CHAPTER 11. ROADWAY DELINEATION MANAGEMENT

INTRODUCTION

An effective system of roadway delineation management is necessary to achieve safe, cost-effective delineation. Programs must be instituted to monitor and record performance of installed delineation systems.

This chapter will discuss some of the approaches that have been adopted for this purpose. In addition, recommendations will identify efficient management based on the latest techniques and research.

SAFETY AND YEAR-ROUND MAINTENANCE

To achieve the safest possible delineation system, the management of roadway delineation must be a closely maintained, year-round program. A highway agency's management of a delineation system will consist of the following responsibilities:

- Define a system by which the current techniques of roadway delineation performance can be objectively judged.
- Institute a system to inventory its markings, their individual condition, and individual past performance.
- Oversee the collection of information for the resulting data base.
- Create specifications that will standardize approved procedures and equipment for data collection.
- Train and certify field inspectors.

MINIMUM RETROREFLECTMTY

Retroreflectivity is the most commonly used method of evaluating the performance of delineation techniques. Research has established that nighttime retroreflective properties of a delineation technique are directly related to its subjective effectiveness. A typical study of this sort was performed by the University of North Carolina.[24] The study showed that if a pavement marking is effective at night (has good retroreflective properties), it will also probably perform well in daylight.

In this chapter, we will concentrate on using a minimum level of retroreflectivity to establish the effectiveness of delineation. The same research as cited above has also attempted to establish a minimum value of retroreflectivity for adequate visibility. Because of the difficulties with measuring techniques (see chapter 2), these values often do not correspond exactly for different instruments (table 17).

Recently, correlation between instruments has improved greatly because many of the instruments' manufacturers have begun to make fine-geometry instruments with great similarity in the measurement angles and areas. With proper calibration, these instruments can normally be counted on to correlate within about 10 percent accuracy. Several separate sets of researchers have now arrived at a value of about 100 millicandelas per lux per square meter as the minimum value for coefficient of retroreflected luminance, R_L for pavement markings.[24,25,26] More information may be found in the references in chapters 2 and 3.

Table 17. Correlation coefficients between pavement marking retroreflectometers

	Ecolux	Potters	Zehn/ PS	Zehntner	Optronik	Erichsen	Ohio #1	Ohio #2	New York	Penn #1	Penn #2	Penn #3	Virginia
Potters	.851												
Zehn/PS	.959	.856											
Zehntner	.845	.56	.86										
Optronik	.947	.802	.992	.916									
Etichsen	.986	.838	.989	.858	.978								
Ohio #1	.916	.919	.98	.757	.953	.952							
Ohio #2	.902	.853	.986	.833	.98	.95	.986						
New York	.723	.752	.887	.723	.884	.81	.918	.95					
Penn #1	.761	.756	.899	.82	.915	.826	.907	.953	.976				
Penn #2	.812	.826	.931	.808	.934	.866	.947	.974	.974	.993			
Penn #3	.769	.699	.898	.876	.927	.832	.881	.943	.939	.992	.977		
Virginia	.711	.561	.866	.829	.893	.809	.834	.907	.939	.927	.903	.947	
Hercules	.656	.722	.826	.723	.838	.733	.86	.904	.975	.986	.973	.965	.895

In general, the average highway agency need not be concerned with problems in the standards. It should instead focus on selecting an appropriate instrument and using that instrument consistently to obtain reliable values.

INVENTORY

Each highway agency's management staff should establish a system to inventory all roadway delineation applied within the agency's jurisdiction. In this way, the agency can monitor any section of roadway and determine what techniques and treatments seem most effective on it. Also, a regular system of inventorying roads will help a highway agency identify problem spots or locations that have become hazardous.

Computerized

Computer data bases that track information on delineation is one method of inventorying roads. These systems consist of a computer that tracks each delineation application's characteristics and vital information. Each entry in the data base might consist of a particular marking project. Alternately, the roadway system could be divided into sections, with each section being monitored separately. Information included could be type of delineation devices, location, materials used, and current state of the devices. These systems will normally rely on subjective nighttime evaluations of retroreflectivity or readings taken with a portable instrument. The following section discusses just how these subjective evaluations should be performed.

Photo Log

The concept of photo log inventory can be illustrated with an example. A study performed in Texas proposed a system to evaluate effectiveness of raised pavement markers (RPMs).[74] The procedure has four possible steps: creation of a photographic inventory, site evaluations of RPMs' effectiveness, use of maintenance photographs, and decision of appropriate actions.

1. *Photographic inventory.* Sites to be evaluated should be photographically inventoried from a vehicle. The appropriate camera setting should be either a l/60-second shutter, f-stop 1.4, or l/30-second shutter, f-stop 1.8. A high-speed 35-mm film, such as ASA 400 pushed two stops, or a night B-mm movie film such as Type G should be used.

2. *Site evaluation.* A panel of five, seven, or nine individuals selected by district personnel should examine the photographs from the sites to be evaluated. This panel is not so large that the members cannot adjust their schedules to perform the evaluation. The odd number prevents ties.

The subject site will be evaluated with respect to the effectiveness of its RPMs. An acceptable rule of thumb is that if 50 peroent of the markers are missing, the system is ineffective. A system is semi-effective when 20 to 30 percent of the markers are missing. Markers become ineffective when their specific intensity is 0.05 candle power per foot candle or less for 75 percent of the remaining markers. A system is semi-effective when 75 percent of the remaining markers have a specific intensity between 0.2 and 0.4 candle power per foot candle. At the time of the study, the only way to determine the specific intensity of the markers was to either remove several randomly selected markers for analysis in a laboratory or use a photometric van.

3. *Maintenance photographs.* When the panel cannot decide the effectiveness of the markers based on their physical properties, a set of maintenance slides should be used. A suggested procedure is for each member of the panel to view the slide of the site in question individually and to consider the set of maintenance standards. After each member selects the most appropriate standard, the panel would reconvene. A decision would be reached by using the standard set of photographs.

4. *Appropriate actions.* If a site is judged to be semi-effective or ineffective, the appropriate action would be taken and that the maintenance activity decided on by the evaluation panel would begin.

Expert panel members should rate the effectiveness of the sites based on the following guidelines:

Effective. A site would be effective if, in the mind of the rater, the RPM system provided sufficient information to drivers without any maintenance needed at the site. The rater should judge the effectiveness based on the number of missing markers, visibility of the markers remaining, test conditions, color of the markers, spacing of the markers, and intended purpose of the pattern.

Semi-effective. A site would be semi-effective if would need maintenance within the following 6 to 12 months to establish it as effective. Completion of the necessary maintenance would depend on the availability of funds and the placement of the site in the maintenance schedule. Semi-effective systems are those that, at the time the location was rated, the drivers considered the RPMs to provide marginally sufficient information.

Ineffective. A site is ineffective if the RPMs are not providing sufficient information to the driver and immediate maintenance is required. No other treatment except total maintenance of the site can be used to provide the required positive route guidance needed by drivers.

The system explained here could be applied easily to an overall management program for an agency's delineation projects.

Other Techniques

There are a few new methods for inventorying roadways. One combines videotaping all of the roads within a highway agency and cataloging the tapes on a computer laser videodisc system. In the past, this system has been used to maintain video records of all roadways and would be used mainly during design of new construction projects. However, once the system has been created, application of the technique to other departments in the highway agency, such as delineation management, would be very simple.

A program like this has begun in the State of Connecticut and is discussed in a Federal Highway Administration report on innovative techniques for traffic control devices.(91)

INSPECTION

Inspection is vital to management of delineation programs for those agencies that do not maintain an inventory of all roadways. Highway agencies should institute a policy for periodic inspection of all delineation projects after their installation and throughout their service lives. Some recommended methods of inspecting delineation are discussed in the following sections.

Daytime

Daytime inspections of delineation will consist normally of tests that require the inspector's presence on the roadway or well-lit conditions for good visibility of the material itself. These include testing of percentage of material remaining, color durability, and cleanliness of RPMs and other retroreflective devices. The method for determining percentage of material remaining is presented in chapter 5. Color durability is- tested using a comparison guide with standard highway colors.

Sometimes retroreflection also will be tested during the daytime. For pavement markings, this may be done manually with the sun/shadow technique or by using a pocket microscope or portable retroreflectometer. With the sun/shadow technique, the marking is viewed at an angle so that the shadow of the viewer's head is directly on the marking, as shown in figure 87. From this position, light from the sun will be directed back to the viewer, causing the marking to "glow." Using this method, an experienced inspector can make a reliable

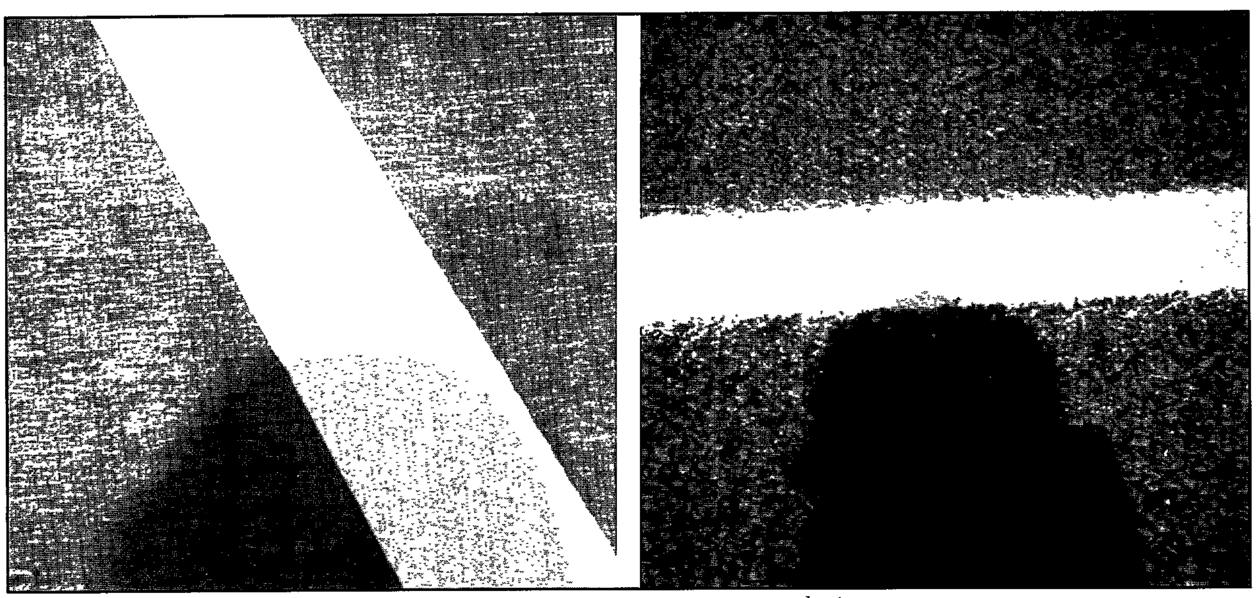


Figure 87. Examples of sun/shadow technique estimate of nighttime effectiveness of the marking.

For warning signs and other types of delineation devices, the Q-beam method of testing discussed in chapter 10 may be employed during daylight.

Nighttime

Research has established that reduced nighttime visibility is normally the first sign of failure for a delineation device. For this reason, retroreflection is tested most often through simple nighttime inspections of a device's brightness and visibility distance. These inspections often are made simply using automobile headlights for illumination. Highway agencies often establish formal guidelines for minimum visibility distances of delineation devices at night. Devices that do not meet the visibility distance requirement are identified for repair, cleaning, or replacement.

A word of caution is included with the use of this practice. Almost all night driving is with low-beam illumination. Most drivers will not use high beams unless oncoming traffic drops below one vehicle every two minutes. Some highway agencies, however, have used high beams at night to establish visibility distances. This practice is discouraged by the FHWA, since it does not represent the average driving situation.

Equipment and Facilities

One of the advantages of the methods described previously is that the equipment and facilities required are minimal. For nighttime inspections of the type discussed, only an automobile and an inspector are needed. Some of the daytime inspections require instruments for measurement. These instruments are discussed in the next section.

FIELD TESTING

Many of the inspection techniques discussed require some form of field testing of installed delineation. This section will discuss the instruments and procedures related to performing field tests.

Instruments

A variety of instruments can be used in the field to test retroreflectivity. These devices range in price from a few dollars for a pocket microscope to $10,000 to $15,000 for a portable retroreflectometer.

Microscope

A pocket microscope, shown in figure 88, may be used to test distribution, quantity, and proper embedment of glass beads in the pavement marking. A pocket microscope is a small, inexpensive, lensed apparatus with magnifying power sufficient for the inspector to discern individual beads.

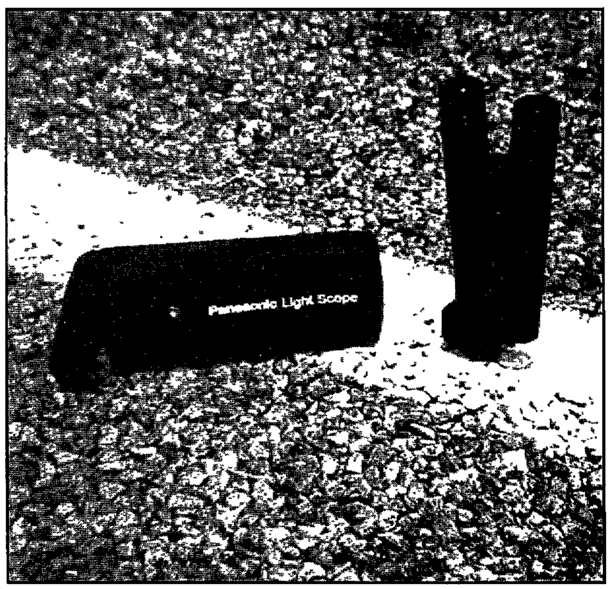


Figure 88. Pocket microscope

Beads should appear uniformly distributed over the marking, densely packed to give good retroreflection. They should not be packed so closely that they obscure the surface of the pigmented binder.

Embedment should be about 55-60 percent of the bead's diameter.

Retroreflectometer

A variety of instruments to test the retroreflectivity of pavement markings electronically are now available commercially. Most of those used are small, hand-held, portable units. These instruments are simply small box-like apparatus with optical devices mounted upon their undersides. The unit is set upon the marking to be tested, the instrument shines a light at a fixed sample area and then measures the percentage of light returned. Most are calibrated to read in units of millicandelas (0.001 candelas) per lux per square meter.

For more information on optical units and some of the problems with current testing standards, see chapter 2.

Portable Equipment

Portable retroreflectometers are used to obtain performance estimates through measurements of retroreflectivity.

These instruments are usually classified by fine and coarse geometry. Fine geometry instruments closely simulate the entrance and observation angles experienced by a driver, while coarse geometry instruments do not. Therefore, the fine geometry instruments are much better at predicting subjective ratings of effectiveness.

These are often used as evaluation criteria, as discussed in the section on Safety and Year-Round Maintenance. Some characteristics of the most popular equipment are given below.

Mirolux 12

Many studies use the Mirolux 12 retroreflectometer, pictured in figure 89, in an attempt to establish minimum retroreflectivity standards. It is a fine geometry instrument with illumination and observation angles of 86 l/2 and 1 l/2 degrees, respectively. The recommended procedure for use consists of the following steps:

1. Zero and calibrate the instrument.
2. Check the battery voltage.
3. Take reading(s). Three readings shol be taken at each location. Each reading should be within **10** percent of the average reading. If any of the readings are not, two more readings should be taken.

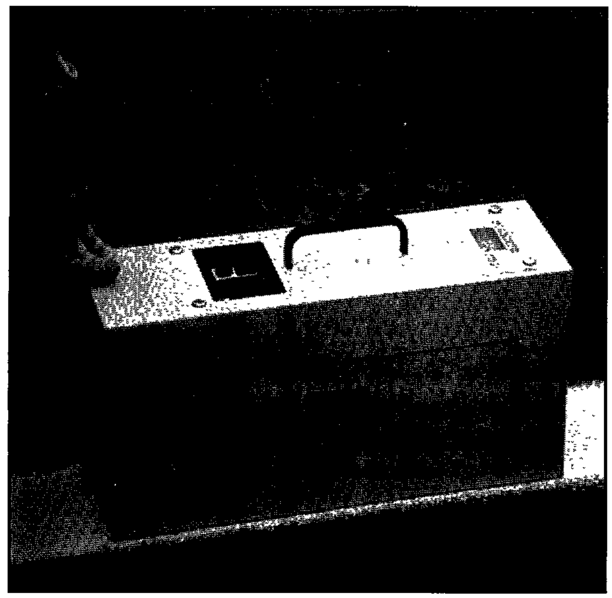


Figure 89. Mirolux 12 retroreflectometer

The instrument is manufactured by MiroBran Assemblers, Inc. (Clifton, NJ). The price is about $4,500. It is considered one of the more cost-effective portable instruments.[25]

Other Instruments

A number of other foreign-built, fine-geometry instruments are being used in the United States. These include the Ecolux, Erichsen, and Optronik brands. Studies have attempted to establish the correlation of readings of these instruments with one another, with other instruments, and with subjective panel ratings.[25,6] In general, the fine-geometry instruments correlate with one another, and with subjective ratings, much more closely than the coarse-geometry instruments.[6] When the instruments have been properly calibrated, the fine-geometry retroreflectometers usually correlate within 10 percent of other fine-geometry instruments (table 17).

Mobile Equipment

One of the limitations with even the fine-geometry instruments has been their lack of flexibility. For most of these instruments, there have always been problems due to the instrument's fixed geometry, sample area, and sensitivity to background light and other environmental interference. A new laser retroreflectometer will rectify some of these deficiencies. Advanced Retro Technology (La Mesa, CA) has developed such a device in cooperation with Potters Industries (Parsippany, NJ); it is described in a study performed by J.J. Rennilson.[92]

Figure 90 shows a schematic diagram of the laser retroreflectometer. In order to block ambient light and enable day/night retroreflectivity measurement, this new device makes use of a specific wavelength of laser light and a narrow band-pass filter. The filter blocks reception by the photoreceptor of all other wavelengths of light. Thus, it makes possible day/night, wet/dry variable geometry retroreflectivity measurements.

Figure 91 shows the laser retroreflectometer mounted on a pickup truck. The laser beam exits through the lower lens and is aimed so that, on level ground, it strikes the pavement marking at a distance of 33 feet (12 meters). The retroreflected light from the marking enters the device through the upper lens. The test vehicle can travel at normal highway speeds while recording data. A video camera mounted on the seat is aimed at the marking being evaluated. The retroreflectometer's alignment is shown on a video monitor and is used by the driver to guide the vehicle. Data captured on a laptop microcomputer mounted on the passenger seat is later analyzed on a microcomputer at the Advanced Retro Technology office.

Initial tests of the device have been highly successful. The results of readings taken in the field under high sun daylight and nighttime conditions for the same marking materials were compared for each marking material tested, yielding a correlation within 2.5 percent. The correlation of the laser retroreflectometer results with laboratory readings for pavement marking tape can be seen in figure 92.

Plans are being made to market and sell this device to highway agencies. At this point, revisions and improvements are being made to the computer hardware and software that facilitate data collection for the system.

When available, this device should be an aid to highway agencies in determining the quality of markings. The device yields good results for retroreflectivity; it is easily mounted on a small truck or van and can be used during the daytime at highway speeds without the need for traffic controls.

The device can be used even to scan retroreflectivity across the face of the marking to measure the uniformity of its retroreflective properties. This ability may allow it to be used on a striping machine as a method of quality control for the pavement marking process.

TORT LIABILITY

Tort liability claims have risen dramatically in recent years (chapter 12). Because of the huge awards that have resulted when these claims have gone against highway agencies, many of these highway agencies have been searching for ways to limit their tort liability.

One of the most effective methods available to a highway agency for reducing exposure to tort claims related to delineation is a comprehensive, efficient roadway delineation management system. This system establishes a reasonable standard of care for a highway agency's activities. If a highway agency has an FHWA-approved policy for management of delineation systems, following the policy takes on the force of a statute governing the actions of the agency.

This is not meant to imply that following a delineation inventorying and management program will guarantee immunity from prosecution. Each court will make a ruling based on the specific concerns of the case. The management system should be used instead to establish the

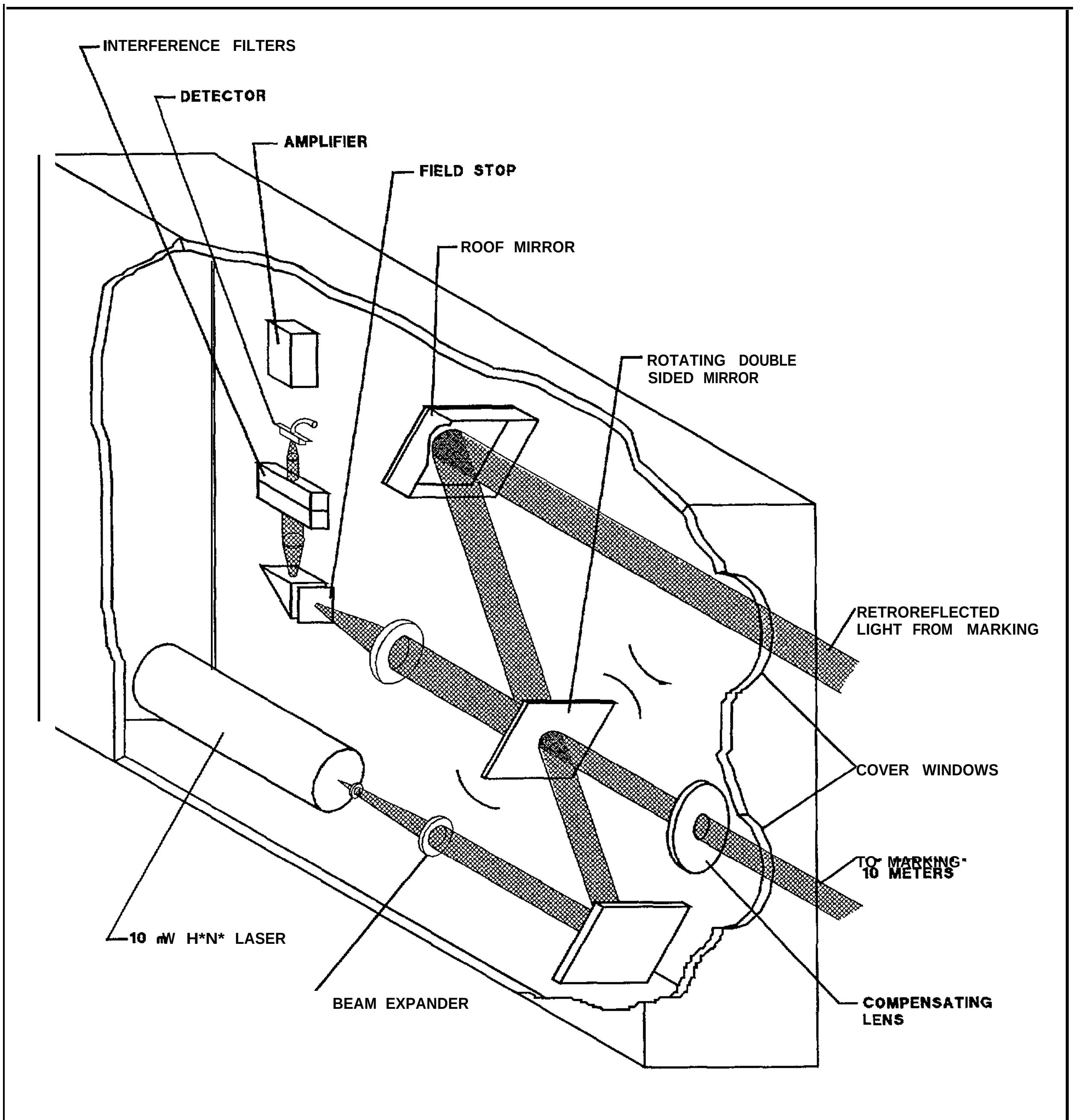


Figure 90. Schematic of laser retroreflectometer

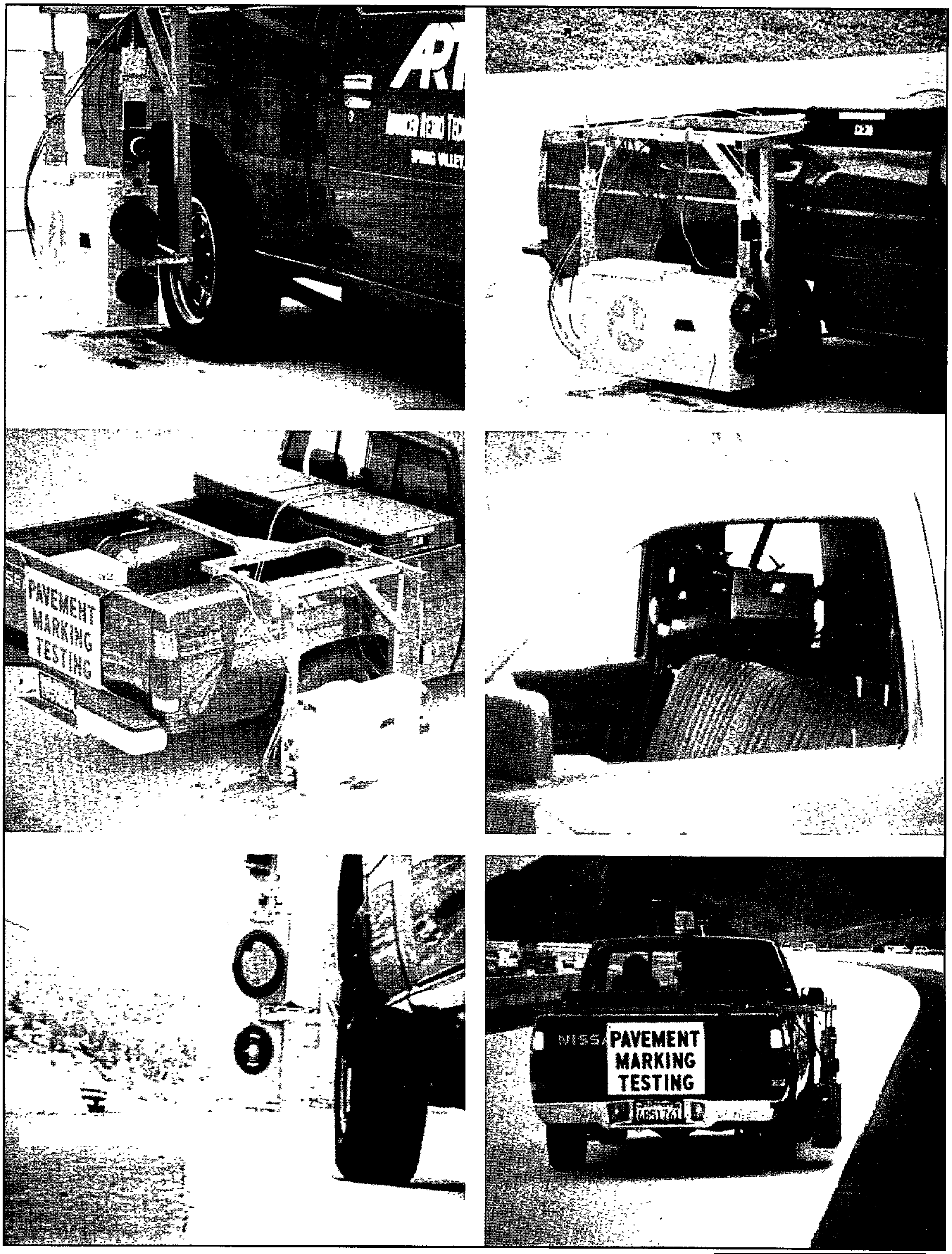
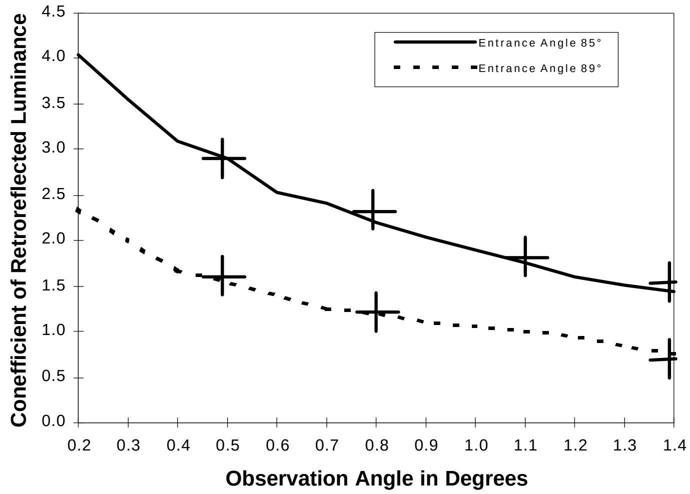


Figure 91. Pictures of the truck-mounted laser retroreflectometer



A calibration factor for the laser retroreflectometer was determined at 0.5 degrees and used to correct the meter readings to yield the coefficient of retroreflected luminance. As a reference, the 40-motor distance mark is given at 0.9 degrees, 89 degrees for the passenger car.

Figure 92. Retroreflection of pavement marking tape as a function of observation angle and two entrance angles

safest roadways possible, thus establishing the highway agency' s paramount concern for the safety of the traveling public.