METHODS FOR EVALUATING DETERIORATION OF IN-SERVICE REFLECTIVE SHEETING SIGNS

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

METHODS FOR EVALUATING DETERIORATION OF IN-SERVICE REFLECTIVE SHEETING SIGNS

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METHODS FOR EVALUATING DETERIORATION OF IN-SERVICE REFLECTIVE SHEETING SIGNS

The Traffic and Field Services Section of the Traffic and Safety Division requested the Research Laboratory to develop a method for numerically evaluating the weathered condition of a sign, especially at the point in time when a sign reportedly begins a rapid deterioration. It was assumed that at that time, sign life could be extended and reflectivity maintained by merely clearcoating the sign. After that time an expensive overlay of aluminum panels with sheeting affixed would be required. The method developed should be such that District Traffic Engineers could inspect large numbers of signs in a short period of time, and would employ a numerical evaluation that would not change from District to District, nor be dependent on differences in individuals.

In order to establish a common basis for evaluating signs, we requested the Traffic Field Services Section to submit locations of sample signs with accompanying evaluations of them. Traffic Field Services selected five signs on I 96 near Brighton representing signs approaching rapid deterioration and termed these signs "Intermediate." They also selected five "New" signs and five signs termed "Old." The "Old" signs appeared to be well past the point of beneficial maintenance by clearcoating. They rated these 15 signs on the basis of daytime appearance only.

After a preliminary study of these signs, two members of the Photometry Unit selected eight additional signs on I 94 near Jackson in four stages of deterioration according to nighttime appearance only. Factors considered were discoloration and apparent brightness of the sign background and legend. The four categories were termed, "New," "Intermediate," "Old," and "Very Old."

Several methods for determining a numerical or a categorical rating for each stage of deterioration were used. A description of the methods, results obtained, and an evaluation of the results follow.

Method 1: Luminance

Sign luminance or brightness measurements were made by means of the Pritchard Brightness Meter. An incandescent spot lamp (Tungsol No. 4537) illuminated the sign from a 100-ft distance. The separation between the lamp and the brightness meter was 7 in., forming an observation angle (the angle formed between the line of a light beam striking a sign and the

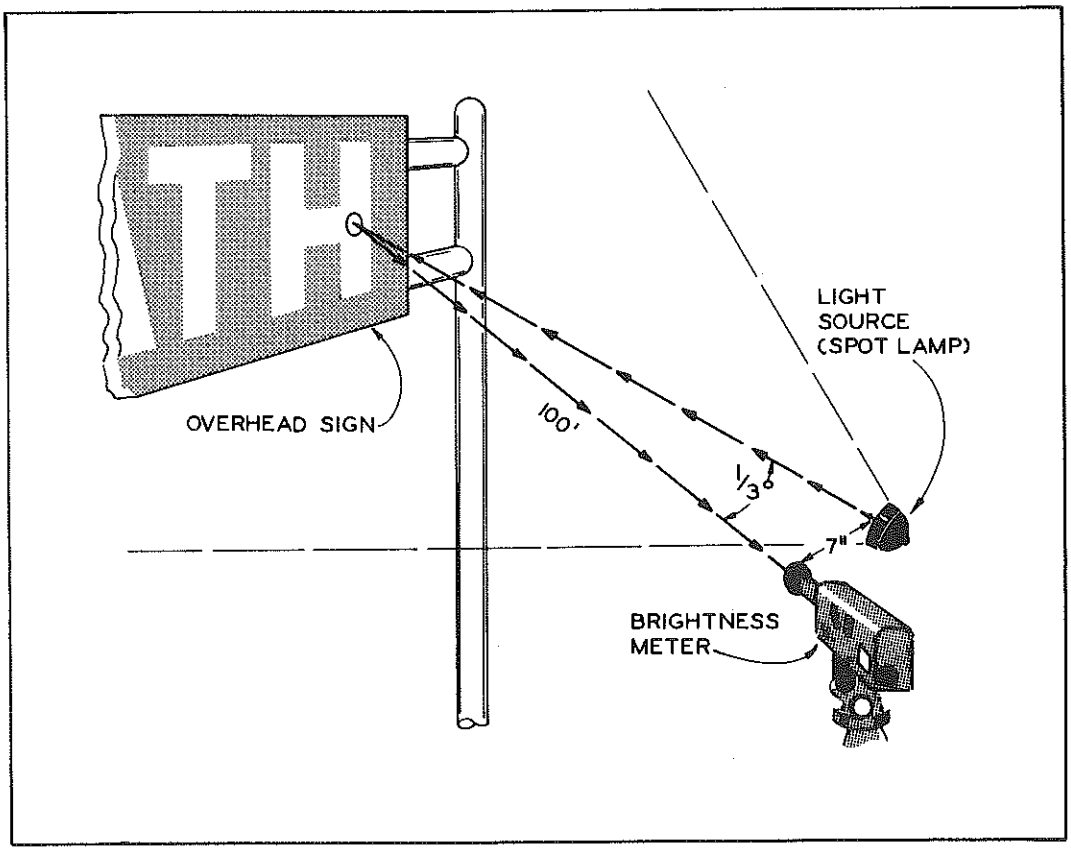

Figure 1. Measuring sign luminance.

line of the reflected beam) of 1/3 degree at the 100-ft test distance. Figure 1 shows the brightness meter, spot lamp, sign relationship and a typical measurement area on the sign legend. A previous study by the Photometry Unit had determined that a 1/3 degree observation angle was typical for an arbitrarily selected 1,000-ft viewing distance with high-beam headlights on an average automobile. To assure that all signs received the same illumination; a regulator, a d-c power supply, and a voltmeter monitor maintained lamp voltage at a constant 12.0 volts.

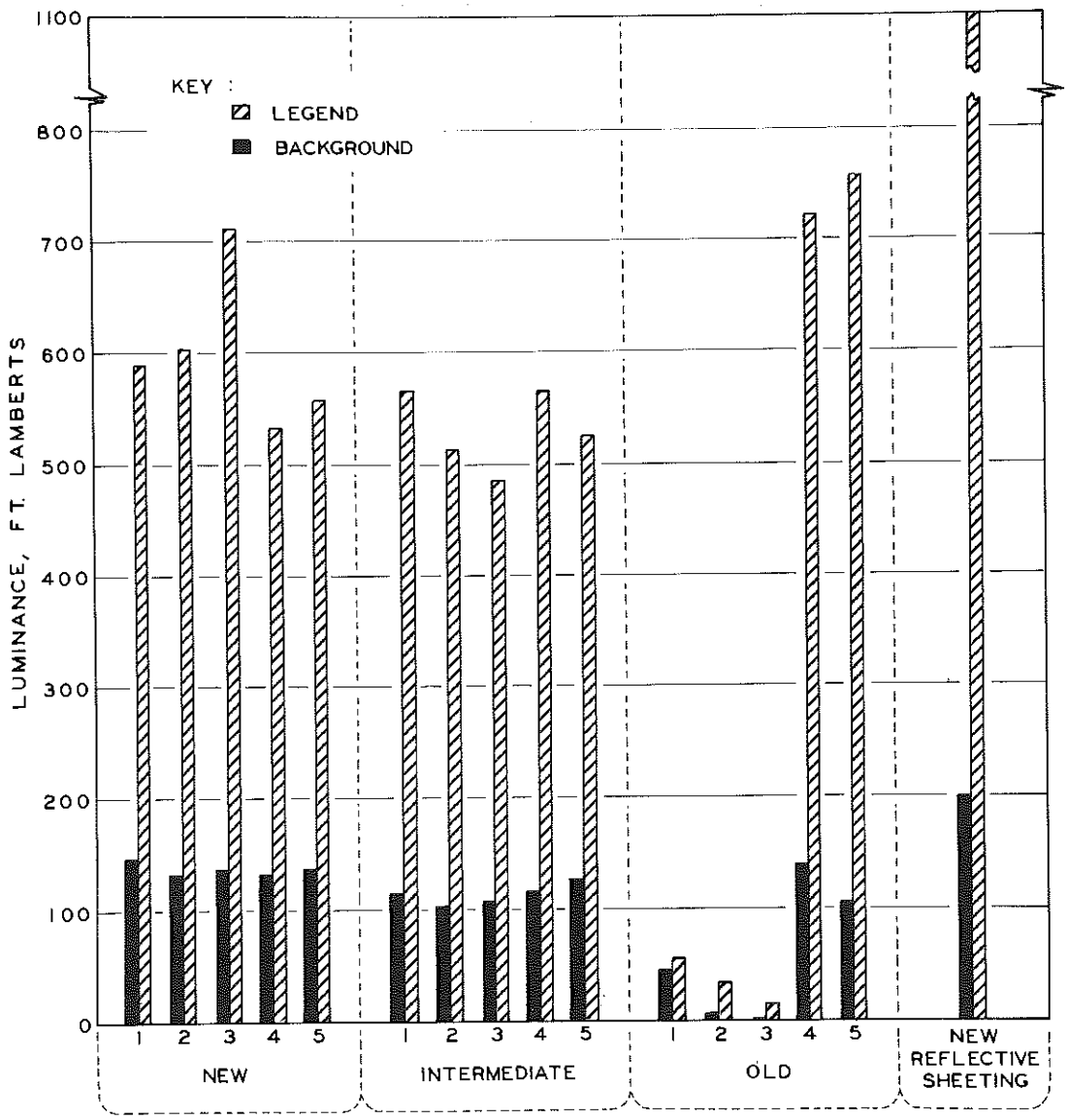

Figure 2. Sign luminance values, I 96.

Figure 2 shows the luminance values for the I 96 signs and new reflective sheeting as a comparison. Figure 3 depicts typical "New" and "Intermediate" signs on I 96. It was found that even though the I 96 "Intermediate" signs had cracks in the legend sheeting, legend and background luminances were not significantly lower than those of the "New" signs on I 96. Figure 4(a) shows a typical letter from "Old" signs on I 96. Luminances for these "Old" signs are numbered 1, 2, and 3, in Figure 2. Figure 4(b) shows a letter typical of the other "Old" signs on I 96, numbered

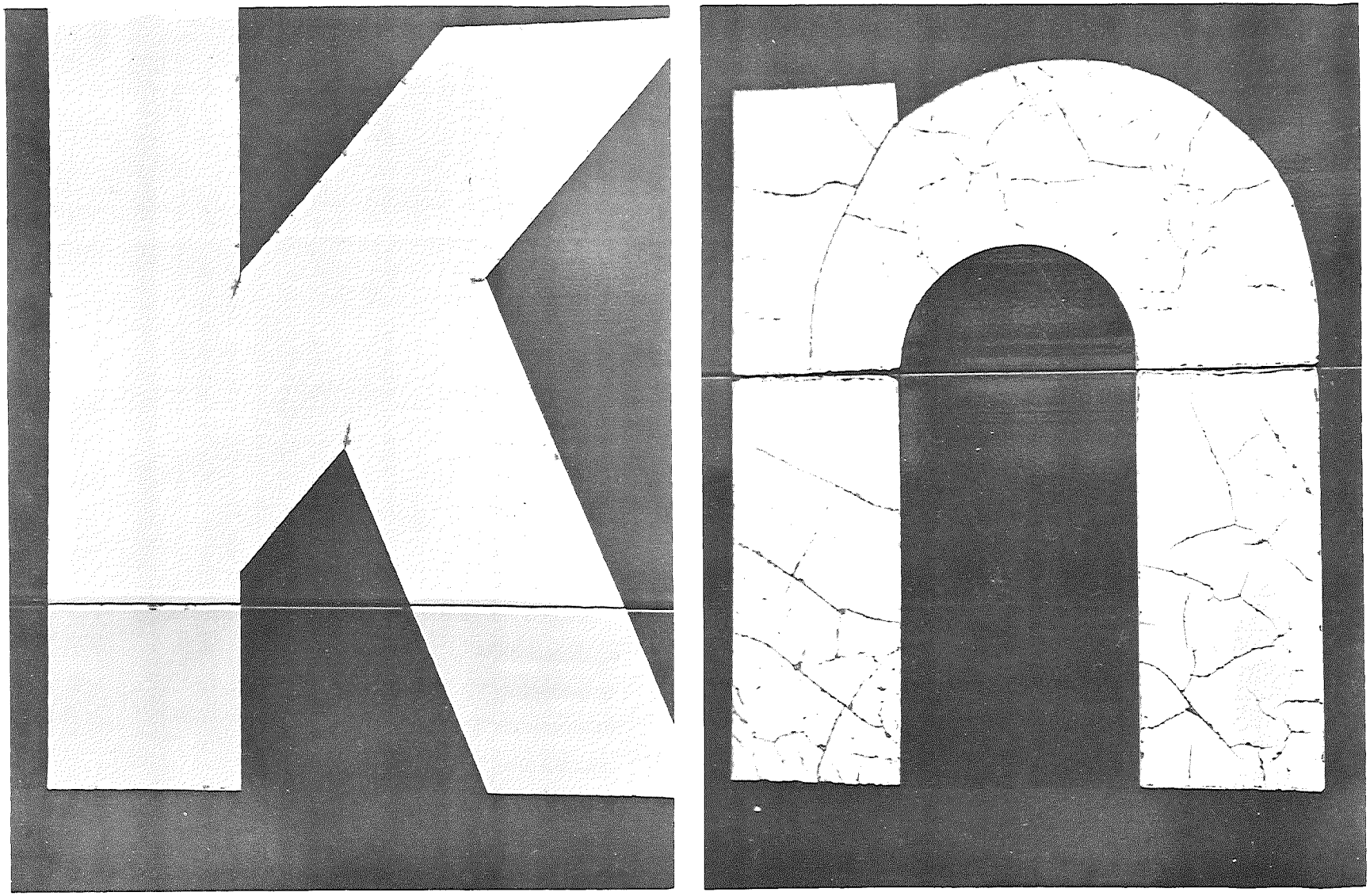

Figure 3. Typical condition of "New" (left) and "Intermediate" (right) signs on I 96.

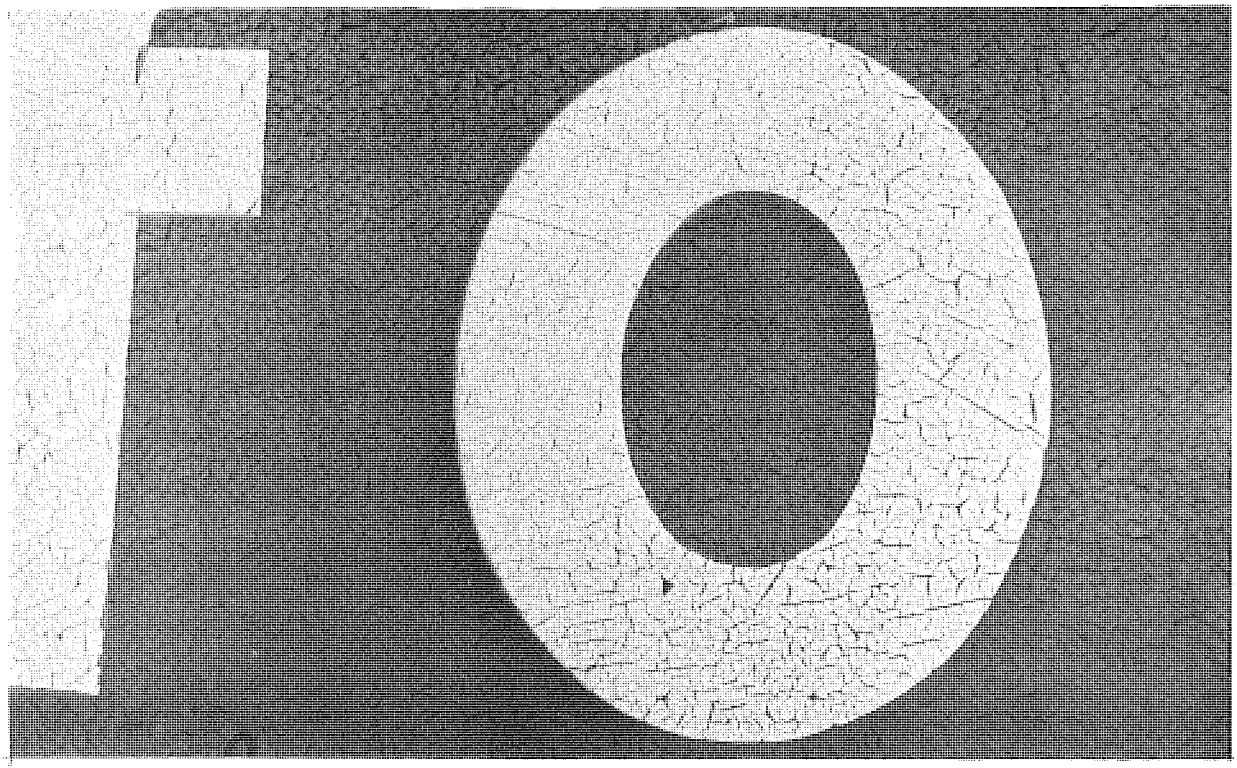

Figure 4a. Typical section of "Old" I 96 signs. Nos. 1, 2, and 3.

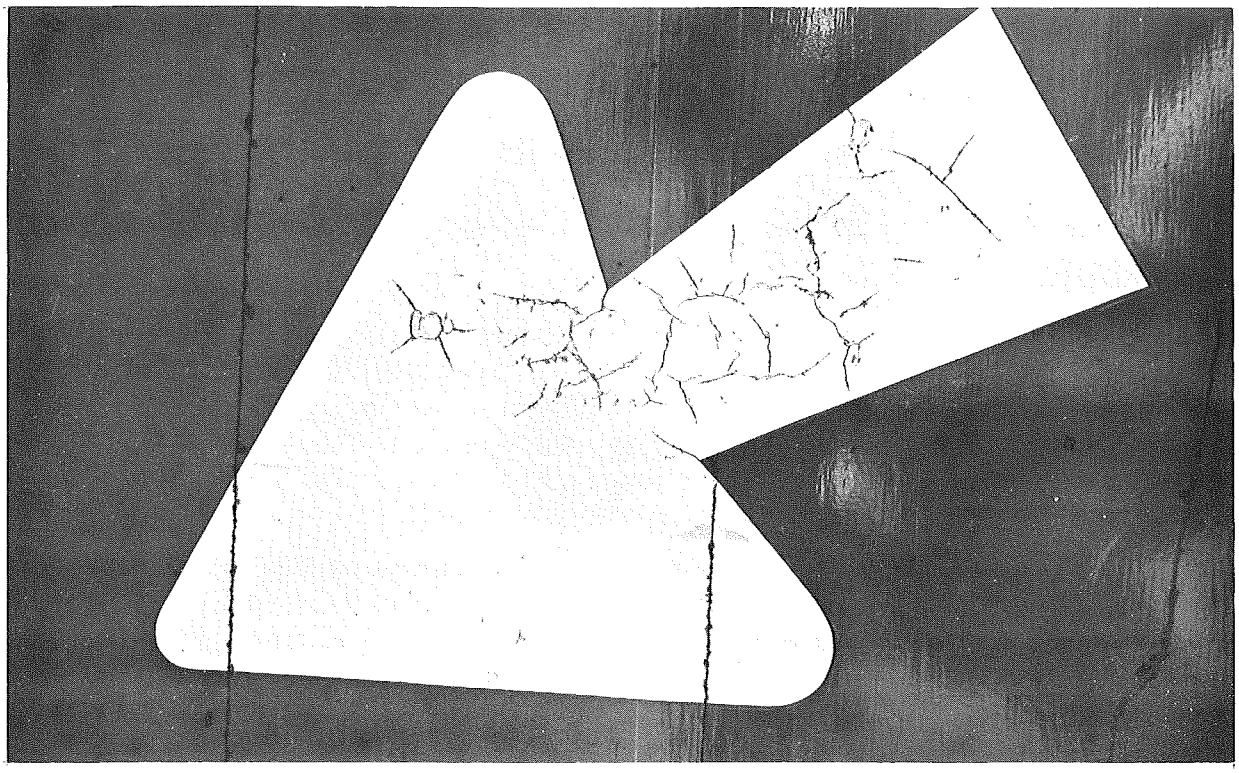

Figure 4b. Typical section of "Old" I 96 signs. Nos. 4 and 5.

4 and 5 in Figure 2. The legend and background luminance values of the above numbered 1, 2, and 3, "Old" signs were approximately 5 to 40 percent of the values for "New" and "Intermediate" signs. These luminances were considered too low for nighttime legibility. The luminance values of the above signs numbered 4 and 5 were as high as values for "New" signs.

The table below shows legend-brightness to background-brightness contrast ratios. The results indicate that there is no correlation between deterioration and contrast ratio. It might be concluded that legend and background deteriorate equally. However, luminances for the "Old" and "Very Old" signs (Fig. 5) indicate that legend may deteriorate more rapidly than the background.

TABLE 1

Contrast Ratio--Legend Luminance: Background Luminance

Sign Condition	Sign Number				
	1	2	3	4	5
New	4.0:1	4.6:1	5.2:1	4.1:1	4.1:1
Intermediate	5.0:1	5.1:1	4.5:1	4.9:1	4.9:1
Old	1.2:1	4.5:1	7.3:1	5.2:1	7.1:1
New Reflective Sheeting		5.2:1			

Of the signs on I 94 classified by nighttime appearance, the "Intermediate" signs were nearly as bright as the "New" signs even though the "Intermediate" sign surfaces exhibited occasional cracks and some discoloration. Figure 5 shows the luminance values for the I 94 signs as compared to new reflective sheeting. Typical examples of "New" and "Intermediate" I 94 signs are shown in Figure 6. Two stages of severe surface deterioration were identified and classified as "Old" and "Very Old" (Fig. 7). Figure 8 shows a detailed view of surfaces classified as "Very Old." The luminance values for the "Old" and "Very Old" signs ranged from 20 to 50 percent of the luminance values for "New" and "Intermediate" signs.

The luminance of the "Very Old" signs was too low for legibility at an adequate distance (greater than 300 ft). The condition of the "Very Old" signs on I 94 was similar to the "Old" signs on I 96, that is, they exhibited numerous and extensive cracks on both the legend and background.

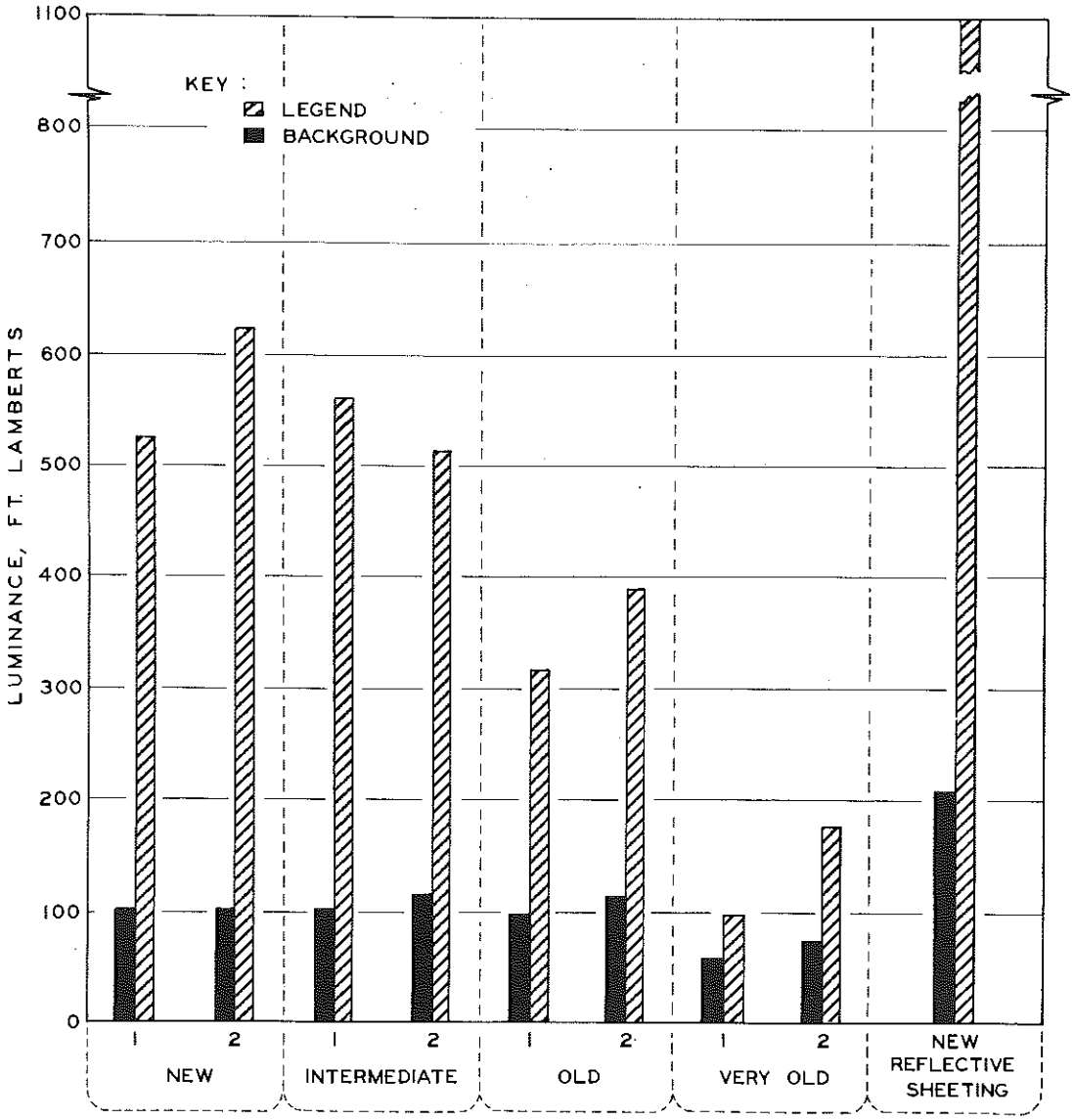

Figure 5. Sign luminance values, I 94.

Evaluation of Method 1

The luminance method can provide values or numerical evaluations of signs independent of human judgement. Under given conditions or standardized conditions results are highly reproducible. However, we found it necessary to use a reference sheeting panel previously calibrated in the laboratory and finally mounted in close proximity to the sign measurement

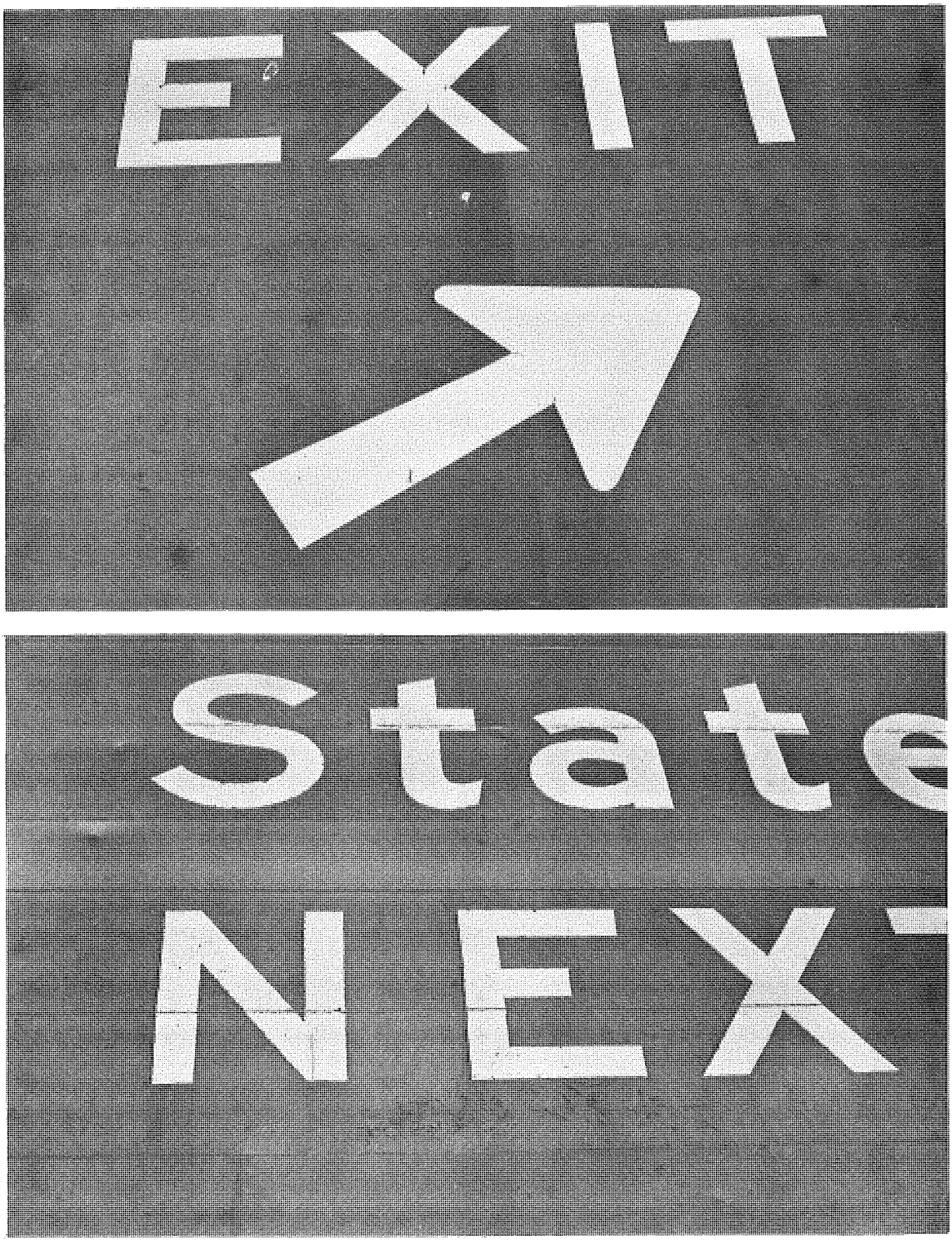

Figure 6. Typical condition of "New" (above) and "Intermediate" (below) signs on I 94.

Figure 7. Typical condition of "Old" (above) and "Very Old" (below) signs on I 94.

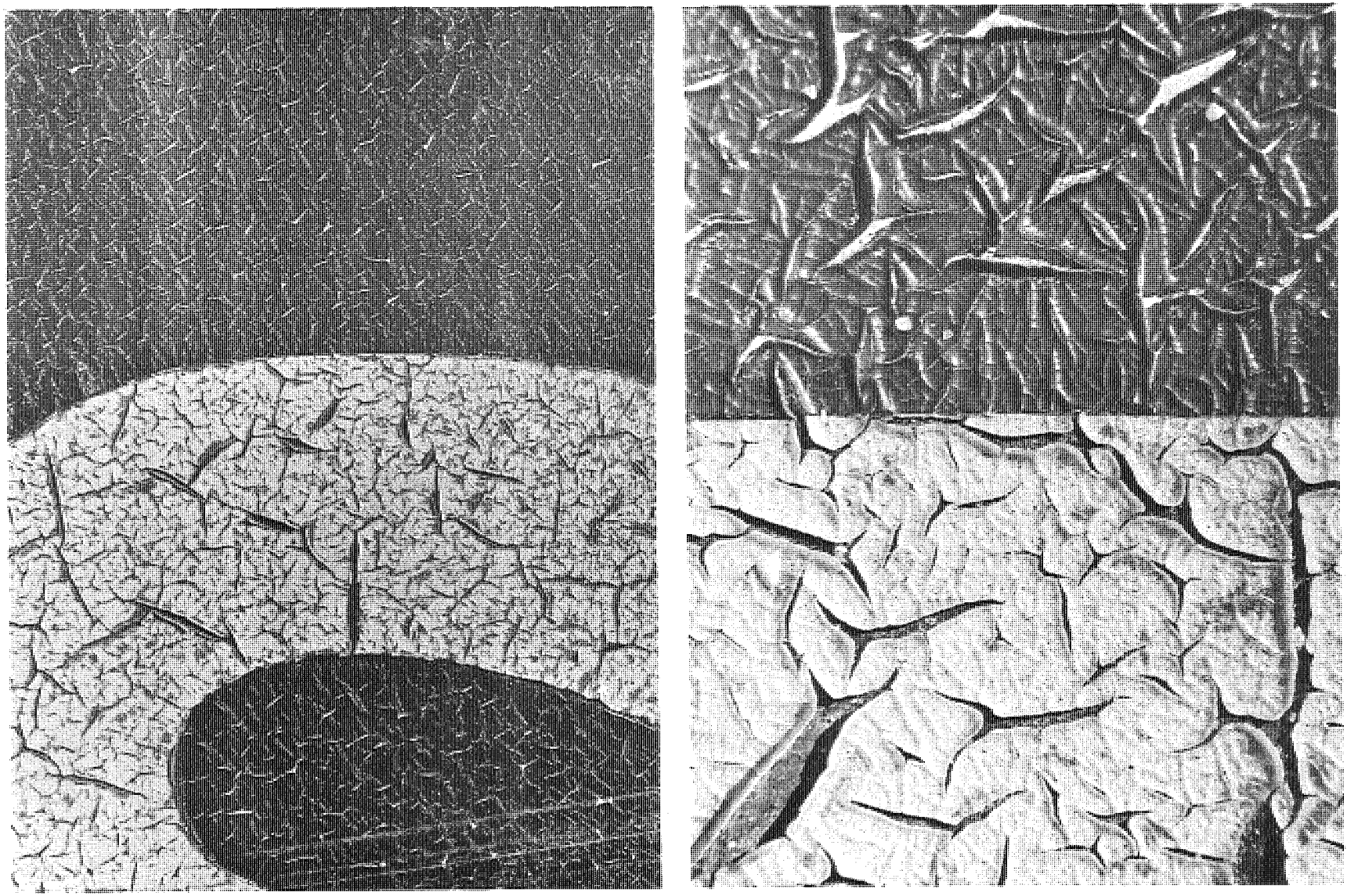

Figure 8. Detail of "Very Old" signs, I 94, showing extreme deterioration.

area in order to obtain sign to sign comparison data. In the field we found that luminance values on the reference panel were not reproducible and probably for a number of reasons. For example, light-source to brightness-meter orientation was easily obtained (Fig. 1) but light-source and brightness-meter orientation with respect to the sign was at best a rough approximation. This orientation, or position in angular space, is very important because luminance measuring angles of up to 30 degrees from the perpendicular to the sign face result in luminance values up to 40 percent less than the values measured at normal incidence. Such angles are possible because of the terrain at the sign sites. Specular reflection caused by the uneven sign surfaces was also a contributing measurement error.

As expected, this procedure is not only time consuming but requires the use of a $2,500 meter plus a light source operating from a supplemental and very stable electrical power supply.

Sign age or sign surface deterioration was not readily apparent from luminance results except for those signs that were severly weathered. Clearcoating the signs further complicated any possibility of predicting sign age because clearcoating raised sign luminance values.

The luminance method can be recommended for special tests associated with the establishment of standards or for evaluating experimental signs. For routine work, however, we quickly noted that the involuntary visual comparison of sign and necessary reference panel made the meter unnecessary.

Method 2: Sixty-Degree Gloss

Sign gloss, the ability of the sign surface to reflect light as a mirror or to produce a mirror image, was measured by means of a Photovolt Glossmeter Model No. 610. The gloss head was placed directly on the washed sign surface for the measurement. The gloss values for I 96 and the I 94 signs and new reflective sheeting are shown in Figures 9 and 10. The results of the gloss tests show that the gloss of the sign face is not affected by sign deterioration unless the sign face has greatly deteriorated.

Evaluation of Method 2

The procedure for measuring gloss is unsatisfactory for at least two of the reasons noted under the luminance procedure; both are time consuming and costly. Placing the gloss meter head directly on the sign face required the use of a lift truck for the overhead and cantilever signs. A gloss meter costs approximately $700.

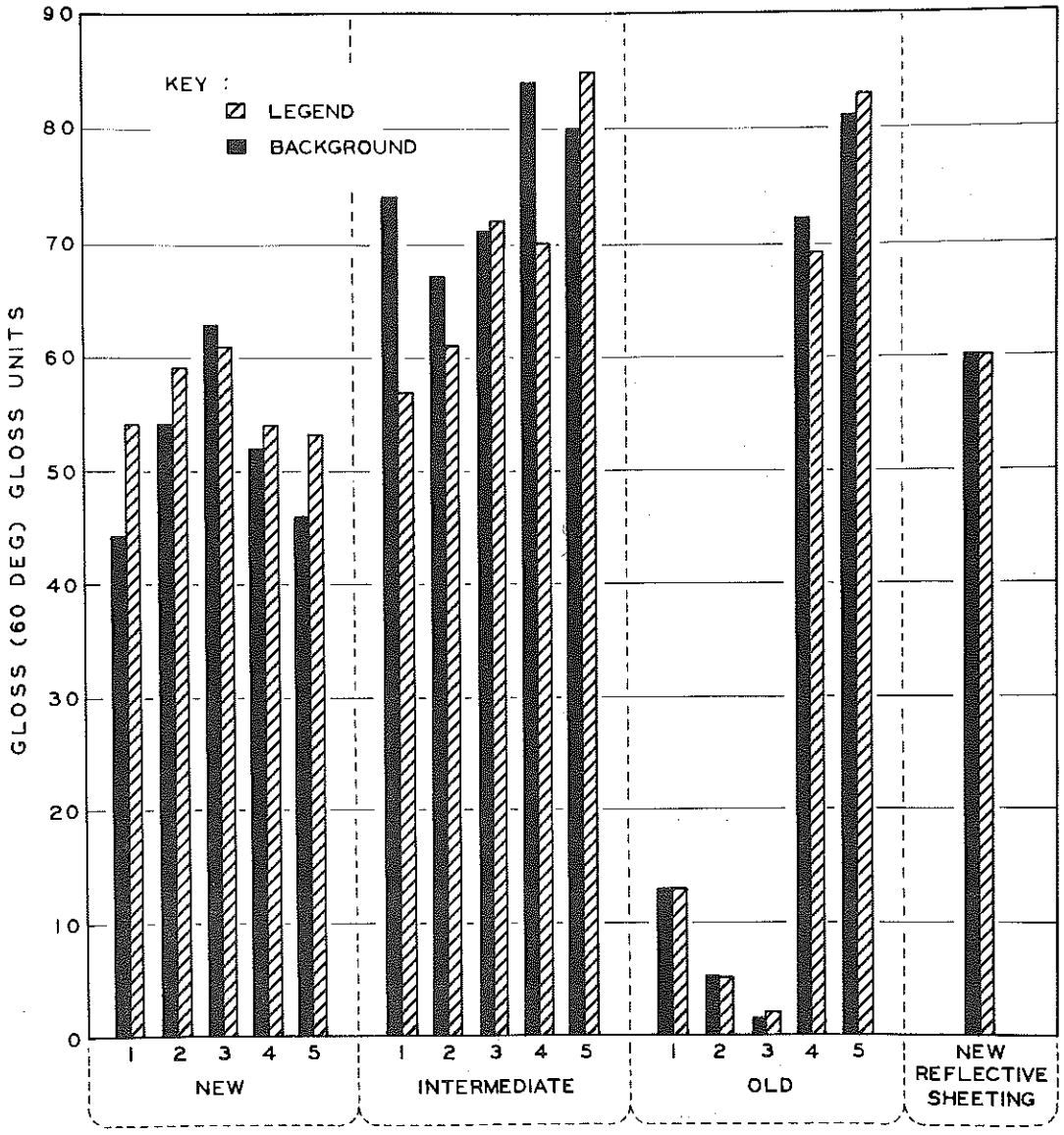

Figure 9. Gloss values of I 96 signs.

Gloss values might be expected to be closely related to surface deterioration but this was not true; except on those signs with severe deterioration. Clearcoating interfered with any possible age-to-gloss relationship because it raised gloss values on most of the treated signs to values higher than those values on new signs. Investigation of the reasons for the unexpected high gloss values on the I 96 "Intermediate" signs showed that the exact age for highway signs cannot be determined. Dates of sign installation and replacement or overlay maintenance are not recorded or marked

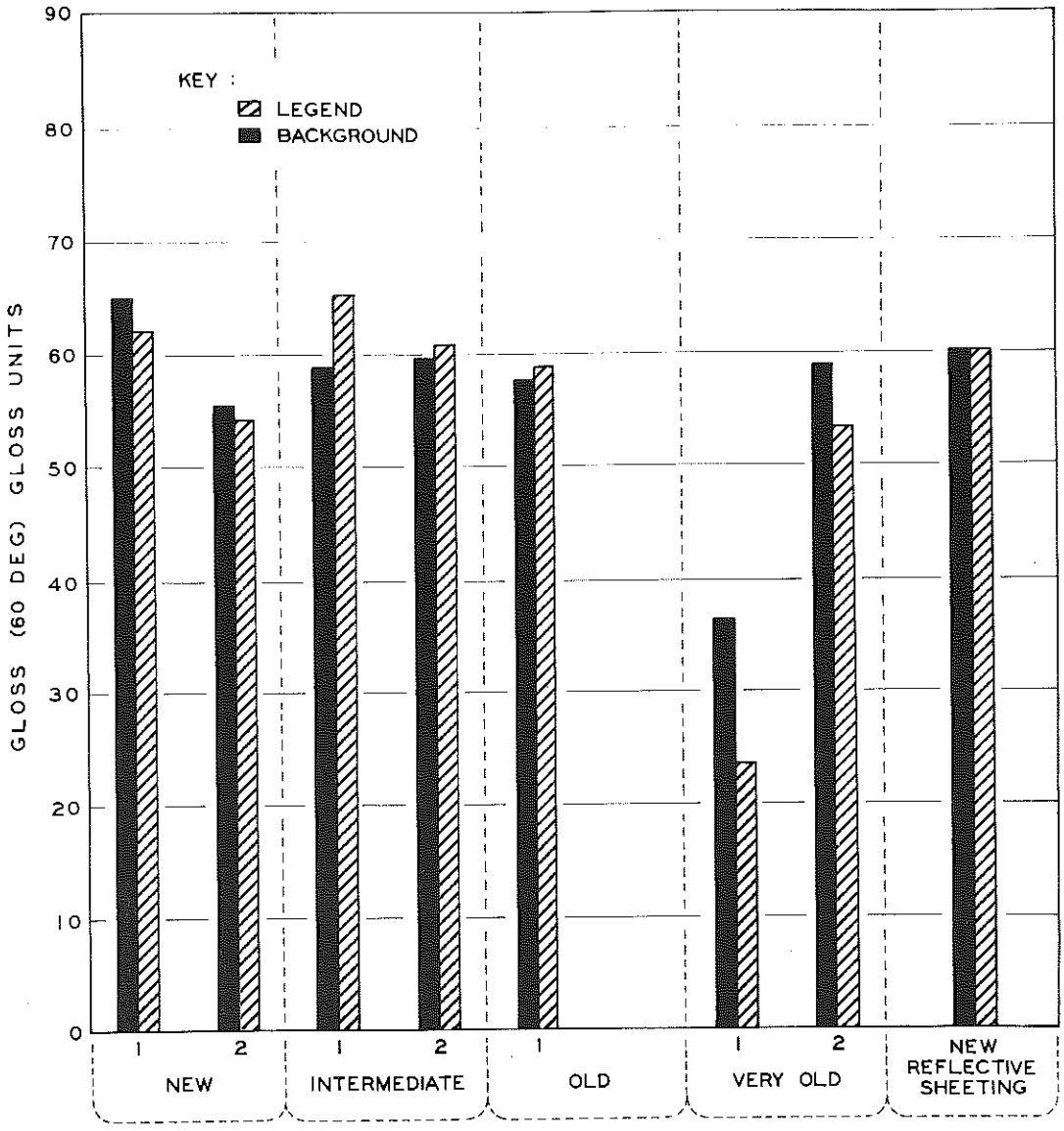

Figure 10. Gloss values of I 94 signs.

on the sign, and clearcoating is recommended either on the basis of memory of a sign's age or as surface appearance warrants the coating. The reason for the high gloss values on the I 96 signs was the clearcoating maintenance about one month prior to our measurements.

Method 3: Photographic

Day and night black-and-white and color photographs were taken. Night photographs were taken with a flash camera. In addition, color slide photo-

graphs were taken from the driver's eye position using illumination from automobile headlamps at 100, 200, 300, and 400 ft from the sign. Photographs from a camera mounted on a tripod directly in front of the vehicle and between the headlamps yielded the same results.

All of the photographic methods depicted differences in sign face weathering as shown in Figures 2, 3, 6, and 7. Color slides from the driver's position, using headlamp illumination, gave an accurate reproduction of actual sign brightness according to the eye when the vehicle was 300 to 400 ft from the sign for both overhead and roadside signs.

Evaluation of Method 3

Black-and-white photographs taken under daylight conditions provided the best means of recording sign surface weathering. The photographs proved to be the only means of recording differences between "New" and "Intermediate" signs. Disadvantages of the method are typical of natural light photography; light intensity is variable, lighting can be highly directional, results cannot be checked immediately, film performance and processing are variable. Long focal-length lenses would be necessary to preclude use of lift equipment which was required to make the short-range photographs of overhead and cantilever signs. This method may have other disadvantages if more than one camera and lens system is used since matching results are required. Cost of the quality camera equipment necessary would be approximately $700.

Color slides recorded the nighttime brightness of sign background and sign legend with sufficient accuracy to visually match observer judgment of brightness. Since nighttime brightness was the primary distinction between "Intermediate" and "Old" signs, even though the surfaces of "Old" signs were severely weathered, the slides provided an acceptable basis for distinction.

A sign evaluation by photographic means is possible because black-and-white film will record surface condition and color slides will record brightness or provide a basis for brightness evaluation. Black-and-white films of signs showing significant phases of surface deterioration could be compared with films of signs in service in order to establish uniform numerical evaluations of surface condition. At night, color slides of roadside signs and overhead signs showing significant changes in brightness could be compared to a sign. This would mean a nighttime inspection using headlights operating under standardized conditions of aiming and intensity, making observations at a known distance, and maintaining a uniform lateral

vehicle position with respect to the sign. An alternate procedure would involve use of a standardized spotlight at a given distance from the inspectors eye or nighttime color photographs taken under precise lighting conditions. Nighttime color photographs would require previous laboratory calibration of the film.

Method 4: Visual

Signs on I 96 were rated visually using a specially prepared reference panel. The panel consisted of a section of 3M silver and green reflective sheeting on a 12- by 18- by 1/8-in. aluminum sheet. The panel was suspended by a rope from the top edge of each sign so as to hang near its center. The sheeting on the reference panel was selected in the laboratory and covered with clear polyethylene to produce a luminance of 450 ft-L for the silver and 80 ft-L for the green.[1] Reflective sheeting with such luminance values was considered just acceptable for legibility at a minimum distance. It must be emphasized that these luminance values were obtained under standardized laboratory conditions and were not reproducible under field conditions and with headlight illumination. However, the laboratory values did provide an arbitrary basis for the comparison of luminance of all signs.

Visual ratings of the I 96 signs were made by three observers from a vehicle using low-beam headlamps. The observers determined whether the sign legend and background were brighter, equivalent, or darker than the reference panel. The results are as follows:

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[1] These limits were fixed in the following manner:

The recommended minimum luminance for maximum legibility distance for a sign in a dark rural area is 10 ft-L (see: "Luminance Requirements for Reflective Signs," Highway Research Board Bulletin No. 179, Allen, Janson, Dyer, Smith, 1967). With headlight glare from oncoming traffic, the minimum rose to 20 ft-L. An unpublished study by this Laboratory, which measured actual sign luminances while a new silver reflective sheeting sign was illuminated by automobile headlamps conforming to SAE standards, showed that field luminances ranged from approximately 27 ft-L to 11 ft-L at a distance of 200 to 1,000 ft, respectively, from the vehicle. These values were applicable to a sign set back 10 ft with a bottom edge height of 8 ft and a vehicle, centered in the driving lane, with high-beam headlamps. If a loss of up to 15 percent in legibility distance can be tolerated, signs yielding 40 percent of the above range of 27 to 11 ft-L field luminances could be used. Signs with luminances lower than 40 percent of these values would mean much greater losses in legibility distance.

Since the luminance of new reflective sheeting as measured with our standardized laboratory set-up at 100 ft was typically 1,100 ft-L for silver sheeting and 200 ft-L for green sheeting, 40 percent maximum luminance would be approximately 450 ft-L and 80 ft-L, respectively.

"New" signs

The majority of observers considered the sign legend and background on all signs as brighter than the reference panel.

"Intermediate" signs, legend

The majority of observers considered the legend on three signs brighter than the reference and on the remaining two signs, equivalent to the reference.

"Intermediate" signs, background

The majority of observers considered the background on three signs brighter than the reference, on one sign equivalent to the reference, and on the other sign, darker than the reference.

During the observations of these signs we noted that factors such as surface cracking and discoloration, while not significantly reducing sign brightness, did influence visual comparisons. This was especially noticeable when observers rated some of the signs equivalent or darker than the reference panel even though sign luminance was higher.

"Old" signs

The majority of observers considered the sign legend and background on three of the five signs darker than the reference, and brighter than the reference on the remaining two signs.

Observer results were the same from a moving vehicle as from a stationary vehicle.

Evaluation of Method 4

Visual comparisons at night between a sign and a reference panel provided an excellent means for evaluating the luminance of "Intermediate" and "Old" signs. The reference panel was readily mounted on the sign and observations were made without special light considerations. Preparing duplicate reference panels in the laboratory in sufficient quantities may be a disadvantage and the limited number of signs that could be inspected in one night might be another disadvantage along with disagreement between observers.

Sufficient information was not available to study the chronology of sign deterioration but if it can be demonstrated that a sign face deteriorates rapidly after reaching a certain luminance level, then the visual rating evaluation may be the simplest and least costly to use. For example, the method could be applied as follows:

1. Comparison observations showed that the "Old" signs on I 96 and the "Very Old" signs on I 94 had luminances well below the reference panel and, therefore, well below levels acceptable for adequate legibility distance. Sign replacement is recommended.

2. The "Old" signs on I 94 appeared to be similar in luminance to the reference panel. Clearcoating is recommended and sign replacement in one to two years is indicated.

3. Signs classed as "Intermediate" or signs beginning to show evidence of deterioration appeared brighter than the reference, however, the signs showed a characteristic discoloration. Clearcoating is recommended.

Maintenance of signs presently in service could be programmed on the basis of such comparison data but this procedure might shorten average sign life because it depends on the development of apparent deterioration. On the basis of the very few signs observed such as the "Old" signs on I 94 and the "Intermediate" signs on I 96 we doubt that the progress of cracking or checking can be arrested by clearcoating. This means that sign maintenance may be required before apparent surface deterioration has taken place and that initial maintenance necessarily becomes related to sign age as determined from records of sign installation. The sign age for initial maintenance in this case could be determined from a detailed study of sign deterioration using one or more of the study methods described.

CONCLUSION

With the exception of the gloss method, three methods have been presented which can be used to evaluate signs for maintenance purposes. It seems obvious, however, that instrumental methods alone (luminance and photographic) are inadequate without observer or inspector opinion. For example, there are factors related to the performance of a sign which should be considered in a sign evaluation. A few of these factors are:

1. Signs in urban areas or high ambient lighting areas should be brighter than signs in rural areas. State-wide application of a given brightness or luminance index for maintenance purposes therefore appears inappropriate.

2. Processing errors during original sign production may cause parts or possibly all of the legend to perform poorly at an early date. Inability to read one letter at an adequate distance should indicate maintenance action.

3. Sign locations or positions have an effect of luminance. Signs mounted on overpasses which are not perpendicular to the roadway or signs located in horizontal or vertical curve areas are not as bright as signs mounted near the perpendicular to lighting and viewing. In this case, the luminance method and photographic method might indicate early replacement when the solution is actually relocation.

4. Atmospheric conditions in certain areas may affect legibility and may accelerate loss of luminance. Semi-annual inspection or viewing under marginal sight conditions may be required.

5. Certain portions of a sign may deteriorate more rapidly than other portions (road spray areas). Again, even though most of a sign is bright; performance is unsatisfactory when the required information is not legible.

RECOMMENDATIONS

With these factors and the capabilities of the evaluation methods in mind, it is believed that sign maintenance can be systematized. In view of the results of this study, it is recommended that the Traffic and Safety Division decide on an evaluation method, combination of methods, or a modified method, and outline a pilot program. It is further recommended that:

1. A program be initiated to catalog Department signing, preferably by computer, in order to establish an installation and maintenance history for every major sign on the trunkline system.

2. The existing sign system be photographed and cataloged along with day and, especially, nighttime inspection remarks.

3. Signs which can readily be evaluated and categorized by daytime observation such as the "Old" on I 96 or "Very Old" on I 94 be replaced. These signs are not legible at night.

4. Clearcoating, washing, patching or other maintenance on the present sign system be recorded in detail and cataloged.

5. Five or six signs at sites in various parts of the State be evaluated at frequent intervals beginning on the day of sign fabrication. Progress of weathering and the beneficence of clearcoating could be studied as noted in the report.

The Research Laboratory would be willing to cooperate in a performance evaluation such as this, upon the request of the Traffic and Safety Division.