOT used in the past
Kentucky	Trapezoidal delineator PENNDOT used in the past on the side

Illinois	Similar to center-mount PENNDOT used in the past (on top and sides)
New York	Similar to center-mount PENNDOT used in the past (on top and sides)
Nevada	Uses two center-mount reflectors aligned vertically
Indiana	Similar to center-mount PENNDOT used in the past (on top)
Maryland	Uses a different trapezoidal shaped delineator than PENNDOT used in the past

States using different spacing (PENNDOT spaces at 80 feet in tangent sections and 40 feet in sharp curves)

Colorado	Spaces at 200-ft
Missouri	Spacing ranges from 100-ft in tangent and flat curves to 60-ft in sharp curves
Oklahoma	Spacing ranges from 90-ft to 50-ft
Kentucky	Spacing ranges from 100-ft to 50-ft
Utah	Spacing ranges from 100-ft to 20-ft
Illinois	Spacing ranges from 400-ft to 20-ft
California	Maximum spacing is 50-ft
Nevada	Spacing ranges from 50-ft to 20-ft
West Virginia	Spacing ranges from 330-ft to 20-ft
Connecticut	Spacing ranges from 200-ft to 20-ft
Ohio	Spacing ranges from 100-ft to 50-ft
Indiana	Spacing in feet = speed limit in mph with a minimum of 20-ft

Florida	Spacing ranges from 80-ft to 40-ft depending on the distance from the barrier to the roadway
Montana	Spaces at 30-ft
Maryland	Spaces at 100-ft to 50-ft
New Jersey	Spaces at 80-ft

States that also use a flexible hinge/base for the top-mounted delineators

West Virginia

California

States using different sized delineators on the top (PENNDOT uses 3"x12", 3" x 5", or 3" x 4")

Nevada	minimum dimension is 6"
Oklahoma	minimum dimension is 6"
Ohio	uses 3" x 6" (also specified a requirement of 7 in ² minimum)
Connecticut	uses 3" x up to 18" depending on the barrier height
West Virginia	uses 4" x 4"
Nevada	uses 3" x 3"
California	uses 3" x up to 12"
Illinois	uses 3 ½" x 4" or circular diameter of 2 ¾"
Utah	uses 3" x 4"

Kentucky	uses 3" x 5"
Missouri	circular 3 1/8" to 3 3/8" in diameter
Delaware	uses 3" x 4"
New York	uses 3" circular diameter
Indiana	uses 3" circular diameter, 7 in ² minimum
Montana	uses 3" x 4 1/4" rectangular reflector or 3" diameter PVC tube wrapped with reflective tape

States using different sized delineators on the side (PENNDOT uses 3 1/2" to 4" x 3" to 4 1/2")

Oklahoma	minimum dimension is 6"
Kentucky	uses 3" x 5"
Illinois	uses 3 1/2" x 4" or circular diameter of 2 3/4"
Ohio	use side-mounted delineators, can not extend more than 5" from barrier
Florida	uses 4" x 4" or 4" x 8"
Indiana	uses 3" x 8"
Maryland	uses 5.1" x 2.8" trapezoidal (5.1" is only at bottom, it narrows towards the top)
New Jersey	uses 3.5" x 3.5"

Miscellaneous Findings

- None of the states surveyed puts more than one row of delineators on the side of the barrier.
- None of the states surveyed uses raised pavement markers or anything similar looking.
- Illinois glues delineators to the barrier, but specifies at least 7 in² of base for adhesion
- California only uses median barrier delineation when the barrier is closer than 8 foot; Ohio only uses it when the barrier is closer than 10 foot (when the reason for the barrier is based strictly on the distance to travel lane; they also have other warrants for installation), Maryland uses it for all barrier within 15 feet.
- Nevada and New York angle the top-mounted delineators towards traffic
- Ohio angles the delineators vertically to facilitate rain washing
- Florida spaces delineators strictly on the distance from the barrier to the roadway, not on horizontal curvature.
- Several states only use top-mounted delineators. Florida, New Jersey, and Maryland only use side-mounted delineators.
- Although it was not found in a standard, South Carolina used several rows of RPMs on the pavement adjacent to the base of the barrier, with reflective paint (like a lane line) on the barrier.

The key findings of this survey are as follows:

- Several states, including neighboring states Ohio and New York, bolt the delineators to the barrier.

- In lieu of a flexible hinge, many states use sturdy metal brackets to counteract blows to the delineators.
- The 3" x 12" top-mounted delineator used by PENNDOT is among the largest of the states surveyed.
- The majority of states surveyed only use top-mounted delineation. Three only use side-mounted delineation. PENNDOT was one of the few states reviewed that used both. None used more than one delineator on the side.
- In general, spacing is in line with other states. However, at 80 feet, closer spacing is used by PENNDOT in tangent sections than most of the other states reviewed. It is also closer than that recommended by the MUTCD, which is 200 feet to 530 feet.

2.4.3 Summary

This review and survey has demonstrated the following general principles:

- Concrete median barrier delineation is an important traffic control device that primarily provides the driver with guidance information on roadway alignment. It also aids the driver in avoiding collisions with the barrier both during day and nighttime conditions. Finally, because the color of the delineator matches the appropriate pavement marking, it also provides regulatory information.
- Concrete median barrier delineation, because of its location in the near roadside area, is subject to many environmental forces, including vandalism, plowed snow, abrasion from

blowing dust and anti-skid material, sunlight, etc. These forces can reduce or eliminate the effectiveness of the delineation in performing its desired intent.

- The effectiveness of concrete median barrier delineation is dependent on atmospheric conditions, and can be rendered completely or partially ineffective due to rain, snow, fog, or particulate matter under certain conditions.
- There is a wide variation in the application of concrete median barrier delineation between states and even within the state of Pennsylvania. Furthermore, there is no guidance on delineation strategies during poor atmospheric conditions.

Specific to PENNDOT's standard, this review suggests that the size of the 3" x 12" (reflective area) delineator likely contributes to its vandalism problem because it is more conspicuous than other delineators. The benefits of the increased conspicuity are questionable because greater conspicuity likely has little value under normal nighttime driving conditions. Even under poor visibility conditions, the prior research is inconclusive about whether a larger reflective area contributes to greater visibility. Some research suggests that only an increase in light intensity contributes to increased visibility. Other states use more reflective material than the ASTM Type V sheeting recommended by the PENNDOT standard. Districts using RPMs in lieu of standard delineators are also using more reflectivity. Perhaps PENNDOT should consider a smaller delineator with greater reflectivity in lieu of the 3" x 12" variety. However, this subject is beyond the scope of this research. For the purposes of this research, the 3" x 12" reflective area delineator will not be used in the field testing.

Chapter 3 Durability Testing

3.1 Introduction and Methodology

Harsh environmental conditions present in the roadside environment where delineators are mounted can result in delineators falling off of the barrier with such frequency that it causes maintenance problems. This is particularly true during the winter months.

A durability test was conducted on S.R. 119, just north of Connellsville, Pennsylvania. Six test sections, each having approximately 17 delineators, were established at this location. Three test sections were adjacent to the northbound lanes, and the remaining three were on the opposite side of the barrier adjacent to the southbound lanes. Conditions in each of the test sections were very similar because they were set up over a short distance, had a uniform cross section, with similar traffic conditions, and identical winter maintenance treatment. This test section was chosen by the PENNDOT District 12-0 Traffic Engineer due to its uniformity with respect to both traffic and environmental conditions. Furthermore, all delineators were installed on the same day by a professional crew of PENNDOT maintenance personnel.

Three different adhesive types were tested: Liquid Nails, Tite Bond, and Peel-n-Stick (with butyl pad). Each adhesive was used to attach all of the delineators in two of the six sections. Each adhesive was used in one northbound and one southbound test section. All delineators were mounted on the side, approximately one foot from the pavement level, where environmental conditions should be harsher than the normal position, which is near the top of the barrier.

In total, 101 delineators were mounted over the six test sections. The delineators were mounted during the first week in September 2001. The survival rate was closely monitored for one year, which was as long of a time period as feasible given the overall length of the research project. In addition, the application rates associated with each of the adhesive types were measured. The results of each are discussed below.

3.2 Results

3.2.1 Application Rate

The application rate associated with each adhesive type was determined by noting the total time to mount all of the delineators using the particular adhesive, and dividing it by the total number of delineators mounted using the particular adhesive. The results of this analysis are shown in Table 3-1 (See Appendix B for additional information). Note that not all of the delineators mounted for this test were included in the application rate determination. Some were not included if unusual circumstances arose, as per the judgment of the researchers. Furthermore, delineators were also mounted on the top of the barrier as place markers at the same time they were mounted on the side in the southbound direction. Finally, note that the installation time includes measurement for the layout of the delineators and the removal of existing delineators in addition to the installation of the new delineators. The removal of existing delineators was found to be negligible, as it was less than five seconds.

Table 3-1 – Application Rates Associated with Each Adhesive Type

Delineator Type	Total Delineators Mounted	Total Time (minutes)	Application Rate (delineators/hour)
Liquid Nails	49	41	72
Tite Bond	50	45	67
Peel-n-Stick	46	35	79

It was found that the application rate associated with the Peel-n-Stick delineators was the highest at 79 delineators per hour. This was expected, as there is no glue to apply to the delineator before attaching it to the barrier. It was nearly 20% faster than the Tite Bond – attached delineators. However, there was not a great disparity between any of the rates. Tests of the statistical significance of the differences in rates revealed that there were no statistically significant differences in any of the rates.

3.3.2 Survival Rate

The 101 side-mounted delineators were distributed among the test sections as shown in Table 3-2. Note that the southbound sections were installed first, beginning in the north with Section 1. It was noted at the time that the barrier was slightly damp due to some morning dew.

Table 3-2 – Arrangement of Delineators in the Durability Test Sections

Southbound Sections	Northbound Sections
Section 1 – 16 Attached Using Liquid Nails	Section 4 – 17 Attached Using Liquid Nails
Section 2 – 16 Attached Using Tite Bond	Section 5 – 16 Attached Using Peel-n-Stick
Section 3 – 18 Attached Using Peel-n-Stick	Section 6 – 18 Attached Using Tite Bond

The total sample size for each adhesive was as follows:

Liquid Nails – 33

Tite Bond – 34

Peel-n-Stick – 34

The survival rate was closely monitored from the time the delineators were mounted in early September 2001 until September 2002. Over that time period, four of the 101 delineators had become detached. All four of the delineators were attached using Liquid Nails. One of these fell from the northbound Liquid Nails test section, and three fell from the southbound Liquid Nails test section. It was noted that one delineator became detached during each of the following four months October, December, March, and May. In short, the survival rates for each adhesive type for the one year period are as follows: Liquid Nails – 88%, Tite Bond – 100%, and Peel-n-Stick-100%.

It must be noted that the winter that occurred during the test period was extremely mild compared to the normal conditions. Table 3-3 shows the normal and actual average temperatures

for Pittsburgh, PA (as recorded by the National Weather Service) during the test period. The usual winter months of December and January were extremely mild. The period of February through May was slightly warmer than usual, with May actually being colder than normal. The last nighttime temperature in the 30's (Fahrenheit) occurred May 23, when the low temperature was 38 degrees

In addition, winter maintenance activities were significantly less frequent than usual. The first snowfall occurred on 11/20/02 when a trace of snow was recorded. There were only seven days all winter that had snowfalls greater than 1 inch. There were two each in December, January, and February, and one in March. The last snowfall occurred April 6 when again a trace was recorded.

Table 3-3 – Actual Mean Temperature vs. Normal Mean Temperature – 9/01 to 9/02, Pittsburgh, PA (Source: National Weather Service)

Month	Actual Mean Temperature (F)	Normal Mean Temperature (F)
9 / 01	62.1	63.9
10 / 01	54.1	52.3
11 / 01	48.2	42.3
12 / 01	37.4	31.4
1 / 02	35.4	27.5
2 / 02	35.0	30.5
3 / 02	40.9	39.8
4 / 02	52.7	49.9
5 / 02	56.7	60.0
6 / 02	70.6	68.4
7 / 02	76.0	72.6
8 / 02	74.1	70.8

3.3.3 Cost Analysis

A cost analysis was performed using the results of the survival and application rate tests. The costs of the materials, installation, and replacement were the primary costs considered. The following assumptions were made in the cost analysis.

- First, it was assumed that the delineators could be replaced at the same unit cost that they were originally installed. This likely underestimates the cost since the fixed costs of installing the delineators are spread over a much smaller quantity when they are being replaced as opposed to the initial installation.
- The costs of traffic control are not included.
- The survival rate in all years of the delineator life cycle is equal to that experienced in the first year. The Liquid Nails adhesive, which had an 88% survival rate for one year, was projected to have a 41% survival rate at the end of five years.
- The life cycle of a delineator is five years. This was provided by the PENNDOT maintenance foreman, and was based on his estimate of the expected duration between total delineator replacement projects at a given location.

The results of the cost analysis are shown in Table 3-4 (See Appendix B for calculations). It was found that the Liquid Nails adhesive yielded the highest associated cost per delineator. This was mainly because of the replacement costs associated with the delineators expected to fall from the barrier. The adhesive with the lowest associated cost was Peel-n-Stick. The cost of the

delineator alone was slightly higher than the others, however, once the cost of the adhesive was added to the Liquid Nails and Tite Bond attached delineators, they were all roughly the same cost. The timesavings associated with the Peel-n-Stick delineators then provided cost savings necessary to make it the least cost choice. Please note that had no delineators become detached during the durability test, the Peel-n-Stick delineators still would have been the least cost choice because of the cost savings associated with the decreased installation time.

Table 3-4 – Cost Analysis

Delineator Type	Material Cost (\$/delineator)	Installation Cost (\$/delineator)	Replacement Cost (\$/delineator)	Total Cost (\$/delineator)
Liquid Nails	3.90	0.89	2.82	7.61
Tite Bond	3.86	0.96	0	4.82
Peel-n-Stick	3.88	0.81	0	4.69

3.4 Concluding Remarks

The purpose of this study was to determine the best adhesive for use to minimize the cost of delineating concrete median barriers. Three adhesive types were tested, and the Peel-n-Stick delineators were identified as the least cost choice. They were the most expensive choice based on the cost of the delineator alone. However, when the cost of the adhesive is added in, they were all virtually the same cost. When the installation time savings offered by the Peel-n-Stick

delineators are considered, they then become the least cost alternative. In addition, the survival rate of the Peel-n-Stick delineators during the one-year durability test was 100%. The durability was also monitored during a six-month period, lasting from September, 2002 to March 2003. This time frame encompassed the winter months, which were harsher than those in the previous winter. It was found that an additional nine delineators became detached. However, Peel-n-Stick maintained a 100% survival rate. It should also be noted that in one of the Peel-n-Stick test sections, there were tire marks on the barrier, and in some cases the delineators were torn in half. Despite the damage done to the delineators, they still remained attached to the barrier. Lastly, although it was not considered, the delay costs for traveling public resulting from the traffic control required to install the delineators would also be the least for the Peel-n-Stick delineators.

Chapter 4 Visibility Testing

4.1 Introduction and Test Description

In response to a perceived need for increased median barrier delineation in areas prone to poor visibility conditions, PENNDOT personnel have informally tried different delineation configurations than those shown on the typical drawings. Most of the variations included a side-mounted delineator near the base of the barrier, as it was felt that this identified the barrier - roadway boundary better for the driver. Some of the variations also included three side-mounted delineators at a single location. One of the delineators was near the top in the location shown on the typical drawings, one was near the bottom as described previously, and a third was placed near the middle of the barrier. This configuration evolved from an unofficial configuration previously used by PENNDOT that utilized raised pavement markers instead of typical delineators. The raised pavement markers were preferred because they were thought to be more durable. However, they had less reflective surface per unit than the typical delineator, hence the need for additional units.

The visibility tests were conducted on US 40 just east of Uniontown, PA on what is locally known as “Summit Mountain.” This area has a history of poor visibility conditions due to fog because it is several thousand feet higher in elevation than the Uniontown area just to the west.

Through the test site, U.S. 40 was two lanes in each direction separated by a typical safety-shaped concrete median barrier located 1 foot from the inside lane in both directions. Lane

widths were 11 feet, and the outside shoulders were paved and were roughly 10 feet in width in the eastbound direction and 8 feet in the westbound direction. The test site was on a 7 to 8% grade, with the eastbound direction being upgrade. The overall site was divided into four subsections, each approximately 1800 feet in length. During the tests, each subsection was to contain a different delineator configuration than the subsection adjacent to it. Two of the subsections were in the eastbound direction and two were in the westbound direction. There was an approximately 2200-foot radius horizontal curve roughly in the middle of the overall site that formed the dividing point for the subsections.

In general, the visibility provided by competing delineators configurations was gauged by traveler speed. During poor visibility conditions, traveler speeds drop well below normal. The delineator configuration that resulted in the highest speed, i.e., most normal speed, was considered to be superior. In each subsection, automated traffic recorders that collected both volume and speed data were placed in both lanes approximately one third of the way into the subsection. In addition, there was a control station in each direction just over the summit where there was no concrete median barrier and hence no delineation or delineation changes from trial to trial. The purpose of these stations was to monitor for drastic changes in speeds from test to test.

Finally, although four test subsections were formed, only two competing delineator types were tested during each phase. Both the eastbound and westbound directions were setup identically. For example, a driver in the eastbound direction would encounter configuration A, followed by configuration B. The driver in the westbound direction would also encounter configuration A followed by B. Since the eastbound and westbound subsections were directly

opposite of one another on the roadway cross-section, if configuration A was in the eastbound direction on one side of the barrier, configuration B would be on the opposite side of the barrier facing westbound traffic. See Figure X for the layout of the test sections.

Figure X - Visibility Test Section Layout

The visibility test was conducted in four phases:

Phase I Traffic speeds and volumes were collected for the base condition, which was an assortment of past delineator installations. It was noted that many of the delineators were missing or old and ineffective.

- Phase II A test was conducted that compared two options of locating a single side-mounted delineator. One version had the single side-mounted delineator mounted near the top in conjunction with the typical top-mounted delineator. This is the current PENNDOT standard installation. The other version had the side-mounted delineator mounted near the bottom with the top-mounted delineator unchanged.
- Phase III In the Phase II testing, the bottom side-mounted delineator outperformed the side-mounted delineator located near the top. Thus, this test compared a single side-mounted delineator with a configuration that used three side-mounted delineators (one near the top, one near the bottom, and one in middle. Both configurations had a single top-mounted delineator as per PENNDOT standards.
- Phase IV In the Phase III testing, there was not a significant difference between the competing configurations. Therefore, the single side-mounted delineator near the bottom configuration was used to test the effectiveness of reducing the longitudinal spacing of the delineators. PENNDOT standards call for the delineators to be spaced at 80 feet in tangent sections and 40 feet in curves. Two of the subsections were setup at this spacing, and two were set up at halved spacing.

The details and results of each of the test phases are provided in the following sections

4.2 Phase I - Baseline Conditions

Traffic volumes and speeds were collected in each of the test subsections and the two control locations on 6/11/01 and 6/12/01. No poor visibility conditions were present during the data collection. Nighttime data was queried from 9pm to 6am, as sunrise was at 5:51 am and sunset occurred at 8:47 pm (National Weather Service - Pittsburgh). The pertinent traffic data are summarized in Table 4-1 (See Appendix C for complete data set). As can be seen, it is normal for speeds to be in the upper 40s or lower 50s through the test site. Furthermore, there is not a great differential between overall speeds and nighttime speeds. Finally, the combined control station speed was 50.6 mph both over the entire time period and during the nighttime.

Table 4-1 Summary of Baseline Conditions

Westbound		East Bound	
Control Station		Control Station	
<u>Overall</u> Average = 48.1mph S = 3.4 mph Volume = 5193 veh	<u>Nighttime</u> Average = 48.3 mph Volume = 619 veh	<u>Overall</u> Average = 53.2 mph S = 3.6 mph Volume = 5077 veh	<u>Nighttime</u> Average = 53.1 mph Volume = 591 veh
Section 1		Section 2	
<u>Overall</u> Average = 53.9 mph S = 4.2 mph Volume = 5268 veh	<u>Nighttime</u> Average = 51.0 mph Volume = 643 veh	<u>Overall</u> Average = 51.5 mph S = 7.11 mph Volume = 5407 veh	<u>Nighttime</u> Average = 50.4 mph Volume = 652 veh
Section 2		Section 1	
<u>Overall</u> Average = 55.5 mph S = 4.8 mph Volume = 4130 veh	<u>Nighttime</u> Average = 55.0 mph Volume = 551 veh	<u>Overall</u> Average = 55.6 mph S = 3.9 mph Volume = 5305 veh	<u>Nighttime</u> Average = 54.7 mph Volume = 645 veh

4.3 Phase II - High vs Low Side-Mounted Delineators

From 11/28/01 to 12/03/01, traffic data were recorded as part of Phase II. In this test, the differences between providing a single side-mounted delineator near the top of the barrier was compared with locating it near the bottom. A summary of general statistics from this test are provided in Table 4-2 (See Appendix D for complete data set). The period from 8 pm to 6 am was used as the nighttime hours. The sunrise during this time period was approximately 7:20am,

and the sunset was approximately 5:00pm. However, the nighttime period was shortened so that commuter traffic and early evening traffic could be missed. During these periods of relatively high traffic, drivers can rely too heavily on the lights of other vehicles for guidance. The combined control station speed was 49.5 mph overall and 50.4 mph during the nighttime. Interestingly, none of the test sections had nighttime speed greater than the overall speed, whereas both the control stations did. The cause of this is unknown. See Figure XI for a detail of the configuration.

Figure XI – Phase II Configuration

Table 4-2 Summary of Results for Phase II of the Visibility Testing

Westbound		East Bound	
Control Station		Control Station	
<u>Overall</u> Average = 51.7 mph S = 2.1 mph Volume = 22787 veh	<u>Nighttime</u> Average = 52.2 mph Volume = 4132 veh	<u>Overall</u> Average = 47.2 mph S = 2.3 mph Volume = 22749 veh	<u>Nighttime</u> Average = 48.0 mph Volume = 3065 veh
Section 1 - High Side Mount		Section 2 - Low Side Mount	
<u>Overall</u> Average = 50.6 mph S = 2.5 mph Volume = 24040 veh	<u>Nighttime</u> Average = 49.6 mph Volume = 3372 veh	<u>Overall</u> Average = 50.2 mph S = 2.8 mph Volume = 23900 veh	<u>Nighttime</u> Average = 49.3 mph Volume = 4421 veh
Section 2 - Low Side Mount		Section 1 - High Side Mount	
<u>Overall</u> Average = 50.3 mph S = 3.2 mph Volume = 23584 veh	<u>Nighttime</u> Average = 48.6 mph Volume = 3289 veh	<u>Overall</u> Average = 49.3 mph S = 3.3 mph Volume = 23736 veh	<u>Nighttime</u> Average = 47.9 mph Volume = 4398 veh

The individual hours during the test were examined to determine the times during which the slowest traffic occurred. The data during these times was aggregated and analyzed in a number of ways. First, the upper sections (Eastbound Section 2 and Westbound Section 1) were compared to each other. Next, the lower sections (Westbound Section 2 and Eastbound Section 1) were compared. Finally, the aggregation of sections with like delineator configuration was compared to one another. In other words, the data for the two Section 1s were aggregated and compared to the Section 2s. In the analysis of the data for this phase and Phase III, it became apparent that the flashing beacon at the summit and the flashing warning sign located in

Eastbound Section #2 had an influence on driver speeds during the slow speed periods. While traffic speeds in other sections were depressed, the speeds in Eastbound Section #2 remained relatively high. For that reason, the data comparisons involving this section were disregarded. In the end, only the data from the lower sections were used in the comparisons.

Table 4-3 shows a comparison of traffic speeds during the four slowest hours sampled. These were determined by ranking all of the hours sampled by the aggregate speed over the four subsections. There was a definitive breakpoint between these four hours and the fifth slowest hour, as there was a differential of 2.1 mph. In general, the procedure to determine the configuration yielding the highest speeds during the slowest period entailed comparing the difference in speeds between the two sections at that time against the difference experienced during the overall nighttime period. In this instance, during the normal nighttime hours, the WB section had speeds (48.6 mph) that were 0.7 mph higher than the EB section (47.9 mph). During the four slowest hours, speeds in the WB section were a total of 4.5 mph higher than the EB section. In four nighttime hours, it was expected that the differential should be 2.8 mph (0.7 mph times 4). Therefore, the delineators in the WB section outperformed those in the EB section by an even larger margin than was the case during the typical nighttime hours. However, it must be noted that the magnitude of the difference is small, and in two of the four hours, speeds in the EB direction were actually greater than those in the WB direction.

Table 4-3 - Comparison of Speeds During the Low Speed Hours – Phase II

Hour (Slowest First)	Overall Speed (mph)	WB Section Speed (mph)	EB Section Speed (mph)	Difference (mph)	Overall Nighttime Difference (mph)	Relative Difference (mph)
1	38.6	37.7	38.0	-0.3	0.7	-1.0
2	40.1	38.6	36.8	1.8	0.7	1.1
3	40.9	36.7	41.1	-4.7	0.7	-5.4
4	41.0	43.1	35.4	7.7	0.7	7.0
AGGREGATE				4.5	2.8	1.7

4.4 Phase III - Low vs Three Side-Mounted Delineators

From 5/31/02 to 6/07/02, traffic data were recorded as part of the third phase of the visibility testing, which was conducted to test for differences between providing a single side-mounted delineator near the bottom of the barrier and providing three side-mounted delineators. A summary of general statistics from this phase is provided in Table 4-4 (See Appendix E for complete data set). The period from 9 pm to 5 am was used as the nighttime hours. The sunrise during this time period was approximately 5:50am, and the sunset was approximately 8:40pm. The combined control station speed was 48.8 mph overall and 48.9 mph during the nighttime.

These results are consistent with the control counts from the other phases. As in Phase II, the nighttime speed is slightly higher than the overall speed. See Figure XIII for the configuration for this phase.

Figure XII – Phase III Configuration

Table 4-4 Summary of Results for Phase III

Westbound		East Bound	
Control Station		Control Station	
<u>Overall</u> Average = 47.4 mph S = 2.9 mph Volume = 42353 veh	<u>Nighttime</u> Average = 47.7 mph Volume = 4333 veh	<u>Overall</u> Average = 50.1 mph S = 4.7 mph Volume = 43725 veh	<u>Nighttime</u> Average = 50.1 mph Volume = 4288 veh
Section 1 - Three Side Mounts		Section 2 - Low Side Mount	
<u>Overall</u> Average = 48.4 mph S = 3.2 mph Volume = 40190 veh	<u>Nighttime</u> Average = 46.2 mph Volume = 4498 veh	<u>Overall</u> Average = 57.9 mph S = 2.3 mph Volume = 46991 veh	<u>Nighttime</u> Average = 57.9 mph Volume = 5402 veh
Section 2 - Low Side Mount		Section 1 - Three Side Mounts	
<u>Overall</u> Average = 54.3 mph S = 2.2 mph Volume = 44017 veh	<u>Nighttime</u> Average = 52.4 mph Volume = 4594 veh	<u>Overall</u> Average = 48.4 mph S = 2.2 mph Volume = 45168 veh	<u>Nighttime</u> Average = 46.9 mph Volume = 4516 veh

As was done with the data from Phase II, the hours were ranked by overall speed and the slowest hours were selected for further analysis. Table 4-5 shows a comparison of traffic speeds during the five slowest hours sampled as part of Phase III. When the analytical procedures used for Phase II were used with these data, it revealed that WB section had the higher overall speeds at nighttime, and that margin grew even larger during the low speed times. Therefore, it was not expected that there was any benefit to the three delineator configuration over the single side-mounted delineator near the bottom.

Table 4-5 - Comparison of Speeds During the Low Speed Hours – Phase III

Hour (Slowest First)	Overall Speed (mph)	WB Section Speed (mph)	EB Section Speed (mph)	Difference (mph)	Overall Nighttime Difference (mph)	Relative Difference (mph)
1	45.1	50.5	41.6	8.9	5.5	3.4
2	46.2	48.4	43.7	4.6	5.5	-0.9
3	46.4	51.5	40.6	10.9	5.5	5.4
4	46.6	50.2	43.0	7.2	5.5	1.8
5	47.6	51.5	43.4	8.1	5.5	2.6
AGGREGATE				39.7	27.5	12.2

4.5 Phase IV - Halved Spacing

From 8/29/02 to 9/04/02, traffic data were recorded for the final testing phase, which was conducted to test for differences between normal PENNDOT spacing and halved spacing. The configuration used in this phase was the single side-mounted delineator near the bottom in combination with a top mounted delineator. A summary of general statistics from this phase is provided in Table 4-6 (See Appendix F for complete data set). The period from 8 pm to 6 am was used as the nighttime hours. The sunrise during this time period was approximately 6:50 am, and the sunset was approximately 7:50 pm. The combined control station speed was 47.6 mph overall and 48.3 mph during the nighttime. These results are consistent with the control

counts from the other phases. As with the other testing phases, the nighttime speed is slightly higher than the overall speed.

Table 4-6 - Summary of Results for Phase IV

Westbound		East Bound	
Control Station		Control Station	
<u>Overall</u> Average = 48.3 mph S = 2.35 mph Volume = 49530 veh	<u>Nighttime</u> Average = 49.5 mph Volume = 7393 veh	<u>Overall</u> Average = 46.8 mph S = 1.12 mph Volume = 49309 veh	<u>Nighttime</u> Average = 46.9 mph Volume = 6545 veh
Section 1 - Halved Spacing		Section 2 - Regular Spacing	
<u>Overall</u> Average = 50.9 mph S = 3.36 mph Volume = 48738 veh	<u>Nighttime</u> Average = 49.2 mph Volume = 7631 veh	<u>Overall</u> Average = 51.1 mph S = 1.98 mph Volume = 48257 veh	<u>Nighttime</u> Average = 50.0 mph Volume = 6599 veh
Section 2 - Regular Spacing		Section 1 - Halved Spacing	
<u>Overall</u> Average = 54.8 mph S = 8.36 mph Volume = 30512 veh	<u>Nighttime</u> Average = 52.9 mph Volume = 4849 veh	<u>Overall</u> Average = 50.5 mph S = 2.00 mph Volume = 19524 veh	<u>Nighttime</u> Average = 49.0 mph Volume = 3008 veh

As with the other phases, the hours were ranked by overall speed and the slowest hours were selected for further analysis. Table 4-7 shows a comparison of traffic speeds during the three slowest hours sampled as part of Phase IV. The same analytical procedures as described under Phase II were used. This analysis revealed that while the WB section had the higher

overall speeds at nighttime, the EB section generally had the higher speeds during the slowest periods. This is the section that had the spacing halved. Therefore, it is expected that the halved spacing was beneficial to the drivers during the slowest periods.

Table 4-7 - Comparison of Speeds During the Low Speed Hours – Phase IV

Hour (Slowest First)	Overall Speed (mph)	WB Section Speed (mph)	EB Section Speed (mph)	Difference (mph)	Overall Nighttime Difference (mph)	Relative Difference (mph)
1	42.7	45.2	39.4	-5.8	3.9	-9.7
2	45.7	48.8	44.6	-4.2	3.9	-8.1
3	47.4	47.2	48.8	1.6	3.9	-2.3
AGGREGATE				-8.4	11.7	-20.1

4.6 Conclusions

In conclusion, from the visibility tests that were conducted, the following recommendations can be made:

In poor visibility conditions, the single side-mounted delineator at the bottom provides better guidance to the driver than the single side-mounted delineator at the top. Note that this assumes a top-mounted delineator will be provided. It is speculated that during poor visibility conditions, more drivers use their low headlight beams, and that this may have contributed to the

results of the test. Also note that these were newly mounted delineators, and that delineators mounted lower to the road are more subject to abrasion and abuse that would cause them to fall off, and materials that can coat the delineator and cause it to lose its reflectivity. Finally, note that of the three tests conducted, the results of this test were the weakest.

There was no difference in speeds found between providing the single bottom side-mounted delineator and three side-mounted delineators. Although the three side-mounted delineator configuration creates a redundancy issue it guards against having no side-mounted delineation for 80' to 160' in the case where the delineator would become detached from the barrier.

The halved spacing provided drivers with better guidance information during poor visibility conditions. Of the three tests conducted, the results of this test were the strongest.

As a result of the visibility testing outcome, PENNDOT has developed a preliminary standard which specifies mounting delineators on the top or on the side near the top and on the side near the bottom. The configuration is shown in Figure XIII. This configuration will be implemented in upcoming construction projects, and monitored to test the effectiveness of the preliminary configuration.

Figure XIII – Preliminary Configuration for PENNDOT Standard

Chapter 5 Summary of Conclusions

5.1 Summary of Conclusions

This research was comprised of three main research efforts:

1. Literature Review and State of the Practice Survey
2. Durability Test
3. Visibility Test

The conclusions from each are summarized below

5.2 Literature Review and State of the Practice Survey

This review and survey demonstrated the following general principles:

Concrete median barrier delineation is an important traffic control device that primarily provides the driver with guidance information on roadway alignment. It also aids the driver in avoiding collisions with the barrier both during day and nighttime conditions. Finally, because the color of the delineator matches the appropriate pavement marking, it also provides regulatory information.

Concrete median barrier delineation, because of its location in the near roadside area, is subject to many environmental forces, including vandalism, plowed snow, abrasion from blowing dust and anti-skid material, sunlight, etc. These forces can reduce or eliminate the effectiveness of the delineation in performing its desired intent.

The effectiveness of concrete median barrier delineation is dependent on atmospheric conditions, and can be rendered completely or partially ineffective due to rain, snow, fog, or particulate matter under certain conditions.

There is a wide variation in the application of concrete median barrier delineation between states and even within the state of Pennsylvania. Furthermore, there is no guidance on delineation strategies during poor atmospheric conditions.

Specific to PENNDOT's standard, this review suggests that the size of the 3" x 12" (reflective area) delineator likely contributes to its vandalism problem because it is more conspicuous than other delineators. The benefits of the increased conspicuity are questionable because greater conspicuity likely has little value under normal nighttime driving conditions. Even under poor visibility conditions, the prior research is inconclusive about whether a larger reflective area contributes to greater visibility. Some research suggests that only an increase in light intensity contributes to increased visibility. Other states use more reflective material than the ASTM Type V sheeting recommended by the PENNDOT standard. Districts using RPMs in lieu of standard delineators are also using more reflectivity. Perhaps PENNDOT should consider a smaller delineator with greater reflectivity in lieu of the 3" x 12" variety. However, this subject is beyond the scope of this research.

Several states, including neighboring states Ohio and New York, bolt the delineators to the barrier. In lieu of a flexible hinge, many states use sturdy metal brackets to counteract blows to the delineators.

The 3" x 12" top-mounted delineator used by PENNDOT is among the largest of the states surveyed.

The majority of states surveyed only use top-mounted delineation. Three only use side-mounted delineation. PENNDOT was one of the few states reviewed that used both. None used more than one delineator on the side.

In general, spacing is in line with other states. However, at 80 feet, closer spacing is used by PENNDOT in tangent sections than most of the other states reviewed. It is also closer than that recommended by the MUTCD, which is 200 feet to 530 feet.

5.3 Durability Test

The purpose of this study was to determine the best adhesive for use to minimize the cost of delineating concrete median barriers. Three adhesive types were tested, and the Peel-n-Stick delineators were identified as the least cost choice. They were the most expensive choice based on the cost of the delineator alone. However, when the cost of the adhesive was added in, they were all virtually the same cost. When the installation time savings offered by the Peel-n-Stick delineators were considered, they then become the least cost alternative. In addition, the survival rate of the Peel-n-Stick delineators during the one-year durability test was 100%. Lastly,

although it was not considered, the delay costs for traveling public resulting from the traffic control required to install the delineators would also be the least for the Peel-n-Stick delineators.

5.4 Visibility Test

In conclusion, from the visibility tests that were conducted, the following recommendations can be made:

In poor visibility conditions, the single side-mounted delineator at the bottom provides better guidance to the driver than the single side-mounted delineator at the top. Note that this assumes a top-mounted delineator will be provided. It is speculated that during poor visibility conditions, more drivers use their low headlight beams, and that this may have contributed to the results of the test. Also note that these were newly mounted delineators, and that delineators mounted lower to the road are more subject to abrasion, abuse that would cause them to fall off, and materials that can coat the delineator and cause it to lose its reflectivity. Finally, note that of the three tests conducted, the results of this test were the weakest.

There was no difference found between providing the single bottom side-mounted delineator and three side-mounted delineators.

The halved spacing provided drivers with better guidance information during poor visibility conditions. Of the three tests conducted, the results of this test were the strongest.

5.5 Recommendations

It is recommended that in areas prone to poor visibility conditions, that consideration be given to decreasing the longitudinal spacing, and providing delineation lower on the barrier than shown in the standards. Site specific conditions and engineering judgment can dictate how much closer the spacing should be, as well as how low on the barrier to mount a delineator. It must be noted that due to time restrictions, this research was not able to address whether delineators remain effective when exposed to conditions near the pavement surface over a long period of time. This should be monitored in the appropriate instances. With respect to durability, in instances where the peel-and-stick delineators (such as those currently offered by Sun Labs) are comparable in price to obtaining the delineators and adhesive separately, that special consideration should be given to the peel-and-stick delineators. Their installation time was found to be less, and their durability was perfect over the one-year period monitored and again during the six-month update. They should also be given special consideration in instances where user delay due to the traffic control set up to install the delineators is critical. Finally, the literature review revealed the ultimate solution to delineation under poor visibility conditions is light-emitting delineation. Consideration should remain open to such solutions.

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Appendix A

Standards and Specifications from Other States

Upon completion of the work under this Section any damage to the pavement or other facilities caused by the operation or the Contractor's equipment, shall be repaired by the Contractor as directed without additional cost to the State.

705.04 Method of Measurement.

Pavement Markers installed as directed and accepted will be measured by counting separately the number of various class and types of markers provided by the plans or proposal.

705.05 Basis of Payment.

(a) UNIT PRICE COVERAGE.

The number of Pavement Markers measured as noted above will be paid for at the respective contract unit price bid for each class and type specified by the plans or proposal. Said contract unit prices bid shall be full compensation for furnishing and installing the pavement markers, removing temporary pavement markers (if required), and for all materials, equipment, labor and incidentals necessary to complete the work.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

705-A Pavement Markers, Class _____, Type _____ - per each

SECTION 707 DELINEATORS AND HAZARD MARKERS

707.01 Description.

This Section shall cover the work of furnishing delineators and hazard markers and the installation of such at the locations designated on the plans or directed, in conformity with the plans and these specifications.

Delineators will be classified by the "type" installation in accordance with plan details, which set forth details of various types of delineator installation. All delineators will be mounted on posts.

Hazard Markers will be classified according to the type of installation, in accordance with plan details. Hazard markers may be composed of sign panel and/or reflectors with backing panel, mounted on posts or highway structures.

707.02 Materials.

Materials furnished for use shall be new, complying with the appropriate sections of Division 800, Materials. Special reference is made to Section 881.

707.03 Construction Requirements.

(a) DELINEATOR INSTALLATIONS.

1. ERECTING POSTS.

The posts for the delineators shall be set at the locations shown on the plans and as directed by the Engineer. Posts shall be erected to a true vertical position. Any post damaged or otherwise unsuitable for the work shall be removed and replaced by the Contractor at his expense. Posts shall be inserted into the ground to a depth of not less than 24 inches {600 mm}.

Posts may be driven where this can be done without damage to the posts or galvanization. Otherwise, at the Contractor's election, posts shall be set in a 6 inch {150 mm} diameter drilled hole and backfilled with sand and thoroughly flooded with water to insure compaction. This backfill shall extend up to the existing ground elevation, or the Contractor may use poured concrete in lieu of sand. If solid rock is encountered, holes shall be drilled and backfilled with concrete to the top of the rock or as directed.

Concrete for setting posts shall be Class A, Type 2 complying with applicable portions of Section 501, with the following modifications:

The concrete may be dry batched at a central mixing plant and delivered to the project. Before the concrete is placed water shall be added. This may be done in small amounts as needed and mixed on a mixing board or in a mortar box. After water is added, the mix shall be used within sixty (60) minutes. Posts shall be held in proper position until the concrete hardens. The concrete shall have cured for 72 hours before any strain is placed on the post.

Test cylinders for the concrete will not be required.

Where posts are required to be set in concrete medians, holes approximately 6 inches {150 mm} in diameter may be drilled or square holes approximately 6 inches by 6 inches {150 mm by 150 mm} may be cut or formed during placing of the concrete median. The posts shall be set by driving or other approved means, to a depth of not less than 24 inches {600 mm} below top of the median and to such greater depth as may be required to erect the delineator at the required elevation, above the pavement. After the post has been set, the hole up to the bottom of the pavement shall be backfilled and compacted; the hole for the depth of the median pavement shall then be filled with one of the appropriate bituminous plant mixes provided in the Specifications.

2. ATTACHING DELINEATORS.

After erection of the delineator posts as noted, the delineators shall be affixed to the post in the manner shown on the plans.

(b) HAZARD MARKERS INSTALLATIONS.

1. ERECTING POSTS.

Posts, when required, shall be installed in the same manner prescribed in Subarticle (a) for delineator posts modified to cover embedment depth of posts shown by plan details.

2. ATTACHMENT OF MARKERS AND PANELS.

After erection of posts, when required, markers and panels shall be affixed to posts or structures as required in accordance with the details shown on the plans.

(c) PUBLIC CONVENIENCE AND FINAL CLEANUP.

The road may be fully open to the public travel during the progress of work under this section. Hence, when work is to be performed under traffic, the Contractor shall operate his equipment as well as store materials and supplies in such a manner as to cause a minimum of inconvenience to the traveling public. Special attention is directed to Article 107.07.

Upon completion of the work under this Section, the Contractor shall remove all surplus and waste material caused by this work and shall restore the area to at least the same condition as was existing prior to commencing of the work. Any damage to slopes, pavement, etc. caused by the operation of the Contractor's equipment shall be repaired as directed without additional cost to the Department.

707.04 Method of Measurement.

Delineator Installations installed as directed and accepted will be measured by counting separately the number of a particular type or types of delineator installations provided by the plans or proposal.

Hazard Marker Installations installed as directed and accepted will be measured by counting separately the number of a particular type or types of hazard marker installations provided by the plans or the proposal.

707.05 Basis of Payment.

(a) UNIT PRICE COVERAGE.

The number of the particular type of Delineator Installations ordered and accepted, measured as noted above, will be paid for at the respective unit prices bid for each type installation. Said unit price bid shall be full compensation for furnishing and installation of the delineators complete in place, including posts, hardware, brackets, braces and all materials, equipment, tools, labor and incidentals necessary to complete the work.

The number of the particular type of Hazard Marker Installations ordered and accepted, measured as noted above, will be paid for at the respective unit prices bid for each type installation. Said unit price bid shall be full compensation for furnishing and installing the Hazard Marker Installation complete in place, including post or anchors as required by plan details, hardware, brackets, braces and all materials, equipment, tools, labor and incidentals necessary to complete the work.

(b) PAYMENT WILL BE MADE UNDER ITEM NO.:

707-A Type _____, Color Delineator Installation - per each

707-B Type _____ Hazard Marker Installation - per each

SINGLE WHITE OR SINGLE YELLOW DELINEATOR
DOUBLE WHITE OR DOUBLE YELLOW DELINEATOR
PIPE DETAIL

360° DELINEATOR
PIPE DETAIL

3"x4" PRISMATIC REFLECTOR

360° DELINEATOR
PIPE DETAIL

- NOTES:
1. Reflective devices shall be plastic prismatic reflectors (3 1/2" diameter circular or 3" x 4" rectangular), reflective sheathing (4" x 4" high reflectivity reflective sheathing) or 4" wide high reflectivity reflective sheathing encircling P.V.C. pipe.
 2. Prismatic reflectors shall be crystal or yellow as required and shall conform to section 1009 of the Standard Specifications.
 3. High reflectivity sheathing shall be silver-white or yellow as required and shall conform to section 1007 of the Standard Specifications.
 4. Base plates for reflective sheathing type reflectors shall be fabricated from .083" thick 3003 H14, 5052-H39 or 6061 T6 aluminum alloy etched on both sides.
 5. Reflective sheathing type reflectors shall be oriented in a square configuration.
 6. Pipes for 360° delineators shall be white or yellow P.V.C. pipe with outside diameter of 3.5" minimum wall thickness of 100". P.V.C. pipe shall be clean.
 7. Steel posts shall conform to ASTM A499, Grade 60, or ASTM A576, Grade 1080 or ASTM A570, Grade 60, and shall weigh 2.00 lbs. ft. with a weight tolerance of 1.5%. Posts shall be hot-dipped galvanized in accordance with ASTM A123.
 8. Posts may be punched the full length with 2 1/8" diameter holes at 1" centers as an acceptable alternate to hole spacing shown.

DETAIL A

- LEGEND:**
①	SINGLE WHITE
②	350° WHITE
●	SINGLE YELLOW
⏏	TRIPLE HORIZONTAL
OBJECT MARKER
③	350° YELLOW
◇	DOUBLE WHITE

DELINEATOR SPACING TABLE

RADIUS OF CURVE IN FT.	SPACING ON CURVE IN FT.	SPACING IN ADVANCE AND BEYOND CURVE IN FT.		
		A	B	C
LESS THAN 150	25	45	75	150
150 - 300	50	90	150	200
300 - 500	75	135	200	200
500 - 1000	100	180	200	200
1000 - 2000	150	200	200	200
GREATER THAN 2000	200	200	200	200

NOTES:

1. DELINEATORS MAY BE USED AS GUIDE MARKERS TO INDICATE ROADWAY ALIGNMENT. WHEN USED, THEY SHALL ALWAYS MATCH THE COLOR OF THE EDGE LINE AND SHALL BE PLACED AS FOLLOWS:
 - A. DOUBLE WHITE DELINEATORS SHALL BE USED ON THE RIGHT SIDE OF RIGHT HAND ACCELERATION AND DECELERATION LANES.
 - B. DOUBLE YELLOW DELINEATORS SHALL BE USED ON THE LEFT SIDE OF LEFT HAND ACCELERATION AND DECELERATION LANES.
 - C. SINGLE WHITE DELINEATORS SHALL BE PLACED ON THE RIGHT SIDE OF LEFT-CURVING INTERCHANGE RAMPS.
 - D. SINGLE YELLOW DELINEATORS SHALL BE PLACED ON THE LEFT SIDE OF THE TANGENT AND RIGHT-CURVING INTERCHANGE RAMPS.
2. SPACING SHALL BE IN ACCORDANCE WITH THE SPACING TABLE. MAXIMUM RAMP SPACING SHALL BE 200 FT.
3. THE CROSSROAD THROUGH AN INTERSECTION IS NORMALLY DELINEATED ON THE RIGHT SIDE WITHIN THE LIMITS OF THE RIGHT-OF-WAY AT RURAL INTERCHANGES AND GRADE SEPARATIONS. IN URBAN AREAS OR WHERE SIDEWALKS ARE PRESENT, CROSSROAD AND ON-RAMP THROAT DELINEATION IS NOT NORMALLY PROVIDED.
4. ALL DIMENSIONS ARE IN FEET, EXCEPT AS NOTED.

TYPICAL RAMP SPACING

NOT TO SCALE

APPROVED WILLIAM	ARIZONA DEPARTMENT OF TRANSPORTATION INTERMODAL TRANSPORTATION DIVISION STANDARD DRAWINGS	2700
INTERCHANGE DELINEATOR SPACING		4-M-4.03

REVISION NO.	DATE	BY	CHKD BY

MAINLINE DELINEATOR SPACING TABLE

RADIUS OF CURVE IN FT.	MIDDLE ORDINATE AT INSIDE OF P.V.M.T. EDGE (in.)	SPACING ON CURVE IN FT.	SPACING IN ADVANCE AND BEYOND CURVE IN FT.		
			A	B	C
LESS THAN 150	GREATER THAN 90.55	25	45	75	150
150 - 300	46.85 - 90.55	50	90	150	300
300 - 500	27.95 - 46.85	75	135	250	450
500 - 1000	15.35 - 27.95	100	180	300	500
1000 - 2000	7.48 - 15.35	150	270	450	500
2000 - 3000	4.33 - 7.48	200	360	500	500
3000 - 4000	3.93 - 4.33	250	450	500	500
4000 - 5000	3.14 - 3.93	300	500	500	500
5000 - 6000	2.75 - 3.14	350	500	500	500
6000 - 8000	1.96 - 2.75	400	500	500	500
8000 - 10560	1.18 - 1.96	450	500	500	500
GREATER THAN 10560	LESS THAN 1.18	500	500	500	500

NOTES:

- WHITE AND YELLOW DELINEATORS SHALL BE USED AS GUIDE MARKERS TO INDICATE ROADWAY ALIGNMENT. THEY SHALL ALWAYS MATCH THE COLOR OF THE EDGE LINE AND SHALL BE PLACED AS FOLLOWS:
 - FREEWAYS:
 - SINGLE WHITE DELINEATORS SHALL BE INSTALLED CONTINUOUSLY ALONG THE RIGHT SIDE EXCEPT WHERE FIXED LIGHTING SOURCE IS IN PLACE.
 - SINGLE WHITE DELINEATORS SHALL BE PLACED ON THROUGH ROADWAYS AT INTERCHANGES REGARDLESS OF A FIXED LIGHTING SOURCE.
 - SINGLE YELLOW DELINEATORS MAY BE PLACED ON THE LEFT SIDES OF SHARP RIGHT HAND CURVES.
 - NON-FREEWAYS:
 - SINGLE WHITE DELINEATORS SHOULD BE INSTALLED ON THE RIGHT HAND SIDE OF ALL HORIZONTAL CURVES WHERE PRACTICAL EXCEPT WHERE A FIXED LIGHTING SOURCE IS IN PLACE.
 - SINGLE YELLOW DELINEATORS MAY BE PLACED ON THE LEFT SIDE OF DIVIDED ROADWAYS AT SHARP RIGHT HAND CURVES.
 - 360° WHITE DELINEATORS MAY BE PLACED ON THE LEFT SIDE OF UNDIVIDED ROADWAYS AT SHARP RIGHT HAND CURVES.
 - DELINEATORS ARE NOT REQUIRED ON TANGENT SECTIONS; HOWEVER, THEY MAY BE USED ON SHORT TANGENT SECTIONS ADJACENT TO CHANGES IN HORIZONTAL OR VERTICAL ALIGNMENT, OR WHERE THE ALIGNMENT MIGHT BE CONFUSING, OR AT PAVEMENT WIDTH TRANSITIONS.
 - DELINEATORS SHOULD BE USED ON SECTIONS OF ROADWAY NOT EDGE STRIPPED.
- SPACING SHOULD BE IN ACCORDANCE WITH THE SPACING TABLE.
- THE MAXIMUM MAINLINE SPACING SHOULD BE 528 FT.
- DELINEATORS SHOULD NOT BE INSTALLED WITHIN ONE QUARTER OF THE NORMAL SPACING BEFORE OR BEYOND A MILEPOST MARKER, SIGN OR OTHER REFLECTIVE MARKER THAT SHOWS ROADWAY ALIGNMENT.
- WHEN A DELINEATOR FALLS WITHIN A CROSSEWALK, DRIVEWAY, SIDEWALK OR RAIL-OF-EGG, IT SHALL BE PLACED IN EITHER DIRECTION, DISTANCE NOT TO EXCEED ONE-QUARTER OF THE NORMAL SPACING. IF SUITABLE PLACEMENT STILL CANNOT BE OBTAINED, THE DELINEATOR SHALL BE OMITTED.
- ON FREEWAYS, DOUBLE YELLOW DELINEATORS MAY BE USED TO MARK MEDIAN ENFORCEMENT, OR EMERGENCY PURPOSES.
- ON NON-FREEWAY DIVIDED ROADWAYS, SINGLE YELLOW DELINEATORS MAY BE PLACED AT MEDIAN OPENINGS WITH LEFT TURN LINES. THE SINGLE YELLOW DELINEATOR AND TRIPLE HORIZONTAL OBJECT MARKER MAY BE MOUNTED ON A SINGLE POST WHEN THE MEDIAN WIDTH IS 4'-0" OR LESS.
- DELINEATORS SHOULD NOT BE INSTALLED ON NON-FREEWAY ROADWAYS IN URBANIZED AREAS.
- WHERE DELINEATORS ARE REQUIRED, THERE SHALL BE A MINIMUM OF THREE DELINEATORS CONTINUOUSLY VISIBLE. WHERE THREE DELINEATORS ARE NOT VISIBLE, ADDITIONAL DELINEATORS SHALL BE PLACED AT THE MIDPOINTS BETWEEN NORMALLY SPACED DELINEATORS UNTIL THREE BECOME CONTINUOUSLY VISIBLE.
- DELINEATORS ARE NOT REQUIRED WHERE THERE ARE GUARDRAIL TABS OR BARRIER MARKERS.
- ALL DIMENSIONS ARE IN FEET, EXCEPT AS NOTED.

NOT TO SCALE

ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION
STANDARD DRAWINGS

ROADWAY DELINEATOR
PLACEMENT

4-M-4.02

From: <Gonzalo_Gomez@dot.ca.gov>
To: <Jim.FrenchIII@mail.wvu.edu>
Date: 3/30/01 6:40PM
Subject: Median Barrier Delineation

Caltrans does have a standard for median barrier marking. It can be accessed through the InterNet at:

<http://issc.dot.ca.gov/trafops/offsigns/delineat/trafman.htm>
(This may not be accessible to the public)

Also, here is a copy of the text:

6-04.9 Median Barrier Delineation

Median barriers should be delineated when the clearance between the barrier and the edge of traveled way is less than
2.44 m.

In general, when delineated, it should be with an approved median barrier marker, the same color as the left edgeline.
They should be placed on top of the barrier at 14.64 m centers.

Markers placed on the sides of barriers, near the splash zone, should be avoided because of the tendency to collect dirt which reduces their effectiveness. See Figure 6-50, TYPICAL MEDIAN BARRIER DELINEATION AND CHANNELIZERS.

(figure is attached as a jpeg file)

I hope this helps.

Gonzalo Gomez
Maintenance Program
California Dept of Trans

(See attached file: TrafMan6-50.jpg)

TYPICAL MEDIAN BARRIER DELINEATION AND CHANNELIZERS

MEDIAN BARRIER DELINEATION

NOTE: The Median Barrier Marker spacing should correspond with the raised pavement marker spacing used on the left edgeline.

CHANNELIZERS

CHANNELIZER NOTES:

1. A minimum post height of 700 mm may be used at locations where speeds are 64 km/h or less.
2. Channelizer posts used in a construction or maintenance zone shall be orange with white reflectors. However, if the channelizers are to remain in place as a permanent roadway feature after the construction or maintenance period, the post shall be white and the color of the reflector shall conform to that of the pavement markings it supplements.

NOT TO SCALE

Delineators 6-04

6-04.1 Introduction

Delineators are retroreflective devices mounted at the side of the roadway, in series, to indicate the roadway alignment. Delineators are effective aids for night driving and under other conditions of reduced visibility. They are devices to guide rather than warn. Delineators may be used on long continuous sections of highway or through short stretches where there are changes in horizontal alignment, particularly where the alignment might be confusing, or at pavement width transitions. An important advantage of delineators is that they remain visible when the roadway is wet or snow covered.

Delineators are normally placed in the ground outside of the edge of pavement. Where delineation is required within a paved area, surface mounted channelizers may be used. See Section 6-06, CHANNELIZERS.

Installations should be inspected at night to ensure that there are no confusing or misleading delineators.

6-04.2 Delineator Design

Delineators shall consist of retroreflector units capable of clearly reflecting light under normal atmospheric conditions from a distance of 300 m when illuminated by the upper beam of standard automobile lights. The size of retroreflector units shall be a minimum of 75 mm x 300 mm for the front, and when applicable, 75 mm x 75 mm for the back.

There are two classes of delineator posts and several types of retroreflectorization as shown in Figure 6-45, TYPICAL DELINEATORS.

6-04.3 Delineator Application

Delineation is intended to be a clear and simple guide to the motorist regarding alignment of the highway.

The color of the delineator retroreflectors shall conform to the color of edgelines except for the use of yellow on the right at narrow bridges and red at truck escape ramps.

Examples of the use of delineators are shown in Figure 6-45, TYPICAL DELINEATORS. Color exceptions, are shown in Figure 6-48, NARROW BRIDGE SIGNING AND MARKINGS and Figure 6-49, TYPICAL RUNAWAY TRUCK RAMP SIGNING AND MARKINGS.

TYPICAL DELINEATORS AND USES:

- Type E - White Retroreflector (2 Sided). For use on the left or right of 2-lane 2-way streets and highways when it is desirable to have a reflector on the front, and one on the back of the delineator facing the opposite direction of traffic.
- Type F - White Retroreflector (1 Sided). For use on the right of freeways and expressways. They may also be used on 2-lane 2-way streets and highways when the Type E is not needed.
- Type G - Yellow Retroreflector (1 Sided). For use on the left of divided highways and 2-lane highway intersections as shown in Figure 6-46, TYPICAL EXAMPLES OF DELINEATOR PLACEMENT WHEN USED AT INTERSECTIONS, ISLANDS, RAMPS AND CONNECTORS.

- Type I - Yellow Retroreflector (2 Sided). For use at approaches to narrow bridges as shown in Figure 6-48, NARROW BRIDGE SIGNING AND MARKINGS.
- Type J - Red Retroreflector (1 Sided). For placement on both sides of Truck Escape Ramps as shown in Figure 6-49, TYPICAL RUNAWAY TRUCK RAMP SIGNING AND MARKINGS.

Delineators with the appropriate retroreflector color are used to indicate the narrowing of the pavement where either an outside or inside lane merges into an adjacent lane. The delineators should be used adjacent to the lane affected for the full length of the convergence and should be so placed and spaced to show the width reduction as shown in Figure 6-15, TYPICAL LANE REDUCTION TRANSITION.

6-04.4 Delineator Placement and Spacing

Delineators, when used, shall be mounted so that the top of the retroreflector is about 1.2 m above the edge of traveled way. They shall be placed 0.61 to 1.83 m outside the outer edge of the shoulder, or if appropriate, in the line with the guardrail post.

Delineators should be placed at a constant distance from the edge of the roadway except that, where a guardrail or other obstruction intrudes into the space between the pavement edge and the extension of the line of delineators, the delineators should be in line with or taper to inside the innermost edge of the obstruction. See Figure 6-45, TYPICAL DELINEATORS.

Unless local conditions justify otherwise, delineators shall be placed on all State highways and should be provided on all city and county roads as follows:

- a. On the outsides of highway curves of 914 m radius or less (including medians in divided highways), freeway exit and entrance ramps and connectors. Exception to this, is where a median barrier is delineated as shown in the Median Barrier Delineation Detail in Figure 6-50, TYPICAL MEDIAN BARRIER DELINEATION AND CHANNELIZERS. Delineator spacing on curves is shown in Figure 6-47, DELINEATOR SPACING ON CURVES.
- b. On the right of tangent sections of freeway entrance and exit ramps, collector roads, freeway connectors and lane reduction transition sections at 60 m spacing.
- c. On embankments higher than 3.0 m and with side slopes steeper than 1:4. Delineator spacing is approximately 160 m.
- d. On approaches to narrow bridges as shown in Figure 6-48, NARROW BRIDGE SIGNING AND MARKINGS.
- e. On tangent sections of rural State highways where there are no reflective pavement markers, such as in snow areas. Delineator spacing is approximately 160 m.
- f. On all new guardrail or bridgerail installations, or when maintenance is required on existing guardrail or bridgerail, within 3.66 m of the edge of traveled way and curves of 900 m radius or less. The spacing on tangent sections is approximately 160 m. For spacing on curves, see Figure 6-47, DELINEATOR SPACING ON CURVES.

Delineators may also be placed as follows:

- a. At intersections, road approaches, and median openings, as shown in Figure 6-46, **TYPICAL EXAMPLES OF DELINEATOR PLACEMENT WHEN USED AT INTERSECTIONS, ISLANDS, RAMPS AND CONNECTORS.**
- b. On sections of highway with non-standard shoulder width.

Where normal uniform spacing is interrupted by driveways, intersections, etc., delineators may be moved a distance not exceeding 1/4 of the normal spacing. If they still fall within such areas, the delineator should be eliminated.

Delineator spacing should be adjusted on approaches to and throughout horizontal curves so that several are always visible to the motorist. On short radius curves, it may be necessary to adjust the delineator several degrees toward the roadway so that it is perpendicular to the line of oncoming traffic.

Miscellaneous Delineators

6-04.5 Culvert Markers

Culvert markers may be placed on both sides of the highway at those culverts where they are necessary. They should be so placed as not to interfere with a line of delineators and shall not be reflectorized, or contain kilometer post marker information. Further information on culvert markers is shown in the Caltrans Maintenance Manual chapter on TRAFFIC SAFETY DEVICES.

6-04.6 Kilometer Post Markers

Procedures and responsibilities for establishing postmile values and placing markers on State highways are described in Chapter 3, ACCIDENT AND ROADWAY RECORDS, Kilometer Post Markers, of this Manual.

6-04.7 Emergency Passageway Marker

Where freeway median passageways are provided for emergency vehicles, delineation for the crossover should be as follows:

- a. At a point, 320 m in advance of the crossover, one Class 1 Delineator, with a yellow post and two 75 mm x 300 mm white retroreflectors stacked vertically (600 mm of white retroreflectance), should be placed on the left side of the through roadway facing approaching traffic.
- b. At a point, 160 m in advance of the crossover, one Class 1 Delineator, with a yellow post and two 75 mm x 300 mm yellow retroreflectors stacked vertically, should be placed on the left side as in (a).

- c. At the far side of the crossover, one Class 1 Delineator, with a yellow post and one 75 mm x 300 mm white retroreflector over one 75 mm x 300 mm yellow retroreflector stacked vertically, should be placed on the left side as in (a).

The need and location of emergency markers may be coordinated between the emergency agency and the Department. See Chapter 7, TRAFFIC SAFETY SYSTEMS of this manual, for a discussion of emergency passageways.

6-04.8 Narrow Bridge Signing and Marking

The placement of warning signs, object markers, delineators, and edgelines at narrow bridges is dependent upon the width of the bridge and approach roadway. Narrow bridge signing and marking shall conform to the details shown in Figure 6-48, NARROW BRIDGE SIGNING AND MARKINGS.

6-04.9 Median Barrier Delineation

Median barriers should be delineated when the clearance between the barrier and the edge of traveled way is less than 2.44 m.

In general, when delineated, it should be with an approved median barrier marker, the same color as the left edgeline. They should be placed on top of the barrier at 14.64 m centers.

Markers placed on the sides of barriers, near the splash zone, should be avoided because of the tendency to collect dirt which reduces their effectiveness. See Figure 6-50, TYPICAL MEDIAN BARRIER DELINEATION AND CHANNELIZERS.

V DUGREL CURVE	R RADIUS (FEET)	SPACING ON CHAVE (FEET)	S SPACING IN ADVANCE OF A AND BEYOND CHAVE (FEET)					
			FIRST		SECOND		THIRD	
			SPACE	SPACE	SPACE	SPACE	SPACE	SPACE
0-50	1440.0	...	...	...	...	...	...	...
1-00	3130.0	278	300	300	300	300	300	300
1-50	3820.0	184	300	300	300	300	300	300
2-00	7085.0	159	300	300	300	300	300	300
2-50	142	142	284	300	300	300	300	300
3-00	1910.0	129	236	300	300	300	300	300
3-50	6317.7	120	233	300	300	300	300	300
4-00	13232.3	105	210	300	300	300	300	300
4-50	17273.3	88	188	296	296	296	296	296
5-00	10661.8	84	188	281	281	281	281	281
5-50	9253.0	80	181	271	271	271	271	271
6-00	485	87	175	260	260	260	260	260
6-50	818.6	83	166	250	250	250	250	250
7-00	1066.0	80	166	232	232	232	232	232
7-50	710.2	77	161	212	212	212	212	212
8-00	674.1	75	150	200	200	200	200	200
8-50	650.2	72	141	181	181	181	181	181
9-00	573.0	69	137	208	208	208	208	208
10-00	545.7	67	126	195	195	195	195	195
11-00	498.3	64	121	181	181	181	181	181
12-00	471.5	63	124	184	184	184	184	184
13-00	364.9	65	109	167	167	167	167	167
14-00	312.8	62	106	157	157	157	157	157
15-00	272.8	65	96	140	140	140	140	140
16-00	259.2	60	80	120	120	120	120	120
17-00	240.0	58	71	107	107	107	107	107
18-00	183.2	56	54	81	81	81	81	81
19-00	141.6	54	48	72	72	72	72	72
20-00	95.0	50	40	61	61	61	61	61

* ON ORIGINATIONAL RECORDS, ONLY THE THIRD SPACE
AND DOUBLE THE SPACING ON THE CURVE, NOT THE
ADVANCE OF THE SPACING ON THE CURVE. (300 MAX.)

● SPACING FOR CURVES NOT SHOWN MAY BE COMPUTED
FROM THE FORMULA $S = 1 - \frac{1}{R} - 50$

SPACING IN ADVANCE OF AND BETWEEN CURVES IS
FIRST SPACE = 2.5, SECOND SPACE = 2.5, THIRD
SPACE = 2.5, SPACES SHOULD NOT BE LESS THAN
1.0. SPACES SHOULD NOT BE MORE THAN 1.1. (SEE
PAGE 100) (SEE PAGE 100)

R = $\frac{375}{V}$

- 1 SEE THE VARIATIONS OF QUANTITIES INCLUDED IN THE PLANS FOR THE NUMBERS AND QUANTITIES OF DELINEATORS REQUIRED TO MARK THE SPACING.
- 2 THE COLOR OF DELINEATORS SHALL BE, IN ALL CASES, CONFORM TO THE COLOR OF THE LANE LINES, EXCEPT:
A. RED DELINEATORS
B. TYPE B DELINEATORS (SEE YELLOW)
3. THE COLOR OF DELINEATION POSTS AND ALL SPECIAL WARNING DEVICES SHALL BE INTERMEDIATE GREEN.
4. DELINEATORS ARE UNDESIRABLE ON ALL ROADWAYS ON THE STATE HIGHWAY SYSTEM THAT ARE OTHERWISE MARKED EITHER BARRED OR LIGHTING IS IN OPERATION HOWEVER, ALL CONCRETE SLOTTED TYPE "C" CUBICATORS SHALL HAVE REFLECTORS OR SUPPLEMENTAL LENS.
5. TYPE 1 FOLLOW-UP DELINEATORS AND WARDINGS ON THE LEFT SIDE OF THREE-LANE ROADWAYS (ADDITIONAL)
- 6 DELINEATORS MAY BE INSTALLED ON THE INVERSE SIDE OF ANY REVERSAL AND/OR FOR A SEPARATE POST ON ANY ROADWAYS OR RAMP WHERE INTERSECTION SHOWS A NEED FOR WARNING--SEE ADVISORY SECTION
- 7 TYPE IN (3-YELLOW) DELINEATORS ARE TO BE INSTALLED TO MARK OF THE EXISTENCE OF OBJECTS NOT ACTUALLY IN THE ROADWAY BUT THAT MAY BE SO CLOSE TO THE EDGE OF THE ROADWAY AS TO BE LIKELY TO BE DETECTED BY DRIVERS, AND TRAILERS HEADS, THE REAR EDGE OF THE WARDING SHALL BE IN LINE WITH THE INNER EDGE OF THE OBSERVATION AREA
- 8 INTERPOLATED RAMP SPACING SHALL BE DETERMINED ON THE RAMP SLOPE, THE TYPE OF TRUCKS AND TRAILERS, AND THE COLOR OF THE YELLOW DELINEATORS TO BE APPROPRIATE (SEE AS ILLUSTRATED ON SHEET NUMBER 3)
- 9 FROMAGE WIND DELINEATORS ARE NOT TO BE INSTALLED WHERE THEY WOULD BE INTERFERING TO WARNING TRAFFIC
- 10 SPACING OF DELINEATORS FOR TUNNELS AND SNOW SLOPS SHALL BE AS SHOWN ON THE PLANS

2. POISTS SHALL BE A UNIFORM PLANGED CHANNEL, SECTION (H-SHAPES) SHALL BE HOT ROLLED STRUCTURAL STEEL, IN-ROLLING CASE STEEL, OR HOT ROLLED STEEL, YIELDING A MINIMUM TENSILE STRENGTH OF 30,000 PSI AND A MINIMUM TENSILE STRENGTH OF 50,000 PSI
3. POISTS SHALL BE SET ON GROUND OR EXCAVATED HOLES, EXCAVATED HOLES SHALL BE PROPERLY DAMPED IN PLACE, OR SHALL BE CONCRETE PADLBS.
4. A MINIMUM OF 3 JOISTS OF $\frac{1}{8}$ " DIAMETER SPACED AS SHOWN, ARE REQUIRED FOR ALL DRAINAGE POSTS
5. AN ADDITIONAL JOIST IS REQUIRED WHEN THE ADJUSTABLE INJECTION HOUSING IS USED

Colorado Department of Transportation

4701 East Alvarado Avenue
Denver, Colorado 80222
Phone (303) 757-8436 FAX (303) 757-5711

Safety & Traffic Engineering Branch KA

Computer File Information			
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Drawing File Name	5812010105.dwg	Scale	1/4" = 1'-0"
Acad Version	R/2000	Units	Feet

[illegible]

TYPICAL DELINEATOR INSTALLATIONS

STANDARD PLAN NO.
S-612-1
Sheet No. 1 of 5

Safety & Traffic Engineering Branch KA

Issued by Traffic Engineering Unit October 1, 2000

Sheet No. 1 of 5

DECEL. LANE & RAMP RIGHT SIDE

RAMP & ACCEL. LANE RIGHT SIDE

DECEL. LANE & RAMP LEFT SIDE

RAMP & ACCEL. LANE LEFT SIDE

TYPICAL INSTALLATION FOR INTERCHANGES

- LEGEND:**
- A - 1st CURVE SPACING TABLE
 - B - 2nd CURVE SPACING TABLE
 - C - SPACING ON CURVE
 - D - BEYOND SPACES (FIRST & SECOND)
 - E - LAST SPACE

NOTE:

DELINERATORS MAY BE INSTALLED IF NECESSARY FOR "WORKING WAY" PROTECTION. SEE OTHER TYPICAL INSTALLATIONS.

TYPICAL SLEEVE INSTALLATION FOR MEDIAN DELINEATOR POSTS

TYPICAL INSTALLATION FOR RAMP CURVES

TYPICAL INSTALLATION FOR INTERSECTIONS WITH ACCEL. & DECEL. LANES

<p>Colorado Department of Transportation</p> <p>4701 East Alameda Avenue Denver, Colorado 80222 Phone (303) 757-9438 FAX (303) 757-9218</p> <p>Safety & Traffic Engineering Branch KA</p>	Computer File Information		Standard Plan Revised		TYPICAL DELINEATOR INSTALLATIONS		STANDARD PLAN NO.
	Path: \\c:\data\cvt\Drawings\Project\Drawings\Standard\	Date	Comments				S-612-1
	Drawing File Name: S812010302.dwg	Scale: 1/4" = 1'-0"	Units: English	Issued By: Traffic Engineering Unit	October 1, 2000		Sheet No. 3 of 5

**MOUNTING POSITION ON
GUARD RAIL TYPE 3**

**TYPICAL GUARDRAIL
REFLECTOR TAB**

SEE THE APPROPRIATE GUARDRAIL STANDARD PLANS FOR REFLECTOR TAB FABRICATION AND PLACEMENT DETAILS

**TYPICAL GUARDRAIL
POST MOUNT DELINEATORS**

POST MOUNT DEFLECTORS SHALL BE
ATTACHED BY A METHOD APPROVED BY THE ENGINEER
OR A METHOD REQUIRED BY THE DEVICE MANUFACTURER

TYPICAL ADJUSTABLE REFLECTOR BRACKET

TYPICAL BRACKET FABRICATION DETAILS

BRACKET NOTES

- 1 THE ADJUSTABLE REFLECTOR BRACKET IS TO BE USED TO "TYPICAL ORIENT" BACK-TO-BACK DELINEATORS USED ON CURVES.
 - 2 REFLECTOR BRACKETS SHALL BE FABRICATED FROM EITHER GALVANIZED SHEET NOT THICKER THAN 18 GAUGE, OR ALUMINUM NOT LESS THAN 0.100 IN. THICKNESS.
 - 3 BOLTS AND NUTS AND WASHERS SHALL BE GALVANIZED OR CHROMIUM PLATED.
 - 4 AN HOOK-UP LINES ARE $3/16"$ DIAMETER AND DELINEATOR POLES REQUIRE AN ADDITIONAL HOLE 2' BELOW THE TOP HOLE PROVIDED IN THE POST.
 - 5 SHOWN BEHIND THE BRACKET APPROX. 10° AS SHOWN. ATTACH TO DELINEATOR POST WITH $3/16"$ BOLTS AND FIELD BRAD AS NECESSARY TO MAINTAIN ORIENT. WHEN THE BRACKET REFLECTOR CAN BE ATTACHED WITH A $7/16"$ TEND EXPANSION NUT ON A BOLT.
- FOR THE HEADS OF ALL BOLTS TO PREVENT NUT LOOSENING, OR ANTI-ROTATION.

TYPICAL REFLECTOR DETAILS FOR CONCRETE BARRIER

BARRIER REFLECTOR NOTES

- 1 BARRIER REFLECTORS REGARDLESS OF TYPE SHALL MEET THE REFLECTIVE QUALITIES SPECIFIED IN SECTION 713 OF THE STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND THE FOLLOWING REQUIREMENTS FOR USE OF THESE REFLECTORS IS MANDATORY:
 - 2 THE COLOR OF REFLECTING SURFACE SHALL MATCH THE COLOR OF THE ADJACENT CURB LINE
 - 3 CONCRETE SURFACE PREPARATION, ADDRESS, AND METHOD OF APPLICATION SHALL BE AS RECOMMENDED BY THE REFLECTOR MANUFACTURER
 - 4 UNLESS OTHERWISE NOTED IN THE PLANS OR DIRECTED BY THE ENGINEER A 200 FOOT WORKZOOM MOUNTED AND CURVE SPACING APPLIES TO BARRIER REFLECTORS
 - 5 THE MOUNT REFLECTIONS ARE STANDARD SUFFICIENT BARRIER REFLECTIONS MAY BE RELINISHED IF SPLITCHED IN THE PLANS
 - 6 A BARRIER REFLECTORS SHALL BE TYPE II (YELLOW YELLOW, BACK-TO BACK)
 - 7 FOR A TWO-WAY ROADWAY BARRIER, REFLECTORS SHALL BE TYPE II (CRYSTAL-CRYSTAL, BACK-TO-BACK)
- END LINE DATA BARRIER REFLECTORS SET 4012 0 01 4-20-20

Colorado Department of Transportation 4201 East Arkansas Avenue Denver, Colorado 80222 Phone: (303) 757-5438 FAX: (303) 757-9219		Computer File Information Path: see dot slide to us/development/Standard/ Drawing File Name: S412010405.dwg Acad Version: R1400 Scale: N/A Units: English	Standard Plan Revised Date: _____ Comments: _____	TYPICAL DELINEATOR INSTALLATIONS Issued by: Traffic Engineering Unit, October 1, 2000	STANDARD PLAN NO. S-612-1 Sheet No. 4 of 5
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612 DELINEATORS AND REFLECTORS

Delineation is intended to be a guide to the vehicle operator as to the alignment of the highway; whatever is needed to provide that guidance in a clear and simple way should be installed. An important advantage of delineators is that they remain visible when the roadway is wet or snow covered.

612.00 INSPECTION - DELINEATORS AND REFLECTORS

BEFORE WORK STARTS:

1. Inspect posts and reflectors for damage
2. Check that location of delineator is correct.

DURING WORK:

3. Inspect for specified height and lateral clearance from roadway.
4. Verify that spacing between delineators complies with the table shown on the Standard.
5. Delineator posts must be plumb.
6. Number and color of reflectors must be correct.
7. Check for painting of posts when required.

2. Anne

This work consists of furnishing and installing reflectors with double white faced, or double yellow faced or white and yellow faced, on P.C.C. Safety Barrier or on concrete surfaces in accordance with the designated locations on Plans and/or as directed by the Engineer.

The reflector shall be ASTRO OPTICS No. JD-1, manufactured by ASTRO OPTICS or Flex 2020 Barrier Delineator 100 mm x 75 mm, manufactured by DURA FLEX or approved equal.

Method of Measurement:

Basis of Payment:

N - 7/12/99

SECTION 705 HIGHWAY DELINEATORS

705-1 Description.

Furnish and install object markers and highway delineators, with supporting posts, of the types and at the locations called for in the plans. Highway delineators consist of a reflector, or reflective sheeting permanently adhered to sheet aluminum, mounted to delineator post. Use only delineator posts, reflectors and reflective sheeting listed on the Qualified Products List.

705-2 Materials.

705-2.1 Delineator Assembly: Meet the requirements of Sections 993 and 994.

705-2.2 Object Markers: Meet the arrangement and design requirements of Section 3C of the MUTCD, with the following additions:

(1) Use 0.080 inch [2.0 mm] aluminum sheets and plates and conform to ASTM B 209 [ASTM B 209M], Aluminum Association Alloy 6061-T6 or 5052-H38, or Fiberglass Reinforced Plastic Sign Panels conforming to 700-2.2.

(2) Obtain the Engineer's approval of the object marker bracket and attachment.

705-2.3 Metal Delineator Posts: Meet the requirements of Section 993.

705-2.4 Flexible Delineator Posts: Meet the requirements of Section 972.

705-2.5 Reflective Sheeting for Delineator Posts: Use Types III-A, III-B, III-C, or III-D reflective sheeting meeting the requirements of Section 994.

705-3 Installation Requirements.

Install the posts and mount the delineator assemblies or object markers to the top of the posts in accordance with the manufacturer's instructions. Install surface mounted posts to a height of 36 inches [1 m] from the existing surface to the top of the posts. Install ground mounted posts to a height of 48 inches [1.2 m] from the existing ground to the top of the posts.

Where reflective sheeting is a part of the delineator assembly, provide an assembly having a minimum of 4 by 8 inches [100 by 200 mm] of reflective sheeting, free of physical damage prior to and after installation. Mount the reflective sheeting using pressure sensitive adhesive in accordance with sheeting manufacturer's requirements, to prevent disbonding of the sheeting during the life of the post.

705-4 Method of Measurement.

The quantity to be paid for will be the number of delineators or object markers furnished, installed and accepted.

705-5 Basis of Payment.

Prices and payments will be full compensation for work specified in this Section, including the cost of labor, materials, and incidental items required to complete the work.

Payment will be made under:

Item No. 705- 1-	Delineator, Single Unit - each.
Item No. 2705- 1-	Delineator, Single Unit - each.
Item No. 705- 2-	Delineator, Double Unit - each.
Item No. 2705- 2-	Delineator, Double Unit - each.
Item No. 705- 3-	Delineator, Triple Unit - each.
Item No. 2705- 3-	Delineator, Triple Unit - each.
Item No. 705- 10-	Object Marker - each.
Item No. 2705- 10-	Object Marker - each.
Item No. 705- 71-	Tubular Delineator (Flexible) - each.

SECTIONAL VIEW

Two single white reflector units placed back to back, one on each side of post to mark roadway on the outside of hazardous curves.

PLAN - TWO-WAY ROADWAYS

PLAN - DUAL HIGHWAYS

SPACING FOR DELINEATORS ON HORIZONTAL CURVES				
Radius of Curve m if feet	Spacing on Curve m if feet	Spacing in Advance and Beyond Curve m if feet		
		1st. Space	2nd. Space	3rd. Space
Less than 30	5	10	20	40
30 - 5 (100)	10	20	40	80
50 - 75 (150)	15	30	60	120
75 - 100 (200)	20	40	80	160
100 - 125 (250)	25	50	100	200
125 - 150 (300)	30	60	120	240
150 - 175 (375)	35	70	140	280
175 - 200 (400)	40	80	160	320
200 - 225 (475)	45	90	180	360
225 - 250 (550)	50	100	200	400
250 - 275 (625)	55	110	220	440
275 - 300 (700)	60	120	240	480
300 - 325 (775)	65	130	260	520
325 - 350 (850)	70	140	280	560
350 - 375 (925)	75	150	300	600
375 - 400 (1000)	80	160	320	640
400 - 425 (1075)	85	170	340	680
425 - 450 (1150)	90	180	360	720
450 - 475 (1225)	95	190	380	760
475 - 500 (1300)	100	200	400	800
500 - 525 (1375)	105	210	420	840
525 - 550 (1450)	110	220	440	880
550 - 575 (1525)	115	230	460	920
575 - 600 (1600)	120	240	480	960
600 - 625 (1675)	125	250	500	1000
625 - 650 (1750)	130	260	520	1040
650 - 675 (1825)	135	270	540	1080
675 - 700 (1900)	140	280	560	1120
700 - 725 (1975)	145	290	580	1160
725 - 750 (2050)	150	300	600	1200
750 - 775 (2125)	155	310	620	1240
775 - 800 (2200)	160	320	640	1280
800 - 825 (2275)	165	330	660	1320
825 - 850 (2350)	170	340	680	1360
850 - 875 (2425)	175	350	700	1400
875 - 900 (2500)	180	360	720	1440
900 - 925 (2575)	185	370	740	1480
925 - 950 (2650)	190	380	760	1520
950 - 975 (2725)	195	390	780	1560
975 - 1000 (2800)	200	400	800	1600
1000 - 1025 (2875)	205	410	820	1640
1025 - 1050 (2950)	210	420	840	1680
1050 - 1075 (3025)	215	430	860	1720
1075 - 1100 (3100)	220	440	880	1760
1100 - 1125 (3175)	225	450	900	1800
1125 - 1150 (3250)	230	460	920	1840
1150 - 1175 (3325)	235	470	940	1880
1175 - 1200 (3400)	240	480	960	1920
1200 - 1225 (3475)	245	490	980	1960
1225 - 1250 (3550)	250	500	1000	2000
1250 - 1275 (3625)	255	510	1020	2040
1275 - 1300 (3700)	260	520	1040	2080
1300 - 1325 (3775)	265	530	1060	2120
1325 - 1350 (3850)	270	540	1080	2160
1350 - 1375 (3925)	275	550	1100	2200
1375 - 1400 (4000)	280	560	1120	2240

GENERAL NOTES

Delineators on tangent sections of main line roadways shall be placed at 120 m (1400') spacing. Delineators on ramps and acceleration and deceleration lanes shall be placed at a maximum spacing of 30 m (100').

Refer to Standard T20011 for details of metal post.

Double white reflector units shall be used to mark the right side of all acceleration and deceleration lanes (double amber for the left side of left-hand acceleration and deceleration lanes). Single delineators shall be used to mark ramps, white on the right side and yellow on the left. Delineators shall be used on ramps to mark the outside of all curved sections.

All dimensions are in millimeters (inches) unless otherwise shown.

DELINEATORS	
DATE	REVISIONS
1-1-97	Revised Standard 2142-12.
6-15-94	Moved G.M. to Specs.
	Added metric.
STANDARD 635001	

STATE DEPARTMENT OF TRANSPORTATION
 DIVISION OF HIGHWAYS
 PROJECT NO. 100-1000
 DRAWING NO. 100-1000
 DATE 10/1/97
 BY [Signature]
 CHECKED [Signature]
 APPROVED [Signature]

GUARDRAIL / BARRIER WALL / BRIDGE RAIL REFLECTORS

SHEETING POSITION CASE II

All dimensions are in millimeters (inches) unless otherwise shown.

REFLECTOR AND TERMINAL MARKER PLACEMENT		STANDARD 635008-01
DATE	REVISIONS	
1-1-01	Reverse direction arrow for two-way traffic	
	view	
1-1-00	New Standard

CASE II

CASE I

TERMINAL MARKER DETAILS

State Department of Transportation	
APPROVED	DESIGNED
DATE	DATE
1-1-01	1-1-01
1-1-00	1-1-00
1-1-00	1-1-00

Min. reflective area
4,194 mm² (6 1/2 Sq. in.)
each side. May be
rectangular or slight
trapezoid.

Minimum total area of
base 4,516 mm² (7.0 Sq. in.)

Cross section may be "L"
shaped and may have
side supports at ends.

REFLECTOR MARKER TYPE C

TYPICAL MOUNTING WITH REFLECTOR

TYPICAL MOUNTING DETAIL
FOR BRIDGE RAIL REFLECTOR

TYPICAL MOUNTING DETAIL
FOR BARRIER WALL REFLECTOR

Dimensions are in millimeters (inches)
unless otherwise shown.

Illinois Department of Transportation	
PROJECT	STATE ROUTE 100
DESIGN	SECTION 100
DATE	10/1/88
BY	Marked
FOR	10/1/88

REFLECTOR MARKER AND MOUNTING DETAILS

(Sheet 2 of 3)

STANDARD 635011-01

REFLECTOR MARKER TYPE A

Adhesive weep slots or holes
equally spaced on both sides

Dimensions are in millimeters (inches)
unless otherwise shown.

DATE	REVISIONS
1-1-01	Revised signature block.
1-1-00	New Standard

REFLECTOR MARKER TYPE B

United States Department of Transportation
 FEDERAL HIGHWAY ADMINISTRATION
 OFFICE OF RESEARCH AND TECHNOLOGY
 WASHINGTON, D.C. 20590
 PROJECT NO. 1-1-01
 DRAWING NO. 1-1-01
 SHEET NO. 1 OF 1

REFLECTOR MARKER AND
MOUNTING DETAILS
(Sheet 1 of 3)
STANDARD 635011-01

STANDARD TERMINAL MARKER

Dimensions are in millimeters (inches) unless otherwise shown.

REFLECTOR MARKER AND MOUNTING DETAILS

(Sheet 3 of 3)

STANDARD 635011-01

DETAIL OF MOUNTING TERMINAL MARKER TO POST

SIGN SIZE	DIMENSIONS			
	A	B	C	D
305x406 (12x16)	103 (4.0)	406 (16.0)	38 (1.5)	50 (2.0)

Approved: _____
 Date: _____
 Prepared by: _____
 Checked by: _____
 Drawn by: _____
 Title: _____
 Scale: _____
 Sheet: _____ of _____

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
GUARDRAIL AND BARRIER WALL DELINEATION

Effective December 15, 1993
Revised January 1, 1997

Description. This work shall consist of furnishing and installing reflectorized guardrail markers, bridge rail markers, or barrier wall markers complete with reflectors or reflective faces as specified, and terminal marker post, when specified

Materials. Materials shall be according to the following

- (a) Terminal Marker Post. The posts shall be according to Article 1006.29 of the Standard Specifications for Type C galvanized posts.

Hardware for attaching sign panels to posts shall be stainless steel and be according to Article 1006.29(d) of the Standard Specifications.

- (b) Terminal Markers.

- (1) Direct Applied Reflectorized Terminal Marker Direct applied reflectorized terminal markers shall be fabricated using Type A or Type AP reflectorized sheeting. All materials used shall be according to Section 1090 and 1091 of the Standard Specifications.

The sheeting shall be uniform in color throughout and be according to the latest appropriate standard color tolerance chart issued by the U.S. Department of Transportation, Federal Highway Administration of through instrumental color testing, the diffuse day color of the reflective material shall be according to Table 1.

TABLE 1
Color Specification Limits (Daytime)
Type AP

Color	1		2		3		4		Reflectance Limit Y(%)	
	X	Y	X	Y	X	Y	X	Y	Min.	Max.
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	30	45
White	0.303	0.287	0.368	0.353	0.340	0.380	0.274	0.316	50	-

The 4 pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1391 standard colorimetric system measured with standard illuminant D 65.

Type AP sheeting shall have the minimum values shown in Table 1091-1 for the type and color of material specified.

Type AP sheeting surface shall exhibit an 85 degree gloss-meter rating of not less than 50 when tested according to ASTM D 523.

The thickness of Type AP sheeting without protective liner shall not be more than 0.64 mm (0.025 inches)

- (2) Post Mounted Reflectorized Terminal Marker. Post mounted reflectorized markers shall be fabricated using a Type I Sign Panel complete with reflectorized sheeting. The reflectorized material shall be Type A or Type AP Sheeting. All materials used shall be according to Sections 1090 and 1091 of the Standard Specifications.

CHECK SHEET #38

(c) Guardrail and Barrier Wall Markers.

- (1) Type A Reflector Marker. The reflectors shall conform to the requirements of Section 1097 of the Standard Specifications.

The steel mounting bracket utilized for attaching reflectors to guardrail shall be fabricated from 12 gauge (minimum) steel, and galvanized according to AASHTO M 111.

The steel banding utilized for attaching reflectors to bridge rail shall be 19 mm (3/4 inch) stainless steel banding.

- (2) Type B Reflector Marker. The reflectors shall be according to Section 1097 of the Standard Specifications.

The lexan mounting bracket shall be made of high impact lexan approved by the Department. The bracket shall be white or brown in color. Brown brackets shall be specified for use with weathering M 222 (M 222M) steel guardrail applications, and white brackets shall be specified for all other applications.

- (3) Type C Reflector Marker. Molded reflective surfaces, when used, shall be according to Section 1090 of the Standard Specifications, except subparagraph (d).

Flexible reflective sheeting faces, when used, shall be fabricated of either a weather resistant sealed micropismatic sheeting or a high-performance reflective sheeting meeting the minimum reflective values for incidence angles of -4 and +30 degrees for Type A sheeting as set forth in Table 1091-1 of the Standard Specifications or the requirements for Type AP sheeting contained herein. The sheeting shall be manufactured by either 3M, Stimsonsite, Reflexite, or an approved equivalent. The Contractor shall furnish written documentation from the sheeting manufacturer that the sheeting is approved as being compatible for use as a permanent reflector face. The sheeting shall adhere securely to the bracket at temperatures of -34 °C to +71 °C (-30 °F to +160 °F) and shall not crack when struck at -23 °C (-10 °F).

The base material shall be fabricated from high impact thermoplastic, lexan, nylon, or other approved material which shall not shatter or crack under impact at temperatures of -34 °C (-30 °F).

CONSTRUCTION REQUIREMENTS

- (a) Terminal Marker Posts. The posts shall be driven by hand or mechanical means to a minimum depth of 900 mm (3 ft.) and installed according to the details shown on the plans or as directed by the Engineer. The top of the post shall be 760 mm (30 inches) above ground. The post shall be protected by a suitable driving cap and if required by the Engineer, the material around the post shall be compacted after driving. The posts shall be vertical and oriented so the face of the terminal marker shall be at 90 degrees to the center line of the adjacent pavement.

Scratching, chipping, or other damage to the post shall be avoided during handling and installation. Chips and scratches may be recoated in the field by a method meeting the coating manufacturer's recommendation except chips and scratches totaling more than 5 percent of the surface area of any one post and/or more than 5 percent of the surface area in 305 mm (1 ft.) segment of any one post shall be cause for rejection of the post.

(b) Terminal Markers.

- (1) Direct Applied Reflectonized Terminal Marker. The direct applied reflectonized guardrail terminal markers shall be installed directly on the guardrail nose. The marker shall be installed as shown on the plans and directly to the guardrail terminal end. The surface of the guardrail terminal end shall be cleaned of all contaminants prior to the installation of the terminal marker. The surface shall be cleaned using a 5-8 percent phosphoric acid solution and rinsed with clean water or as recommended by the manufacturer of the direct applied terminal marker sheeting and as approved by the Engineer.
- (2) Post Mounted Reflectonized Terminal Marker. Post mounted reflectonized terminal markers shall be installed on terminal marker posts. A minimum of 2 bolts per post shall be required for reflectonized terminal marker panel attachment.

(c) Guardrail and Barrier Wall Markers.

- (1) **Type A Reflector Marker** Type A reflector marker shall be installed on guardrail or bndgerail as shown on the plans. When installed on guardrail, bolts for fastening will be required. The bolt-on guardrail marker shall consist of 1 or 2 round prismatic reflectors as specified attached to a steel mounting bracket. The reflector(s) shall be securely fastened to the bracket with an aluminum rivet. When used with "W" section guardrail, it shall be attached by loosening a guardrail bolt, then slipping the slotted bracket under the head of the bolt and retightening the bolt.

Type A Reflective Markers shall be used on oval or circular bridge rails. The marker shall be attached to the bridge rail using stainless steel banding.

The face of the marker shall be vertical and oriented so the reflector face shall be at 90 degrees to the centerline of the guardrail web, or to the centerline of the bridge rail.

- (2) **Type B Reflector Marker.** Type B reflector marker shall be installed on the concrete barrier wall or guardrail, as shown on the plans, using an adhesive. The direct applied marker shall consist of 1 or 2 round prismatic reflectors as specified attached to a lexan mounting bracket. The locations for mounting the markers on barrier walls shall be as directed by the Engineer.

The surface of the guardrail or the barrier/bridge parapet wall to which the marker is to be applied shall be free of foreign matter and any material which would adversely affect the bond of the adhesive. Cleaning of the surfaces shall be to the satisfaction of the Engineer.

An adhesive meeting the reflector unit manufacturer's specifications shall be placed either on the surface or the bottom of the marker in sufficient quantity to ensure complete coverage of the contact area with no voids present and with a slight excess after the marker is pressed firmly in place.

The face of the marker shall be vertical and oriented so the reflector face shall be at 90 degrees to the centerline of the guardrail web, or to the surface of the barrier.

- (3) **Type C Reflector Marker** Type C reflector marker shall be installed on concrete barrier wall as shown on the plans. The direct applied barrier wall marker shall consist of 1 or 2 reflective surfaces as specified applied to a base fabricated of suitable material.

Basis of Payment This work will be paid for at the contract unit price each for **TERMINAL MARKER-DIRECT APPLIED, TERMINAL MARKER-POST MOUNTED, TERMINAL MARKER POSTS, and GUARDRAIL MARKERS and BARRIER WALL MARKERS** of the types and lens color specified.

The cost of work and material involved to perform any necessary alterations to the embedment length of the terminal marker post shall be included in the contract unit price bid for Terminal Marker Posts.

① Bidirectional reflectors shall be attached as shown and shall be spaced at the number of feet which is equal to the number of miles per hour in the posted speed limit, with a minimum spacing of 20 ft.

- ② Barrier delineators shall be mounted on both sides of the barrier when the barrier is used to separate opposing traffic.
3. Bidirectional reflectors and barrier delineators shall not be used on temporary concrete barrier located along a tapered alignment when it is located behind drums or other reflective delineation devices
- ④ The dimensions of the lifting slots are subject to adjustment as necessary to accommodate handling equipment.
- 5 For energy absorbing terminal, see use number of bays shown in Table No.1 for legal posted speed.
6. Maximum barrier taper rate /slopes for lane closures for legal posted speed are shown in Table No.2.

TABLE NO. 1

CONSTRUCTION ZONE SPEED	NUMBER OF DAYS REQUIRED
45 mph or less	3 Day
Over 45 mph	6 Day

TABLE NO. 2

CONSTRUCTION ZONE SPEED	TAPER FLARE RATE
65 mph	16 : 1
50 mph	14 : 1
45 mph	13 : 1
40 mph	11 : 1

INDIANA DEPARTMENT OF TRANSPORTATION
TEMPORARY CONCRETE BARRIER

JANUARY 2001

STANDARD DRAWING NO E 602-TCCB-01

to Anthony L. Drzewiecki 1-22-01
Karlson Associates Inc. 1-22-01

DATE	DESCRIPTION	AMOUNT
1-2-91	First Fund	100.00

160 All welders and welding operators shall be previously qualified by tests in accordance with Part B, Section IX, of the ASME Boiler and Pressure Vessel Code. Evidence of previous qualification of the welders and welding operators to be employed may be accepted. The same process and type of equipment that is required for execution of the contract work shall be used in qualifying welders and welding operators.

SECTION 804 -- DELINEATORS

804.01 Description. This work shall consist of furnishing and erecting delineators in accordance with 105.03 and 107.12. Delineators shall be installed as required unless approval is obtained from the District Traffic Engineer to make modifications.

MATERIALS

10 804.02 Materials. Materials shall be in accordance with the following:

Delineator Posts	910.15
Flexible Delineator Posts	913.07
Delineators	913.08

The types of delineators shall be:

- (a) D1 - single;
- 20 (b) D2 - double;
- (c) D3 - triple.

Hardware for mounting delineators on posts shall be aluminum alloy in accordance with 913.10(e)2; stainless steel or galvanized steel in accordance with 913.10(e)1; or aluminum pull-through blind rivets. Bolts and lock-nuts or rivets shall be 4.8 mm (3/16 in.) diameter.

CONSTRUCTION REQUIREMENTS

30 804.03 Delineator Visibility. Delineator reflector units shall be positioned so as to be visible for a distance of 300 m (1000 ft) on tangent sections or at maximum visibility distances on curves. These locations shall be established under normal weather and atmospheric conditions when illuminated by the upper beam of standard automobile headlights.

804.04 Posts. Posts shall be installed in accordance with 802.07.

40 804.05 Flexible Delineator Posts. These posts shall be installed according to the manufacturer's recommendations and shall be set so that the top is no more than 13 mm (1/2 in.) from any vertical plane through the bottom.

804.06 Method of Measurement. Delineators with posts, delineator posts, and flexible delineator posts will be measured by the number of units of the type specified.

804.07 Basis of Payment. The accepted quantities of delineators, delineators with post, delineator post, and flexible delineator post, if set out as a separate pay item, will be paid for at the contract unit price per each for the type specified, complete in place.

50

Payment will be made under:

Pay Item	Pay Unit Symbol
Delineator.....	EACH
Delineator Post	EACH
Delineator Post, Flexible.....	EACH
Delineator with Post, _____ type	EACH

60

Where new delineator posts are installed to replace existing delineator posts, the cost of the removal of the existing post shall be included in the cost of the new post.

SECTION 805 -- TRAFFIC SIGNALS

805.01 Description. This work shall consist of furnishing miscellaneous materials, not furnished by the Department, and installing traffic signals in accordance with these specifications and in reasonably close conformance with the lines, grades, and locations shown on the plans or as directed.

MATERIALS

10

805.02 Materials. Materials shall be in accordance with the following:

Aggregate, Class A, B, C, D, or E size No. 8	904.02
Castings for Handhole	910.05(b)
Concrete, Class A, B, or C.....	702
Reinforced Concrete Pipe.....	907.02
Traffic Signal Materials and Equipment.....	913.15
Treated Lumber.....	911.02

20

The proposed work shall be examined in order to determine what materials not furnished by the Department are required to complete the contract. The Department will furnish only the materials specified on the Department Furnished Materials special provision. If materials to be furnished by the Contractor are listed, the list is only a guide for estimating purposes. All additional materials required to complete an operating installation as specified shall be furnished.

90 The color of the post and the reflective sheeting shall match the color of the adjacent edgeline.

When installed, the flexible post shall withstand, without damage, five vehicle impacts at ambient air temperatures of 0°C (32°F) and at 30°C (85°F) each. The vehicle impacts shall include both bumper and tire impacts. It shall be able to bend to an angle of 85 degrees from vertical and right itself to within 10 degrees of the vertical immediately and stand erect within 4 h within the same ambient air temperature range.

100 Only flexible delineator posts from the Department's list of approved Flexible Delineator Posts shall be used. Flexible delineator posts will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

913.07.1 Tubular Marker. The vertically placed portion of this device shall consist of high density polyethylene plastic in accordance with ASTM D 5203. The base material shall be butyl rubber in accordance with ASTM D 5900 or high impact polystyrene in accordance with ASTM D 4549. Epoxy material used to attach the base to the roadway surface shall be in accordance with the manufacturer's recommendations. The tubular portion shall be covered with high intensity reflective sheeting in accordance with 913.10(b).

110

913.08 Delineators.

(a) Acrylic Plastic Delineators. Acrylic plastic delineators shall consist of a hermetically sealed optical system with a circular plastic face and prismatic molded rear surface. The optical system shall have a minimum diameter of 75 mm (3 in.) with a minimum area of approximately 4520 mm² (7 in.²). The trademark of the manufacturer shall be molded legibly into the face of the lens. Color shall be clear, red, or yellow in daylight as well as when viewed by reflected light at night. Photometric or optical requirements shall equal or exceed the following minimum values:

120

Observation Angle Degrees	Entrance Angle Degrees	Specific Intensity Candelas/lux (candle power/footcandle)		
		Clear	Yellow	Red
0.1	0	11.1 (119)	7.3 (79)	2.6 (28)
0.1	20	4.4 (47)	2.6 (28)	1.0 (11)

Note: The observation angle is the angle at reflector between the observer's line of sight and direction of light incident on reflector. The entrance angle is the angle at the reflector between the direction of light incident on it and the direction of reflector axis. The specific intensity is the candlepower returned at the chosen observation angle by a reflector or reflective surface for each lux (footcandle) of illumination at the reflector.

130 The opaque backing shall be made from aluminum sheet having a minimum thickness of 0.50 mm (0.02 in.). The backing shall form an integral part of the delineator and shall retain the optical system securely. A single aluminum grommeted hole in the center of the reflector shall be provided for mounting. The inside diameter of the grommet hole shall be 5 mm (3/16 in.).

Only acrylic plastic delineator models and colors from the Department's list of approved Delineators shall be used. Acrylic plastic delineators will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

140 (b) Reflective Sheeting Delineators. Reflective sheeting delineators shall consist of reflective sheeting affixed to an aluminum backing material. The white delineator shall be 75 mm by 200 mm (3 in. by 8 in.) $\pm$ 3 mm ($\pm$ 1/8 in.). The yellow delineator shall be 125 mm by 125 mm (5 in. by 5 in.) $\pm$ 3 mm ($\pm$ 1/8 in.). The backing material shall be in accordance with 913.10(a) except the minimum thickness shall be 1.6 mm (0.064 in.). Reflective sheeting shall be in accordance with 913.10(b).

There shall be two mounting holes, 5 mm (3/16 in.) in diameter, with one at the top and one at the bottom. The holes shall be 150 mm (6 in.) $\pm$ 2 mm (1/16 in.) center to center for the rectangular shape. Holes shall be 125 mm (5 in.) $\pm$ 2 mm (1/16 in.) center to center and in the corners of the square units. Completed delineators shall be dip coated with a high gloss clear finish coat as specified and supplied by the sheeting manufacturer. The finished units shall be clean cut, sharp, and have essentially a plane surface.

150 Material furnished under this specification shall be covered by a type C certification in accordance with 916.

(c) Barrier Delineators. The delineators shall consist of a transparent acrylic plastic face, herein referred to as the lens, and an opaque back fused to the lens under heat and pressure around the entire perimeter to form a unit permanently sealed against dust, water, and water vapor. The reflector lens shall be colorless.

160 The lens shall consist of a smooth front surface free from projection or indentations other than for purposes of identification or orientation of the reflector. The rear surface shall have a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trademark shall be molded legibly into the face of the lens.

The reflector lens, having a minimum effective reflex area of 4194 mm² (6.5 in.²), shall be methyl methacrylate in accordance with Federal Specification LP-380C, type 1, Class 3. Photometric or optical requirements shall equal or exceed the minimum values in 913.08(a).

170 Only barrier delineator models and colors from the Department's list of approved Delineators shall be used. Barrier delineators will be placed and maintained on the Department's approved list in accordance with ITM 806, procedure G.

913.09 Glass Beads. Glass beads shall be in accordance with AASHTO M 247, Type I except sampling shall be in accordance with the frequency manual. The beads shall have a moisture resistant coating.

**STANDARD SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION
EDITION OF 2000**

Approved for January 1, 2000

J. M. Yowell
State Highway Engineer

Copies of this publication may be obtained from:

**Transportation Cabinet
Department of Administrative Services
Division of Management Services
State Office Building
Frankfort, Kentucky 40622
(502) 564-6927**

Kentucky

SECTION 508 — PERMANENT CONCRETE MEDIAN BARRIERS

508.01 DESCRIPTION. Prepare the foundation for the median barrier; furnish, place, consolidate, finish, and cure the barrier; construct all transverse joints; construct other incidentals necessary to complete the work; and attach delineators and other appurtenances when specified in the Contract.

508.02 MATERIALS AND EQUIPMENT.

508.02.01 Concrete. Conform to Subsection 601.02 and 601.03.

508.02.02 Steel Reinforcement. Conform to Section 811.

508.02.03 Joint Material. Conform to Section 807, preformed fillers.

508.02.04 Dowel Bars. Conform to Section 811.

508.02.05 Tie Bars for Precast Sections. Conform to Section 811.

508.02.06 Mortar Sand. Conform to Section 804.

508.02.07 Cement. Conform to Section 801.

508.02.08 Water. Conform to Section 803.

508.02.09 Masonry Coating. Conform to Section 828.

508.02.10 Delineators for Barriers. Use Stimsonite Marker 962, AKT Corporation Marker No 181, or a Department approved equal.

508.02.11 Forms. Conform to Subsection 601.02. In addition to the requirements for slip forms, use a slip form or extrusion machine that is equipped with automatic guidance controls capable of sensing grade and alignment from an outside reference consisting of a taut line or wire.

508.03 CONSTRUCTION. Construct concrete median barriers of each type to the lines, grades, cross section, and details specified in the Plans and Standard Drawings. Use Class A concrete according to Subsection 601.03. When it is necessary to transition the concrete median barrier into a section different from the uniform section specified in the Plans, such as at a bridge pier, sign pedestal, or bridge end wall, do so in a smooth, uniform manner as shown on the Standard Drawings. Provide concrete median barrier that are precast, cast-in-place using fixed forms, or slip formed according to Subsection 601.03.12.

Bevel the upper longitudinal edge of the barrier 7/8 inch, or construct it to a radius satisfactory to the Engineer.

When required, construct items such as delineators and conduit according to the Contract. Secure conduit to prevent movement.

Cure cast-in-place concrete median barriers according to Subsection 501.03.15. Use the same method of curing on each continuous section of the barrier. Cure precast concrete median barriers according to Subsection 605.03.05.

508.03.01 Fixed Form Construction. Construct 1/2-inch transverse expansion joints throughout the entire cross section at uniform intervals of no less than 15 feet or greater than 25 feet. For construction in conjunction with PCC pavements, locate transverse expansion joints so that a joint occurs at the same stations as that of the rigid pavement transverse joints. Construct additional transverse contraction joints in the barrier

if necessary to maintain the 15 to 25-foot interval. Fill all transverse and longitudinal joints with preformed joint filler. Construct one-inch expansion joints over expansion joints in rigid pavement or base. Construct 1/2-inch expansion joints when the barrier abuts a bridge and at all box inlets, lamp posts, sign posts, and similar structures that project through, into, or against the concrete median barrier.

The Department will allow construction of joints according to Subsection 508.03.02. Conform to the tolerance requirements of Appendix A, Tabulation of Construction Tolerances. Uniformly coat the median barriers with masonry coating.

508.03.02 Slip Form Construction. Suspend reference lines from supports set at intervals no greater than 10 feet on vertical and horizontal curves or 25 feet on uniform grades or tangents. Do not use ski or shoe sensors to reflect the grade of the subgrade unless the ski or shoe can ride on the completed pavement surface.

Provide a construction joint between the base and the barrier. Construct a 2 by 4-inch key, either depressed or raised, in the base. Insert steel dowels in the plastic concrete immediately behind the slip form machine at the locations shown on the Standard Drawing. Place the base using slip form or extrusion methods.

Immediately repair all surface pits larger than 1/2 inch in diameter and all gouges behind the slip form machine. The Engineer will not require further finishing, other than a light longitudinal brushing or brooming.

Provide short sections, such as sections adjacent to structures, terminal sections, etc. that are cast using fixed forms.

Construct one-inch transverse expansion joints at intervals no greater than 500 feet. Construct one-inch transverse expansion joints over all transverse expansion joints in rigid pavement or base. Construct 1/2-inch expansion joints when the barrier abuts a bridge and at all box inlets, lamp posts, and similar structures that project through, into, or against the concrete median barrier. Fill all transverse and longitudinal joints with preformed joint filler.

Construct 1/8-inch transverse contraction joints 2 inches deep at uniform intervals of 20 to 30 feet. Make contraction joints by cutting into the plastic concrete using an edging tool and trowel, using removable inserts, or sawing. When sawing contraction joints, saw as soon as practical after the concrete has set sufficiently to preclude raveling, and before any shrinkage cracking occurs in the concrete. The Engineer will not require sealing of contraction joints.

Construct construction joints as one-inch expansion joints. When constructing a concrete median barrier over PCC pavement or base, locate transverse joints in the barrier to match transverse joints in the pavement or base. Construct additional transverse contraction joints in the barrier if necessary to maintain the 20 to 30-foot interval specified above. When constructing transverse joints in the PCC pavement or base at variable intervals, adjust the joint interval in the wall to match the joint interval in the pavement or base and construct additional joints as necessary to avoid exceeding the 30-foot maximum interval.

Conform to the tolerance requirements of Appendix A, Tabulation of Construction Tolerances

508.03.03 Precast Construction. Construct precast units according to Subsection 605.03. Place the precast units on a bed of mortar, and trim and discard excess mortar. Uniformly coat the median barriers with masonry coating.

When precast concrete median barriers are specified or allowed for installation on an existing facility, anchor them as the Plans specify.

When using precast units, cast short sections, transitions, terminal sections, and other supplemental sections using fixed forms.

When casting threaded inserts into the barrier for use in lifting, protect the inserts by installing a solid, full-length, threaded, plastic bolt, coated with waterproof grease. Install the bolt immediately after manufacturing the barrier section. Leave the bolt in place at all times while the barrier is in storage or in service, except when using the insert for lifting. Entirely fill joints between units, including the 2 by 10-inch groove, with grout

imposed or one part mortar sand and 2 parts cement with enough water to make the mixture plastic.

When the barrier abuts a bridge or other rigid structure, cut off the tie bars or fill the groove with grout, as applicable, and install 1/2-inch preformed joint filler in the joints.

Install 1/2-inch preformed joint filler at all box inlets, lamp posts, sign posts, and similar structures that project through, into, or against the concrete median barrier.

Conform to the tolerance requirements for cast-in-place construction of Appendix A, Tabulation of Construction Tolerances.

Ensure that all concrete median barrier are uniform in appearance, and true to line and grade. Repair or remove and replace all portions of the barrier that are not within the specified tolerances, or precast units that cannot be correctly installed

508.04 MEASUREMENT.

508.04.01 Concrete Median Barrier. The Department will measure the quantity in linear feet along the top centerline of the barrier. The Department will not measure furnishing, installing, or maintaining lifting devices in precast median barriers for payment and will consider them incidental to this item of work. The Department will not measure portions of the barrier that are not within the specified tolerances, precast units that are not correctly installed, or damaged units.

508.04.02 Concrete Terminal Sections. The Department will measure the quantity by each individual unit.

508.04.03 Delineators for Barriers. The Department will measure the quantity by each individual unit.

508.04.04 Masonry Coating. The Department will measure the quantity according to Subsection 601.04.

508.05 PAYMENT. The Department will make payment for the completed and accepted quantities under the following:

Code	Pay Item	Pay Unit
1951-1955, 1958-1978, 1986-1999	Concrete Median Barrier, Type	Linear Foot
1956-1957	Concrete Terminal Section, Type	Each
1984, 1985	Delineator for Barrier, Color	Each
2998	Masonry Coating	See Subsection 601.05

The Department will consider payment as full compensation for all work required under this section.

STANDARD DRAWINGS

COMMONWEALTH OF KENTUCKY

TRANSPORTATION CABINET

1998

ISSUED BY KENTUCKY DEPARTMENT OF HIGHWAYS

FRANKFORT, KY.

KENTUCKY TRANSPORTATION CABINET
LEADER

NOTES

1. DELINEATORS SHALL BE MEASURED AND PAID FOR AT THE CONTRACT UNIT PRICE EACH, AND SHALL INCLUDE ALL MATERIALS AND LABOR NECESSARY FOR ONE COMPLETE INSTALLATION.
2. CODE PAY ITEM PAY UNIT
1984 DELINEATOR FOR BARRIER-WHITE EACH
1985 DELINEATOR FOR BARRIER-YELLOW EACH
3. THE DELINEATORS SHALL BE YELLOW IN COLOR WHEN THE BARRIER IS PLACED IN THE MEDIAN AND/OR ON THE LEFT SIDE OF THE DRIVING LANE. THE DELINEATORS SHALL BE WHITE IN COLOR WHEN THE BARRIER IS PLACED ON THE RIGHT SIDE OF THE DRIVING LANE.
4. OTHER TYPES OF DELINEATORS SHALL BE PERMITTED IF APPROVED IN WRITING BY THE ENGINEER. THE DELINEATORS DIMENSIONS SHOWN ARE APPROXIMATE AND ARE SUBJECT TO MANUFACTURER'S TOLERANCES.
5. THE DELINEATOR UNIT SHALL HAVE THE REFLECTIVE SURFACE INSTALLED FACING TRAFFIC.
6. CLEAN THE AREA TO RECEIVE THE REFLECTOR WITH A STEEL WIRE BRUSH TO REMOVE ALL LOOSE CONCRETE AND/OR DIRT.
7. DELINEATORS SHALL BE ATTACHED TO CONCRETE MEDIAN BARRIER WITH AN EPOXY ADHESIVE OR OTHER APPROVED MATERIALS.
8. THE STIMSONITE MODEL NO. 962 SHALL NOT BE PLACED ON TOP OF BARRIER WALL.
9. THE DELINEATORS MAY BE "ASTRO OPTICS" MODEL NO. JD-1 OR "STIMSONITE" MODEL 962.

FRONT ELEVATION
STIMSONITE

SIDE ELEVATION

MODEL NO. JD-1
(REFLECTOR ONE SIDE)

OR

MODEL JD-2
(REFLECTOR TWO SIDES)

FRONT ELEVATION
ASTRO OPTICS

SIDE ELEVATION

DELINEATOR SPACINGS ON HORIZONTAL CURVES	
DEGREE OF CURVE	SPACING ON CURVES
$\leq 2^\circ$	30.5 METERS
$> 2^\circ \leq 4^\circ$	23 METERS
$> 4^\circ$	15 METERS

SPACING ON TANGENTS = 30.5 METER INTERVALS

NORMAL (SOLID) WALL SECTION

ASYMMETRICAL (SOLID) WALL SECTION

(SEPARATE SEGMENT) WALL SECTION

KENTUCKY DEPARTMENT OF HIGHWAYS	STANDARD DRAWING NO. RBM-020-06
DELINATORS FOR CONCRETE BARRIERS	DATE: 10-1-78 BY: [Signature] CHECKED: [Signature] APPROVED: [Signature]

Barrier Wall and W-Beam Barrier Markers

BARRIER WALL MARKER (TYPICAL)

W-BEAM MARKER (TYPICAL)

NOTES:

1. Barrier Markers shall be Yellow in color when placed on left Median-Side Barrier, White when placed on right Shoulder-side Barrier.
2. See SHA list for approved models and needed parts.
3. Refer to Sids. 665.03 thru 665.06 for placement, spacing and mounting height.

SPECIFICATION NO. 65 03	EXISTING WORK STATE APPROVED <i>[Signature]</i>	<p>Maryland Department of Transportation</p> <p>STATE HIGHWAY ADMINISTRATION</p> <p>STANDARDS FOR HIGHWAY AND BRIDGE STRUCTURES</p> <p>BARRIER MARKERS</p>												
APPROVED <i>[Signature]</i> SPECIAL AGENT IN CHARGE		<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th>DATE</th> <th>BY</th> <th>REVISION</th> </tr> <tr> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> </tr> <tr> <td> </td> <td> </td> <td> </td> </tr> </table>	DATE	BY	REVISION									
DATE	BY	REVISION												
		STANDARD NO. MD - 665.03												

Delineation Placement

Typical Spacing for Post Mounted Delineators

Mainline - 264'
 Accel/Decel and C/D roads - 100' (double delineators) Refer to Std. 665.05
 Ramps - Refer to Std. 665.05

Typical Spacing for Permanent Barrier Wall Mounted Markers

(For all Barrier Walls within 15' of the travel lane)
 Mainline - 100' Note: Spacing should be reduced to 75' in curves less than 1000' and 50' in curves less than 300'.
 Accel/Decel and C/D roads - 100' (double delineators) Refer to Std. 665.05
 Ramps - Refer to Std. 665.05

Typical Spacing for W-Beam Mounted Delineators

(For all W-Beam Barriers within 5' of the shoulder)
 Mainline - 100' Note: Spacing should be reduced to 50' in curves with a radius less than 1000' and in tangent sections less than 500' in length.
 Accel/Decel and C/D roads - 100' (double delineators) Refer to Std. 665.05
 Ramps - Refer to Std. 665.05

Note: Delineators located within 50' of a utility should be installed at the utility and combined with the appropriate UMIS.

SPECIFICATION		EFFECTIVE DATE (MM/YY)		Maryland Department of Transportation STATE HIGHWAY ADMINISTRATION STANDARDS FOR HIGHWAYS AND INCIDENTAL STRUCTURES PLACEMENT OF DELINEATORS	
NO. 665.03		2007/01			
APPROVED		7/1/14
APPROVED BY STATE HIGHWAY ADMINISTRATION DATE: 7/1/14		STANDARD NO. MD - 665.03	

Placement of Barrier Wall Mounted Markers

Placement of Post Mounted Delimiters

Placement of T-Beam & Wood Post Delimiters

- NOTES:
- The height of the delimiter should be within 2" of the dimensions shown.
 - Barrier Markers should be top and side mounted in construction zones. Permanent installations should use mounted only.
 - Height of delimiter may be increased as necessary in areas having excessive ponded water storage.

SPECIFICATION NO. 11-11	CATEGORY CODE	
	11-11	11-11
APPROVED [Signature]	DESIGNED BY	DATE
	11-11	11-11
[Logo]	APPROVED BY	DATE
	11-11	11-11

Maryland Department of Transportation
STATE HIGHWAY ADMINISTRATION
 STANDARDS FOR HIGHWAYS AND INCIDENTAL STRUCTURES
PLACEMENT OF DELINEATORS AND MARKERS

STANDARD NO. MD - 665.04

SP. ACROSS	SPACING IN AVERAGE		SP. ACROSS	SPACING IN AVERAGE	
	SP. ACROSS	SP. ACROSS		SP. ACROSS	SP. ACROSS
1000	1000	1000	1000	1000	1000
2000	2000	2000	2000	2000	2000
3000	3000	3000	3000	3000	3000
4000	4000	4000	4000	4000	4000
5000	5000	5000	5000	5000	5000
6000	6000	6000	6000	6000	6000
7000	7000	7000	7000	7000	7000
8000	8000	8000	8000	8000	8000
9000	9000	9000	9000	9000	9000
10000	10000	10000	10000	10000	10000

1. Double the weight of the seed in the tank of the sprayer. (This is to ensure that the seed is well covered by the liquid.)
2. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
3. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
4. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
5. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
6. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
7. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
8. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
9. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)
10. Use a sprayer for the first, second and third treatments. (This is to ensure that the seed is well covered by the liquid.)

1008 N 1003	00354	0
1001	00352	0
1004	00351	0
1005 N 1	00350	0
1007 N 1001	00349	0
1002	00348	0
1006	00347	0
1003	00346	0
1009	00345	0
1000	00344	0
1008	00343	0
1007	00342	0
1006	00341	0
1005	00340	0
1004	00339	0
1003	00338	0
1002	00337	0
1001	00336	0
1000	00335	0
1009	00334	0
1008	00333	0
1007	00332	0
1006	00331	0
1005	00330	0
1004	00329	0
1003	00328	0
1002	00327	0
1001	00326	0
1000	00325	0
1009	00324	0
1008	00323	0
1007	00322	0
1006	00321	0
1005	00320	0
1004	00319	0
1003	00318	0
1002	00317	0
1001	00316	0
1000	00315	0
1009	00314	0
1008	00313	0
1007	00312	0
1006	00311	0
1005	00310	0
1004	00309	0
1003	00308	0
1002	00307	0
1001	00306	0
1000	00305	0
1009	00304	0
1008	00303	0
1007	00302	0
1006	00301	0
1005	00300	0
1004	00299	0
1003	00298	0
1002	00297	0
1001	00296	0
1000	00295	0
1009	00294	0
1008	00293	0
1007	00292	0
1006	00291	0
1005	00290	0
1004	00289	0
1003	00288	0
1002	00287	0
1001	00286	0
1000	00285	0
1009	00284	0
1008	00283	0
1007	00282	0
1006	00281	0
1005	00280	0
1004	00279	0
1003	00278	0
1002	00277	0
1001	00276	0
1000	00275	0
1009	00274	0
1008	00273	0
1007	00272	0
1006	00271	0
1005	00270	0
1004	00269	0
1003	00268	0
1002	00267	0
1001	00266	0
1000	00265	0
1009	00264	0
1008	00263	0
1007	00262	0
1006	00261	0
1005	00260	0
1004	00259	0
1003	00258	0
1002	00257	0
1001	00256	0
1000	00255	0
1009	00254	0
1008	00253	0
1007	00252	0
1006	00251	0
1005	00250	0
1004	00249	0
1003	00248	0
1002	00247	0
1001	00246	0
1000	00245	0
1009	00244	0
1008	00243	0
1007	00242	0
1006	00241	0
1005	00240	0
1004	00239	0
1003	00238	0
1002		

SPECIAL PROVISIONS - SP5BOOK

PAGE 411

JULY 27, 1994**Last Revision 4/3/01 - The SP5 Book was totally renumbered as of 10/4/99**

S- .2 Measurement will be made by the number of drum-like channelizers furnished and installed as specified. (Replacement barrels will also be measured for payment.) Payment will be made under Item 2563.603 (Channelizer Barrel) at the Contract bid price per each, which shall be compensation in full for all costs incidental thereto.

SP5-240**S- (2563) MEDIAN BARRIER DELINEATOR**

This work shall consist of furnishing, installing and maintaining barrier delineators on median barriers in accordance with the provisions of Mn/DOT 2564, the details shown in the Plans, and the following:

S- .1 The reflectors shall be one of the following (7-7/8" X 4-1/2" in size) or an approved equal, or a substitute barrier at a closer spacing, as directed by the Engineer:

- A) Davidson Portable Concrete Barrier Marker
Davidson Plastic Co.
18726 East Valley Hwy.
Kent, Washington 98032
- B) Guardrail and Barrier Delineator, 965, Simsonite
Signals Products Division, Amerace Corp.
7542 North Natchez Avenue
Niles, IL 60648.
- C) Reflexite Barrier Mount Delineator
Reflexite Corp.
315 South Street, P.O. Box 1628
New Britain, Conn. 06050
- D) Duraflex Flexx 2020 Barrier Delineator
Duraflex Corp.
297 Margaret King Ave.
Ringwood, N.J. 07456

S- .2 Measurement will be made by the number of barrier delineators furnished and installed as specified. Payment will be made under Item 2563.603 (Median Barrier Delineator) at the Contract bid price per each, which shall be payment in full for all costs involved.

7-5.06.02 Narrow Bridges/One Lane Bridges

A narrow bridge shall be defined as any of the following:

- A bridge with a minimum driving surface width greater than 5.5 m (18 feet) and less than the roadway approach width (not including shoulders).
- A bridge where engineering judgment of approach grades, curvatures, number of trucks or other considerations justifies a narrow bridge classification.

Narrow bridges should be marked and delineated as shown in Figure 7.27.

A one-lane bridge is defined as any bridge having a clear opening width of 5.5 m (18 feet) or less. One-lane bridges shall be marked and delineated as shown in Figure 7.28.

7-5.06.03 Cattle passes/Large Culverts

Cattle passes and larger culverts that meet one of the following descriptions are subject to the provisions of this subsection.

- headwalls are present and are not protected by guardrail, subject to engineering judgement
- minimum width of 1 m (42 inches) and a maximum width of 6 m (20 feet). Large culverts (6 m [20 feet] or wider) may be treated as a bridge, subject to engineering judgement.
- any culvert with an end or opening that is within 2.5 m (8 feet) of the shoulder P.I. This 2.5 m (8 foot) distance was selected because it may allow a motorist to pull off of a narrow shouldered roadway if other conditions permit.
- other structures as determined by the district/division traffic engineer.

All drainage structures and cattle passes meeting the above criteria should be marked with Type 2 object markers as described in Section 3C-3 of the MN MUTCD and the following:

- The Type 2 Marker used shall be a 150 x 300 mm (6" x 12") marker constructed of 1.6 mm (0.062") aluminum or other lightweight material such as fiberglass or flexible urethane sheeting. The marker shall use Yellow High Intensity Reflective Sheeting of a type compatible with the base material.
- On special flexible post designs that cannot accommodate the 150 x 300 mm (6" x 12") marker, a 75 x 300 mm (3" x 12") marker may be used.
- Two markers shall be mounted back-to-back on a flexible post or 3.0 kg/m (2-pound) steel post. A

flexible post is preferred due to its resistance to being knocked down by snowplows and farm equipment. Additionally, it provides better daytime visibility.

- The two-way marker assembly shall be installed on the near right side immediately in front of the structure as shown in Figure 7.29.

The typical marking of cattle passes and large culverts not protected by guardrail are shown in Figure 7.29.

7-5.06.04 Guardrail

All guardrails shall be delineated with the snowplow marker. A typical application of these object markers can be found in Figure 7.26.

7-5.06.05 Islands and Interchange Gores

A typical application of the placement of object markers on Islands or Interchange gores can be found in Chart 7-5 and Figure 7.26.

7-5.06.06 End of Roadway

A typical placement of markings for a roadway that ends with no alternative vehicular path is shown in Figure 7.26.

7-5.06.07 Other Objects

Objects located within the clear zone should be marked with the proper object marker. The clear zone should be determined as stated in Chapter 4 of Road Design Manual, Part I.

7-6.00 DELINEATION**7-6.01 Purpose**

Delineators, which are considered guide markers rather than warning devices, are effective aids for night driving. They may be used on long, continuous sections of highway or through short stretches where there are changes in vertical or horizontal alignment, particularly where there is a lack of contrast between the pavement and shoulder. Delineators are placed or removed by maintenance personnel or by contract. Chart 7-6 and Figure 7.30 display different types of delineators.

7-6.02 Types and Materials

Delineator types and the reflective sheeting they require are indicated in Chart 7-6. All but the cylinder style require wide angle VIP, Type B reflective sheeting. Standard Number 4, a reflective sheeting designed to adhere to curved surfaces, is used on the cylinder style delineator.

These delineators, with the exception of the cylinder style, are used to outline changes in alignment, lane transitions, through lane and ramp alignments, and intersections. At intersections where 360° retroreflectivity is desirable, the cylinder type is used.

Acrylic, plastic, and prismatic reflectors are generally not specified for Mn/DOT applications.

7-6.03 Delineator Colors

Delineators shall conform to the color of pavement marking they supplement.

7-6.04 Delineator Location

The details of height and location of delineators are shown in Figure 7.30 and stated below.

7-6.04.01 Delineator Height and Lateral Placement

Delineators, if used, should normally be installed so that the mounting height to the bottom of the delineator is 1.2 m (4 feet) above the surface of the nearest traffic lane. They shall be no more than 3.6 m (12 feet), nor less than 0.2 m (2 feet), outside the roadway or pavement edge. On roadways with shoulders, delineators should be installed 1.8 m (6 feet) outside the shoulder break. Along curbed sections of roadways, delineators shall be placed not less than 1.8 m (2 feet), nor more than 1.5 m (5 feet), from the curb face.

7-6.04.02 Delineator Spacing

Delineators should be placed at a constant distance from the edge of the roadway except, where a guardrail or other obstruction intrudes into the space between the pavement edge and the extension of the line of delineators. The delineators should then be in line with or inside the innermost edge of the obstruction. A typical delineator installation is shown in the MN MUTCD, Section 3D-5, and Figure 3-20.

A simple method for field personnel to determine the degree of curve or the radius of a curve is shown in Figure 7.31.

1. Along Horizontal Curves

When applied on the approaches to and throughout horizontal curves, spacing should permit several delineators to always be visible along the curve ahead of the driver. Table III-1 in Section 3D-5 of the MN MUTCD shows the recommended spacing for delineators along horizontal curves. A typical layout for delineator spacing on horizontal curves is shown in Chart 7-8.

2. Along Vertical Curves

When applied on crest vertical curves, the spacing should permit a minimum of three delineators to be visible from all points along the centerline of the curve at an eye level of 1.2 m (4 feet) above the

pavement.

3. Along Tangent

When applied delineators should be spaced 160 m (0.1 mile) apart along the through roadway, except along acceleration and deceleration lanes where the spacing should be as indicated in section 3D-5 of the MN MUTCD. Where normal spacing is interrupted by driveways, crosswalks, etc.; and where, under the normal spacing a delineator would fall within such an area, that delineator may be moved in either direction a distance not exceeding 25% of the normal spacing. If the delineator still falls within that area, it should be omitted.

7-6.04.03 Intersections

A method of delineating intersections is shown in Figure 7.31.

7-6.04.04 Divided-Highway Crossovers

Delineation of divided-highway crossovers is shown in Figure 7.32.

7-6.04.05 Interchanges

Delineations of cloverleaf and diamond interchanges are shown in Figures 7.33 to 7.36.

7-6.04.06 Guardrail

Three cable guardrail shall be delineated as shown in Standard Plate No. 8330 D which states that every endpost and every fourth intervening post shall have a 75 mm (3-inch) wide silver-white strip of reflective sheeting mounted on a flexible strip of aluminum which is mounted around the post approximately 190 mm (7.5 inches) from the top of the post. Platebeam guardrail delineation is under investigation.

7-6.05 Deer Reflectors

Each district/division may make the decision to remove existing deer reflectors based on any of the following conditions:

1. The existing installations are more than six years old and there is no intent of maintaining them due to replacement costs (lack of maintenance funds), complicated installation procedures, and a lack of staff.
2. The existing installations are a problem for maintenance activities (their lateral placement causes mowing and snow removal problems).
3. Written documentation indicates that either the number of deer kills has not been significantly reduced or the number of deer kills has actually increased.

7-7.00 REFERENCES

1. Minnesota Department of Transportation, Minnesota, **Manual on Uniform Traffic Control Devices**, 1991.
2. American Association of State Highway Officials, **A Policy on Geometric Design of Rural Highways**, 1990.
3. State of Minnesota, **Minnesota Statutes**.
4. Minnesota Department of Transportation, **Standard Signs Summary**, 1997.
5. Minnesota Department of Transportation, **Road Design Manual**, 1982.
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7-7.00 REFERENCES

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3. State of Minnesota, Minnesota Statutes.
4. Minnesota Department of Transportation, Standard Signs Summary, 1997.
5. Minnesota Department of Transportation, Road Design Manual, 1982.
6. Minnesota Department of Transportation, Bicycle Transportation, Planning and Design Guidelines, June, 1996.
7. American Association of State Highway and Transportation Officials (AASHTO), Guide for the Development of Bicycle Facilities. 1991.

TYPES OF DELINEATORS

TYPICAL DELINEATOR PLACEMENT

HAZARD PLATE MARKER AT EXIT GORE

Text Ref.: 7-6.01

July 1, 1999

DELINEATOR TYPES & INSTALLATION

FIGURE
7.30

Wide Angle VIP Reflective Sheeting (TYPE B)

INFORMATION
SEE MN MUTCD

NAME	DELINEATOR	SIZE	COLOR	SECTION
One Tenth Mile Marker		100 x 100 mm (4" x 4")	White or Yellow	Section 2D-46
Guide Marker Plate (X4-6)		200 x 600 mm (8" x 24")	Black top on White or Yellow	None
Chevron Alignment Sign (W1-8)		450 x 600 mm (18" x 24")	Black on Yellow	Section 2C-10
Alignment Marker		100 x 200 mm (4" x 8")	White or Yellow	None

Standard Number 4 Reflective Sheeting (FLEXIBLE)

Cylinder Style		150 mm (6") Diameter 225 mm (9") Height	White or Yellow	Section 3D-4.5
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Text Ref.: 7-5.04

July 1, 1998

DELINEATOR FABRICATION DETAILS

CHART
7-6

11/15/2014

DOUBLE DETAIL SECTION

ELEVATIONS

NOT SCALE 3/4\"/>

TYPICAL SECTION

ELEVATION

BARRIER FOR SUPPLIED PAVEMENT

BARRIER IN LEFT TRANSITION *
* INSTALLATION USED ONLY WHEN BARRIER IS OUTSIDE OF THE CURB FLOW

CAST-IN-PLACE CONCRETE

GENERAL NOTES

1. ALL DIMENSIONS ARE IN FEET AND INCHES. FRACTIONS SHALL BE IN 16THS OF AN INCH.
2. THE BARRIER SHALL BE CAST-IN-PLACE CONCRETE.
3. THE BARRIER SHALL BE 48\"/>

SECTION A

SECTION B

SECTION C

SECTION D

SECTION E

SECTION F

SECTION G

SECTION H

SECTION I

SECTION J

SECTION K

SECTION L

SECTION M

SECTION N

SECTION O

SECTION P

SECTION Q

SECTION R

SECTION S

SECTION T

SECTION U

SECTION V

SECTION W

SECTION X

SECTION Y

SECTION Z

SECTION AA

SECTION AB

SECTION AC

SECTION AD

SECTION AE

SECTION AF

SECTION AG

SECTION AH

SECTION AI

SECTION AJ

SECTION AK

SECTION AL

SECTION AM

SECTION AN

SECTION AO

SECTION AP

SECTION AQ

SECTION AR

SECTION AS

SECTION AT

SECTION AU

SECTION AV

SECTION AW

SECTION AX

SECTION AY

SECTION AZ

SECTION BA

SECTION BB

SECTION BC

SECTION BD

SECTION BE

SECTION BF

SECTION BG

SECTION BH

SECTION BI

SECTION BJ

SECTION BK

SECTION BL

SECTION BM

SECTION BN

SECTION BO

SECTION BP

SECTION BQ

SECTION BR

SECTION BS

SECTION BT

SECTION BU

SECTION BV

SECTION BW

SECTION BX

SECTION BY

SECTION BZ

SECTION CA

SECTION CB

SECTION CC

SECTION CD

SECTION CE

SECTION CF

SECTION CG

SECTION CH

SECTION CI

SECTION CJ

SECTION CK

SECTION CL

SECTION CM

SECTION CN

SECTION CO

SECTION CP

SECTION CQ

SECTION CR

SECTION CS

SECTION CT

SECTION CU

SECTION CV

SECTION CW

SECTION CX

SECTION CY

SECTION CZ

SECTION DA

SECTION DB

SECTION DC

SECTION DD

SECTION DE

SECTION DF

SECTION DG

SECTION DH

SECTION DI

SECTION DJ

SECTION DK

SECTION DL

SECTION DM

SECTION DN

SECTION DO

SECTION DP

SECTION DQ

SECTION DR

SECTION DS

SECTION DT

SECTION DU

SECTION DV

SECTION DW

SECTION DX

SECTION DY

SECTION DZ

SECTION EA

SECTION EB

SECTION EC

SECTION ED

SECTION EE

SECTION EF

SECTION EG

SECTION EH

SECTION EI

SECTION EJ

SECTION EK

SECTION EL

SECTION EM

SECTION EN

SECTION EO

SECTION EP

SECTION EQ

SECTION ER

SECTION ES

SECTION ET

SECTION EU

SECTION EV

SECTION EW

SECTION EX

SECTION EY

SECTION EZ

SECTION FA

SECTION FB

SECTION FC

SECTION FD

SECTION FE

SECTION FF

SECTION FG

SECTION FH

SECTION FI

SECTION FJ

SECTION FK

SECTION FL

SECTION FM

SECTION FN

SECTION FO

SECTION FP

SECTION FQ

SECTION FR

SECTION FS

SECTION FT

SECTION FU

SECTION FV

SECTION FW

SECTION FX

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CONCRETE - 4\"/>

DATE: 01/01/2000
TIME: 01:00:00
BY: A.A.N.

SECTION C-C
(STEEPLED PARAPET)

SECTION E-E

SECTION D-D

SECTION A-A

BARRIER RAIL REFLECTOR INSTALLATION

TYPICAL GUARDRAIL-GUIDE POST INSTALLATION

GENERAL NOTES:

1. ALL REFLECTORS SHALL BE SELECTED & INSTALLED PURSUANT TO THE PROJECT PLANS & SPECIFICATIONS OR AT THE DIRECTION OF THE ENGINEER. THE OBJECTIVE REFLECTORS ARE FOR MOUNTING LOCATION INFORMATION ONLY.
2. SPACING: SEE "REFLECTOR PLACEMENT ON GUARDRAIL" NOTES AND TABLE "A", OF THIS SHEET.
3. REFLECTORS SHALL BE MOUNTED AT THE ANGLE SPECIFIED BY THE MANUFACTURER OR AS DIRECTED BY THE ENGINEER.
4. COLOR SHALL COMPLY WITH THE GUIDELINES ESTABLISHED BY THE M.U.T.C.D., 1988 EDITION AND REVISIONS THEREOF.

REFLECTOR PLACEMENT SPACING ON GUARDRAIL/BARRIER RAIL

SPACING SHALL BE:

- (a) 15 METERS ON TANGENTS AND ON CURVES OF 50 METER RADIUS OR GREATER, IF LESS THAN 90 METER RADIUS SEE TABLE "A".
- (b) REFLECTORS SHALL BE OMITTED ON THE FLARED SECTIONS OF GUARDRAIL.
- (c) NO DIRECT PAYMENT FOR REFLECTORS ON BARRIER RAIL.

TABLE "A"

Radius of Curve/Reflector Spacing (in METERS)	6 m	9 m	11 m	12 m	15 m
≤ 15					
15					
45					
60					
75					
90

GUARDRAIL-GUIDE POST LOCATION

ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

STATE OF MICHIGAN
DEPARTMENT OF TRANSPORTATION

REFLECTORS
GUARDRAIL-GUIDE POST

DATE: 12-13-88
DRAWN BY: J. J. JONES
CHECKED BY: J. J. JONES
APPROVED BY: J. J. JONES

N. D. O. T.

Spec Number *	Product Types	Manufacturer's Name Address	Product Name	Remarks	Carded/ Effective Date	ID Number
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625.02.02	REFLECTIVE MARKERS ON PORTABLE PRECAST CONCRETE BARRIER	Astro Optics 156 Williams St. Carpentersville, IL 60110 847/428-3181 Fax 847/428-3979 gl@astrooptics.com	FB-33 or Flexi-Tab Marker		02/3/93	S014
		Bunzl Extrusion-Tacoma, Inc. (Davidson Plastics Co.) 3110 70 th Ave. East Tacoma, WA 98424 253/284-8000 Fax 253/284-8060 www.davidsonplastics.net	PCBM-12		12/17/97	S015
		Duraflex Corp. 297 Margaret King Ave. Ringwood, NJ 07456 973/962-7779	FLEXOX 2020 W75 mm x 75mm Reflective Shooting		12/17/97	S016
625.02.02a	BARRIER MARKER DRUMS ON CONCRETE BARRIER RAILS	Boebe, Inc./Stinson Equipment Ltd. 1895 Grant St. N.E. Salem, OR 97303 503/315-2097	Saddlemarker Drums (Stock No. 083W00)		12/15/97	S101

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620.04 Guide Rail Mounted Flexible Delineators.

Flexible delineators shall be mounted on the spacer of beam guide rail using either a "U" channel base on the I-beam spacer or a flat base attached to a wood, polymer, or other solid top spacer. The base shall be attached to the spacer using an adhesive recommended by the manufacturer of the base and panel. The first delineator shall be placed on the beam guide rail end treatment, positioned so that the reflector area is facing the direction of traffic, then subsequently every 25 meters (13 sections of guide rail) for tangent mainline roadway, and every 13.5 meters (seven sections of guide rail) for curved mainline roadways with radii less than 580 meters. If a parabolic flare in the beam guide rail exists, the second delineator shall be placed at the end of the flared section with subsequent delineators spaced as stated above. If the distance between the end of the beam guide rail is greater than 6 meters on curved mainline roadways, or 12 meters on tangent mainline roadways, a delineator shall be installed on the last post or end treatment.

Retroreflective sheeting, Type IV-A shall be applied to the upper portion of the flexible delineator panel. The retroreflective sheeting shall cover a minimum area of 115 by 115 millimeters (115 by 230 millimeters for deceleration and acceleration lanes). The color shall be white when the delineator is located on the right side to the direction of traffic and shall be yellow when the delineator is located on the left side to the direction of traffic.

620.05 Barrier Curb Mounted Flexible Delineators.

The first flexible delineator shall be placed at the beginning of the concrete barrier curb section, positioned so that the reflector area is facing the direction of traffic, then subsequently every 24 meters. If the distance between the end of the concrete barrier curb and the adjacent delineator is greater than 12 meters, a delineator shall be installed on both sides of barrier curb openings.

Concrete barrier curb mounted flexible delineators shall be attached to the side of the barrier curb, 75 millimeters from the top of the barrier, using a method recommended by the manufacturer of the delineator unit.

Retroreflective sheeting, Type IV-A shall be applied to the upper portion of the flexible delineator panel facing traffic and perpendicular to the top of the concrete barrier curb. The retroreflective sheeting shall cover an area of 90 by 90 millimeters. The color shall be white when the delineator is located on the right side to the direction of traffic and shall be yellow when the delineator is located on the left side to the direction of traffic.

COMPENSATION**620.06 Method of Measurement.**

Flexible delineators will be measured by the number of units.

620.07 Basis of Payment.

Payment will be made under.

<i>Pay Item</i>	<i>Pay Unit</i>
FLEXIBLE DELINEATORS, GROUND MOUNTED	UNIT
FLEXIBLE DELINEATORS, GUIDE RAIL MOUNTED	UNIT
FLEXIBLE DELINEATORS, BARRIER CURB MOUNTED	UNIT

SECTION 621 - CRASH CUSHIONS**621.01 Description:**

This work shall consist of furnishing and constructing crash cushions. Crash cushions shall be integral barrier system crash cushions composed of sand-filled frangible impact

sign supports shall be adjusted by rotating the sign on the posts. Signs mounted on "U" post sign supports shall be adjusted as specified in Subheading 2 of the second paragraph of Subsection 619.03

619.05 Cleaning Signs.

Before final inspection, all sign faces and support surfaces shall be cleaned of all foreign matter. Necessary measures shall be taken to provide that all signs, sign supports, and sign sites are in good condition and have a good appearance

COMPENSATION**619.06 Method of Measurement.**

Signs of the various sizes will be measured by square meter.

Guide signs of the various types will be measured by the square meter.

619.07 Basis of Payment.

Payment will be made under:

<i>Pay Item</i>	<i>Pay Unit</i>
SIGNS	SQUARE METER
GUIDE SIGNS, TYPE GA, "U" POST SUPPORTS	SQUARE METER
GUIDE SIGNS, TYPE GA, BREAKAWAY SUPPORTS	SQUARE METER
GUIDE SIGNS, TYPE GA, NON-BREAKAWAY SUPPORTS	SQUARE METER
GUIDE SIGN PANELS, TYPE GO	SQUARE METER
GUIDE SIGN PANELS, TYPE GOX	SQUARE METER

Separate payment will not be made for posts for signs

Payment for sign support structures will be made in accordance with Section 509

Payment for sign illumination will be made in accordance with Section 705

Payment adjustments for strength will be made in accordance with Subsection 914.02, Subpart F, and will be applied to the lot for those Pay Items specified in that Subpart.

SECTION 620 - DELINEATORS**620.01 Description.**

This work shall consist of furnishing, assembling, and erecting flexible delineators

MATERIALS**620.02 Materials.**

Materials shall conform to the following:

Retroreflective Sheeting.. .. .	916 04
Flexible Delineators.	916 14

CONSTRUCTION**620.03 Ground Mounted Flexible Delineators.**

Flexible delineator units shall be driven vertically into the ground to a minimum depth of 450 millimeters. Units shall be installed so that the plane face of the center of the reflective area is at an angle of zero degrees with a perpendicular to the direction of traffic

Retroreflective sheeting, Type IV-A shall be pre-applied to the front (surface facing traffic) of the unit by the manufacturer. The retroreflective sheeting shall cover a minimum area of 75 by 300 millimeters, beginning a maximum of 50 millimeters from the top of the post. The color shall be white when the delineator is located on the right side to the direction of traffic and shall be yellow when the delineator is located on the left side to the direction of traffic.

894.05 B 5 d

Base posts shall be punched on center line with a minimum of twelve 7/16-inch diameter holes on one inch centers. The first hole shall be one inch from the top. The bottom of the post shall be pointed for easy installation.

The sign post, base posts, retainer-spacer, and anchor plates shall be galvanized according to AASHTO M-232.

- 6 **Structural Steel Posts.** Structural steel posts shall be fabricated from material conforming to Section 834.01 A. and shall be galvanized according to Section 854 after fabrication

894.06 DELINEATORS.

- A. **Posts.** Steel posts shall meet ASTM A-702.

Steel posts shall be galvanized according to AASHTO M-111 or be aluminum posts fabricated from aluminum alloy meeting ASTM B-308, Alloy 6061-T6

Posts shall have holes at one inch spacing the entire length of the post.

- B **Reflectors.**

1. **Reflective Sheeting.** Type III reflective sheeting for delineators shall be white or yellow adhesive coated, permanently adhered to aluminum or galvanized steel.

The reflective sheeting shall meet Section 894.02. Backing material shall meet Section 894.01.

The finished reflector shall show careful workmanship; be free of burrs, scratches, or damaged reflective sheeting; and have essentially a flat surface.

2. **Acrylic Plastic.**

- a. **Metal Parts.** The housing shall be .020-inch ASTM B-209 3003-H14 or 5052-O sheet aluminum formed to approximately 3-1/4 inches in diameter and .235-inch in depth to retain the acrylic reflector. The housing shall be provided with 4 embossed circular reinforcement ribs and marked with the manufacturer's name and part number

An aluminum grommet with a 3/16-inch inside diameter shall be expanded within the reflector mounting hole

- b. **Acrylic Plastic.** The reflector shall be an acrylic plastic manufactured from methyl methacrylate. The reflector shall consist of a clear and transparent plastic face, with a minimum of 7 square inches of reflective area, referred to as the lens. It shall have a heat sealable plastic coated metallic foil back fused to the lens under heat and pressure around the entire perimeter of the lens and the central mounting hole to form a unit permanently sealed against dust, water, and water vapor. The reflector shall be colorless, yellow, or red

The lens shall consist of a smooth front surface free from projection or indentation other than the central mounting hole and identification with a rear surface bearing a prismatic configuration such that it will provide total internal reflection of light.

- c. **Optical Requirements.** The optical requirements shall be as follows:

Color	Candelas per Foot-Candle per Square Foot Divergence Angle, ± 0.1 Degrees	
	Entrance Angle, Deg.	
	0	20
Crystal or Silver	119	47
Yellow	71	28
Red	29	11

The reflex reflector to be tested shall be located 100 feet from a single light source having an effective diameter of 2 inches; the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by a photoelectric photometer having a minimum sensitivity of 1×10^{-7} foot candles per mm scale division. The photometer shall have a receiver aperture of 0.5 inch diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 2.1 inches for 0.1° observation angle. During testing, the reflector shall be spun to average the orientation effect. If a test distance other than 100 feet is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

Failure to meet the specific intensity minimum shall constitute failure of the reflector being tested; failure of more than 2 reflectors out of 50 subjected to test shall constitute failure of the lot.

- d. **Durability.** The durability tests shall be as follows:

- (1) **Seal Test.** The following test shall be used to determine if a reflector is adequately sealed against dust and water.

Submerge 50 samples in a water bath at room temperature. Subject the submerged samples to a vacuum of 5 inches for 5 minutes, then examine them for water intake. Failure of more than 2% of the number tested shall be cause for rejection.

- (2) **Heat Resistance Test.** Three reflectors shall be tested for 4 hours in a circulating air oven at $175^\circ \pm 5^\circ\text{F}$. The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples, after exposure to heat, shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

- C. **Fasteners.** Aluminum tension pin fasteners shall be an aluminum alloy meeting ASTM B-211 Alloy 2024-T4 or 6061-T6. The collar shall be aluminum alloy

894.06 C

meeting ASTM B-211 Alloy 6061-T67 or 6061-T6. The fasteners shall conform to the Contract.

Steel tension pin fasteners shall be a medium carbon steel with a minimum shear strength of 70,000 psi and a minimum tensile strength of 67,500 psi. They shall be galvanized according to AASHTO M-232 conforming to the Contract.

894.07 SAMPLING AND TESTING.

- A. **Base Metal.** The Contractor shall furnish to the inspector a certification as specified in Section 801.01.
- B. **Solutions for Cleaning and Etching.** The solutions used for cleaning and etching shall not vary more than 10% from the manufacturer's recommendation. In addition, all treatment tanks shall be charged with fresh chemicals at least once a year. Titration equipment shall be available for the inspector's use to check the solution strengths.
- C. **Inspection.** All material and finished signs are subject to inspection at the place of manufacture and shall be subject to final inspection at the time of erection. Test panels, 12 inches by 12 inches representative of any stage of production, shall be furnished upon the inspector's request. These panels shall be processed with the regular production run and witnessed by the inspector. All surfaces exposed to weathering shall be free of any defects that may impair the serviceability or detract from the general appearance or color matching of the sign. Signs with any defects or damage that would affect their appearance or serviceability will not be accepted. No repairs shall be made to the face sheet without the approval of the inspector. Signs not conforming in all respects to the requirements will be rejected.
- D. **Reflective Sheeting.** The reflective sheeting shall be certified by the manufacturer that the minimum brightness values previously listed for each color, have been met. The color of each type shall be checked by the inspector using the standard color charts as specified.
 - 1. **Reflective Sheeting Flexibility.** The Contractor shall furnish test specimens for each color of reflective sheeting according to AASHTO M-268. Type III and Type IV reflective sheeting shall be applied to a plate as specified in AASHTO M-268 and shall be furnished for each color. These test specimens shall be processed with the regular production run and witnessed by the inspector.
 - 2. **Inspection.** The reflective sheeting packages shall be inspected before installation on sign backings. The Contractor shall provide access by the inspector and shall indicate the roll packages or flat packages to be used on a particular Project. The inspector will mark the roll of flat material and note the manufacturer's date. All material used on that Project shall be used within one year of this date. If this date is past on the date of inspection, the roll shall be rejected.
- E. **Torque Control Nuts.** The Contractor shall furnish to the inspector a certification, as specified in Section 801.01, if torque control nuts are chosen for use.

0110

7-12

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0110

NOTES

1. Type C detectors (retro-reflectors) shall be spaced on the right of the through roadway at 400 (122 m) intervals without regard to curves. Type D detectors (retro-reflectors) shall be spaced on the left of the through roadway.
2. Detector's angle should be at least one side of intersection ramps and shall conform to the relative edge line color.
3. No detector's should be placed in a blind spot.
4. When the edge of the roadway is not straight, the detectors shall be placed at the intersection of the curve in relation to the line of travel.
5. Detector's shall be placed in a blind spot.
6. Detector's shall be placed in a blind spot.

BRIDGE PARAPET BRACKET

BRIDGE RAIL BRACKET

BRIDGE DECK BRACKET

BRIDGE DECK BRACKET SHALL BE MADE OF 1/2 INCH X 1/4 INCH PLATE

TYPICAL DELINEATOR PLACEMENT

SPACING ON RAMP

HORIZONTAL CURVES

TRANSITION SPACING (m)	TRANSITION SPACING (ft)	TRANSITION SPACING (m)	TRANSITION SPACING (ft)
100	328	100	328
200	656	200	656
300	984	300	984
400	1312	400	1312
500	1640	500	1640
600	1968	600	1968
700	2296	700	2296
800	2624	800	2624
900	2952	900	2952
1000	3280	1000	3280

TRANSITION SPACING SHALL BE 400 (122 m) FOR CURVE RADII, 100 (30 m) TO 200 (61 m). TRANSITION SPACING SHALL BE 200 (61 m) FOR CURVE RADII, 200 (61 m) TO 400 (122 m). TRANSITION SPACING SHALL BE 100 (30 m) FOR CURVE RADII, 400 (122 m) TO 1000 (305 m).

SPACING ON RAMP

HORIZONTAL CURVES

TRANSITION SPACING (m)	TRANSITION SPACING (ft)	TRANSITION SPACING (m)	TRANSITION SPACING (ft)
100	328	100	328
200	656	200	656
300	984	300	984
400	1312	400	1312
500	1640	500	1640
600	1968	600	1968
700	2296	700	2296
800	2624	800	2624
900	2952	900	2952
1000	3280	1000	3280

TRANSITION SPACING SHALL BE 400 (122 m) FOR CURVE RADII, 100 (30 m) TO 200 (61 m). TRANSITION SPACING SHALL BE 200 (61 m) FOR CURVE RADII, 200 (61 m) TO 400 (122 m). TRANSITION SPACING SHALL BE 100 (30 m) FOR CURVE RADII, 400 (122 m) TO 1000 (305 m).

LATERAL PLACEMENT

**IX. RAISED PAVEMENT MARKERS, DELINEATORS, BARRIER REFLECTORS
AND OBJECT MARKERS**

A. Raised Pavement Markers

Raised pavement markers (RPMs) should normally be included in new and resurfacing construction projects on State maintained roads and urban Interstates. They may also be included in the plans at other locations as specified in the RPM Program.

Standards and guidelines for RPMs are addressed in Sections 3A-10, 3B-15 and 3B-16 of the OMUTCD, and RPM specifications are covered in Items 621 and 721. The SCDs TC-65.10, 65.11 and 65.12 incorporate the various installation details, and should be listed on the Title Sheet.

The plans shall call for the removal of existing RPM castings which would otherwise be abandoned and paved over, and their return to ODOT.

Testing procedures for RPMs are covered in Supplement 1062.

B. Delineators

Sections 3D and 4F-5 of the OMUTCD, AS 4C-7 and SCD TC-61.10 address current standards and guidelines concerning delineation on the rural state highway system. Delineator reflector color shall match that of the nearest edge line.

On divided highways, freeways and expressways inside cities, delineation should be provided on unlighted or partially lighted sections and may be considered on fully lighted sections.

Flexible posts are required on state maintained routes.

C. Barrier Reflectors (Permanent)

Barrier reflectors shall be erected on all new or reconstructed guard rail, new concrete barrier and new or reconditioned bridge parapets. Standards and specifications for barrier reflectors are covered in AS 4C-9 and CMS Items 626 and 720.04.

Barrier reflector color shall match that of the nearest edge line.

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D. Barrier Reflectors (Temporary)

These are used for maintaining traffic flow during construction. Although they are paid for under Item 614, they are identical to those described in AS 4C-9 and CMS Item 626.

E. Temporary Raised Pavement Markers

Temporary raised pavement markers are covered on SCD MT-101.20.

F. Object Markers

Object markers are covered in Sections 3C and 4F-4 of the OMUTCD.

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November 18, 1986
AS 4C-9

OHIO DEPARTMENT OF TRANSPORTATION
POLICY ON
BARRIER REFLECTORS

I. PURPOSE

Installation of reflectors can be an effective method of delineating concrete or guardrail barriers along the roadway and on bridges. Their purpose is to provide additional delineation and guidance during darkness and/or adverse weather conditions.

The purpose of this policy is to provide guidelines for use in determining locations to be treated with barrier reflectors and establish standard installation and maintenance practices.

II. APPLICATION

This policy is applicable to all highways on the rural state highway system and may be applied to state and/or federally funded projects regardless of the type of existing or proposed pavement markings and regardless of the presence of edge lines, reflectorized glare screens, raised pavement markers or highway lighting. However, these reflectors should not be installed: where standard post delineators in good condition are already in place along the barrier, where conditions require standard delineators or where barrier replacement is scheduled within two years (except for temporary barriers in work zones).

III. PRINCIPLES AND GUIDELINES

A. The use of barrier reflectors should be considered at the following locations:

1. Identified Night Barrier-Involvement Accident Locations and Sections.

These locations and sections are identified on the basis of night barrier-involvement accidents, and selected by analysis of accident records.

2. Potential Night Barrier-Involvement Accident Locations and Sections.

- a. Curves 5 degrees or greater.

- b. Bridge locations on narrow (21 feet or less) two-lane highways.

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- c. Tangent sections and curves flatter than 5 degrees on narrow two-lane highways.
 - d. Concrete or guardrail barriers 10 feet or less from the near edge of pavement.
 - e. Barriers with portions which encroach to within 10 feet of the traffic lane, e.g. at the approach to a bridge end or pier. When reflectorized, the entire length of barrier and not just the encroaching portion should be treated.
 - f. Portable concrete barriers and guardrail within construction work zones, to include G-R-E-A-T attenuation terminals.
- g. Where the barrier is on a tangent section adjacent to a curve, delineation should be extended through the curve with raised pavement markers, barrier reflectors or post delineators.
- C. When the distance between successive treated sections is, or will be, less than 0.5 mile, the reflector treatment may be extended to cover all barriers in the "gap".

IV. INSTALLATION

A. Spacing

Generally, reflectors should be spaced to keep them within the motorists' view at all times. For the following situations the spacing should be as noted when barrier reflectors are used (for purposes of these measurements, anchor assemblies are not included in the length of the barrier):

1. Tangent highway sections and curves flatter than 5 degrees - 100 feet apart, except as noted below in item 3;
2. Curves 5 degrees or greater and lane reduction tapers (e.g. an interim concrete barrier used at the temporary terminal of a freeway) - 50 feet apart;
3. Tangent barriers and transition sections (from one offset distance to a closer one) 200 feet or less in length - at least three reflectors per direction, one located at each end and one in the middle;
4. Spacing shall be reduced 50% in work zones. Also in work zones, the barrier reflectors on temporary concrete barriers should be supplemented by large cylindrical reflectors (approximately 6 inch diameter x 12 inch height), or other retroreflective devices of comparable size which will maintain the desired reflectivity in curved sections, mounted on top of the barrier midway between the side-mounted barrier reflectors. Reflectorized glare screening is also acceptable.

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B. MOUNTING

1. On concrete barriers the height to the top of the reflector should be 26 inches above the near edge of pavement; but the top of the reflector should not be less than 3 inches below the top of the concrete barrier.
2. On guardrail barriers the height of the reflector will depend on the type of guardrail; however, it should be approximately 21 inches above the near edge of pavement. For beam guardrail, the reflector should be approximately in the middle of the vertical face.
3. When mounted on a flat surface, the reflector face should be tilted upward from the vertical or plumb position 2 to 3 degrees to facilitate "rain washing" of the reflector face.
- C. Bi-directional barrier reflector installation may be used on the outside of curves.
- D. The color of the barrier reflector shall be white when used on barriers along the right side of the road and yellow for barriers on the left.

V. REFLECTOR MAINTENANCE

To maintain their effectiveness, barrier reflectors should be maintained in good condition by appropriate district field forces.

Warren J. Smith
Director of Transportation

mf1

SECTION 1

SECTION 1
TYPICAL SECTION OF DIVIDED HIGHWAY SHOWING THE PLACEMENT OF A GUARDRAIL ON THE OUTSIDE SHOULDER.

NOTE: THE GUARDRAIL SHALL BE PLACED AT THE OUTSIDE EDGE OF THE SHOULDER, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

TYPE 1 - GALVANIZED STEEL
TYPE 2 - ALUMINUM

SECTION 2
TYPICAL SECTION OF DIVIDED HIGHWAY SHOWING THE PLACEMENT OF A GUARDRAIL ON THE INSIDE SHOULDER.

NOTE: THE GUARDRAIL SHALL BE PLACED AT THE INSIDE EDGE OF THE SHOULDER, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

TYPE 1 - GALVANIZED STEEL
TYPE 2 - ALUMINUM

TYPE 1 CODE 1

TYPE 1 CODE 2

TYPE 1 CODE 3

NOTE: THE GUARDRAIL SHALL BE PLACED AT THE OUTSIDE EDGE OF THE SHOULDER, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

TYPE 1 - GALVANIZED STEEL
TYPE 2 - ALUMINUM

TYPICAL DELINEATOR PLACEMENT AT MEDIAN OPENINGS

NOTE: THE DELINEATOR SHALL BE PLACED AT THE MEDIAN OPENING, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

ALTERNATE POST SECTIONS

NOTE: THE ALTERNATE POST SHALL BE PLACED AT THE MEDIAN OPENING, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

CENTER MOUNT REFLECTOR

NOTE: THE CENTER MOUNT REFLECTOR SHALL BE PLACED AT THE MEDIAN OPENING, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

TYPICAL DELINEATOR SPACING FOR INTERCHANGE RAMP

NOTE: THE DELINEATOR SHALL BE PLACED AT THE MEDIAN OPENING, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

DIVIDED MULTILANE ROAD

NOTE: THE DELINEATOR SHALL BE PLACED AT THE MEDIAN OPENING, AND SHALL BE INSTALLED IN SUCH A MANNER AS TO PREVENT THE ESCAPE OF VEHICLES FROM THE HIGHWAY.

MATERIALS SPECIFICATIONS

ALL THE 1995 STANDARD SPECIFICATIONS FOR THE DESIGN AND CONSTRUCTION OF A HIGHWAY SHALL BE USED.

SECTION	DESCRIPTION	QUANTITY	UNIT	PRICE
1	GUARDRAIL	100	LINEAL FEET	1.00
2	DELINATOR	10	POSTS	2.00
3	REFLECTOR	100	POSTS	1.00
4	POST	100	POSTS	1.00
5	REFLECTOR	100	POSTS	1.00
6	POST	100	POSTS	1.00
7	REFLECTOR	100	POSTS	1.00
8	POST	100	POSTS	1.00
9	REFLECTOR	100	POSTS	1.00
10	POST	100	POSTS	1.00

1995 SPECIFICATIONS

001-1

1.00

FOR PERMANENT WALL —

BARRIER DELINEATOR SHALL BE PLACED AT 90' c/c (MAX). DELINEATOR SHALL HAVE 6" (MIN.) REFLECTIVE AREA. SEE THE 1999 STANDARD SPECIFICATIONS FOR DETAILS. DELINEATOR TO BE INSTALLED AS RECOMMENDED BY THE MANUFACTURER.

- * TWO DELINEATORS (ONE ON EACH SIDE OF BARRIER) SHALL BE USED IF TRAFFIC IS ON BOTH SIDES AND GLARE SCREEN IS IN PLACE. REFLECTORS SHALL FACE TRAFFIC.

BARRIER DELINEATORS

@ 50' c/c

BARRIER DELINEATORS FOR PERMANENTLY
INSTALLED CONCRETE MEDIAN BARRIER

TYPE 1 (CRYSTAL)

TYPE 1 (AMBER)

TYPE 2 (CRYSTAL/CRYSTAL)

TYPE 2 (AMBER/AMBER)

PLAN OF CONNECTION

DETAIL OF CONNECTION

CONNECTOR PIN ASSEMBLY

ELEVATION

END ELEVATION

BAR LIST			
ITEM	QTY	DESCRIPTION	REMARKS
1	1	1/2" x 10"	
2	1	1/2" x 10"	
3	1	1/2" x 10"	
4	1	1/2" x 10"	
5	1	1/2" x 10"	
6	1	1/2" x 10"	
7	1	1/2" x 10"	
8	1	1/2" x 10"	
9	1	1/2" x 10"	
10	1	1/2" x 10"	

NOTES: 1. All bars shall be of A36 steel. 2. All bars shall be of 1/2" diameter. 3. All bars shall be of 10" length. 4. All bars shall be of 10" width. 5. All bars shall be of 10" height. 6. All bars shall be of 10" depth. 7. All bars shall be of 10" area. 8. All bars shall be of 10" volume. 9. All bars shall be of 10" weight. 10. All bars shall be of 10" cost.

TYPICAL DETAIL OF PORTABLE MODULAR GLASS SCREEN

STUD MOUNT-MECHANICAL

GLUSH MOUNT-ADHESIVE

BASE RAIL FASTENING

TYPICAL BASE RAIL ANCHORING METHODS

OKLAHOMA DEPT. OF TRANSPORTATION
TRAFFIC STANDARDS DIVISION
TRAFFIC CONTROL STANDARD
PRECAST CONCRETE MEDIAN BARRIER (PORTABLE TYPE)
AND PORTABLE MODULAR GLASS SCREEN
[SECTION 101-101]
[SECTION 101-101]
[SECTION 101-101]

03/29/01

FOR PORTABLE WALLMBLY

* BARRIER DELINEATOR @ 40' SPACING ON TANGENTS AND @ 20' SPACING ON CURVES. DELINEATOR SHALL HAVE 7.0 SQ. IN. (MIN.) REFLECTIVE AREA. DELINEATOR TO BE INSTALLED AS RECOMMENDED BY THE MANUFACTURER.

COST TO BE INCLUDED IN OTHER ITEMS OF WORK.

TWO DELINEATORS (ONE ON EACH SIDE OF BARRIER) SHALL BE USED IF TRAFFIC IS ON BOTH SIDES OR ONE DELINEATOR MAY BE MOUNTED ON TOP OF BARRIER. REFLECTORS SHALL FACE TRAFFIC

FLEXIBLE
TO MEDIA

END ELEVATION

FLEXIBLE PLASTIC POSTS

REFLECTIONS	NUMBER OF REFLECTIONS
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TYPE - 10

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100	REMARKS	DATE	TIME

Outside conductors

Ground conductors

Return path

We tell you the principle and the construction of the four-wire system.

HORIZONTAL CURVES

Place 1 1/2" pin to roadway in 10' lines
on center of a 10' long curve
on 10' station

STATION	10' STATION	10' STATION	10' STATION
10	10	10	10
20	20	20	20
30	30	30	30
40	40	40	40
50	50	50	50

[illegible][illegible][illegible]

TABLE A

CURVE	SPACING
100 m	10
150 m	15
200 m	20
250 m	25
300 m	30
350 m	35
400 m	40
450 m	45
500 m	50

1. The design speed on the left side of the road is 100 km/h. The design speed on the right side of the road is 150 km/h. The design speed on the left side of the road is 100 km/h. The design speed on the right side of the road is 150 km/h.

FINISHING NOTES:

1. The road is to be constructed in accordance with the design.
2. The road is to be constructed in accordance with the design.
3. The road is to be constructed in accordance with the design.

DIRECTION OF TRANSPORTATION	
STANDARD	
TRAFFIC DELINEATOR INSTALLATIONS	
DATE	REVISION
10 JAN 1980	1
ORG NO RD805	

All dimensions are in mm unless otherwise noted

FLARED

FOUR-LEG CHANNELIZED

THREE-LEG CHANNELIZED

Section 00840 - Delineators

Description

00840.00 Scope - This work consists of furnishing and installing delineators at locations shown or established.

Materials

00840.10 Delineators - Materials shall meet the following requirements:

Flexible Delineators	02850.30
Galvanized Support Posts	02850.10
Reflective Sheeting	02850.40
Target Members	02850.20

00840.11 Delineators At Guard Rail Locations - Delineators installed at guard rail locations shall be guard rail mounted (Type 4). Full length ground mounted delineators (Types 1 and 2) may be substituted.

00840.12 Use of Salvaged Materials - Delineator components salvaged from existing or temporary delineators may be reused in new permanent delineator installations providing they are of the current design, conform to these specifications and are free of damage which would impair their appearance or serviceability.

Suitability of salvaged materials proposed for reuse will be determined by the Engineer.

Construction

00840.40 Lines, Grades and Preparation Work - Install delineator posts to the lines, grades and spacings shown and as established. To avoid difficult installation at any individual post site, the spacing may be varied 5% in either direction and deviate from line by 150 mm in either direction as approved. Remove vegetative growth, litter and debris from the post sites.

00840.41 Installation of Delineator Posts - Drive or set the delineator post firmly in the ground so it meets the impact resistance requirements according to 02850.30(c-8). Post depths may vary from that recommended by the manufacturer. Posts set in sandy, gravelly or other unconsolidated material may need to be longer to provide adequate anchorage. Posts may be shortened to avoid unnecessary penetration in solid rock or in large rock fragments, as approved by the Engineer. If set in rock, drill a 230 mm deep hole, 25 mm greater in diameter than the large dimension of the post, and grouted in place with a fine mortar grout. The posts shall be vertical and firm. Remove and discard posts which become split, cracked, twisted, bent, or the tops become badly misshapen due to installation and replace with undamaged posts.

Firmly attach guard rail mounted delineators to guard rail posts as shown.

00840.42 Target Members - Assemble, fasten, set and align target members and reflective material appropriate to the type and color of delineators involved as shown or directed. All fastenings shall be tight. Attach the reflective sheeting to the posts by an approved positive means which has adequate strength to prevent loss of the reflective material during the life of the post or target.

Finishing and Clean Up

00840.70 General - Repair and restore exposed damaged surfaces of installed delineators as directed. Replace parts of delineators showing damage beyond repair with new parts.

00310.43. Remove and dispose of excess excavated materials and litter and debris resulting from the operations according to 00310.43. Replace fouled stone bases with clean material of the kind which became fouled. Clean traveled surfaces and finish areas disturbed by the operations to the lines, slopes and conditions of the current project.

Measurement

00840.80 Unit Basis - The quantities to be paid for will be the actual number of each type of delineators furnished, installed, and accepted regardless of color or number of reflectors, measured as units in place

Required preparation work, earthwork, grouting, backfilling, repair, restoration replacement, and cleaning up are considered as incidental to delineator installation and no separate measurement for this work will be made

Payment

00840.90 Unit Basis - The accepted pay quantities will be paid for at the contract unit price per each for the pay item "Delineators, Type ____". Payment will be payment in full for furnishing and placing all materials, including all equipment, tools, labor, and incidentals necessary to complete the work.

In the pay item the type of delineator will be inserted with a separate pay item provided for each type

The pay item "Delineators, Type 4" will apply to all guard rail mounted delineators and also for ground mounted delineators substituted.

Rhode Island

SECTION T.18

DELINEATORS AND HAZARD MARKERS

T.18.01 DESCRIPTION. This work shall consist of furnishing and erecting delineators and hazard markers of the type and design as indicated on the Plans and/or as directed by the Engineer, all in accordance with these Specifications. This work also includes the provision of flexible delineator posts.

T.18.02 MATERIALS. Single or multi-reflector delineators, reflectorized sheeting, and posts shall conform to the applicable requirements of SECTION M.16; SIGNS AND SIGN SUPPORTS, of these Specifications.

T.18.02.1 Flexible Delineator Posts. The delineators shall be manufactured from a flexible material which meets the following requirements:

- a. **Height.** The overall dimensions of the delineator post shall be such that when installed in accordance with the manufacturer's instructions, the top of the post shall be 48-inches above the final surface.
- b. **Delineator Posts** shall remain flexible at temperatures between 0°F and 140°F and shall be durable, resistant to impact, ultraviolet light, ozone hydrocarbons and other atmospheric weathering. Posts shall be white or yellow in accordance with details indicated on the Plans.
- c. **Posts** may be either a one-piece system or a two-piece system. When a two-piece system is used, the post portion shall be readily replaceable without removing or partially removing, the anchor and without displacing the soil around the anchor.
- d. **Surfaces.** Both the front and back surfaces of the delineator shall be smooth surfaces capable of accepting