Visibility of Reflectorized License Plates

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Studies by the National Safety Council have established that peril to life and vehicle trebles after sunset, primarily as a result of reduced visibility. Low illumination, contrast extremes, atmospheric conditions, and attendant driver reaction at day's end contribute a host of physical and sensible limitations.

Other statistics show that rear-end collisions are the largest single factor in rural motor vehicle accidents. In spite of very considerable and progressive efforts of the automobile industry and enforcement agencies, unlighted, over-aged, damaged, or improperly maintained or equipped vehicles are a continuing hazard to the motorist and a constant challenge to safety leaders. The reflectorized license plate offers a universal opportunity and practical enforcement device for maintenance of minimum protection.

This paper presents data to establish typical visibility distances of unlighted vehicles, both with and without reflectorized license plates, relative to safe stopping distances. Visibility and performance limitations imposed by rain, mist, snow and glare have been considered in establishing performance criteria, because 25 percent of all accidents occur under such conditions. Observations indicate that a completed plate capable of reflecting 5 c. p. per incident foot-candle provides the minimum brilliance for requisite warning in typical situations. Practical considerations include ease of cleaning, damage resistance, and effective performance although bent or mutilated.

The experience of several states has shown that such reflectorized license plates have aided enforcement agencies. Legibility distance from the rear is markedly improved and the front license plate of lighted vehicles is both visible and legible to the motorist approaching from the opposite direction. This feature assures positive delineation of "one-eyed" vehicles and location of parked cars prevalent in residential areas.

●PERIL to life on streets and highways trebles after sunset according to published reports of the National Safety Council. Three times the number of deaths per 100,000,000 vehicle-miles driven occur after dark, and nearly three-fourths of these fatalities occur to occupants of motor vehicles in rural areas.

Notwithstanding the effect of increased vehicle occupancy on night fatality rates, surveys in three states have shown that more than one-third of all night traffic accidents were directly related to lack of visibility. Reduced visibility is more indirect, but no less a factor in a high proportion of the balance. Senses dulled by alcohol, fatigue, and poor eyesight are not only more commonly encountered at night, but also are most significant at this time of contrast extremes—from almost total absence to irritating glare. As reported by the National Safety Council and defined by Delaware, more than one-third of all drivers involved in fatal accidents in Delaware over a three-year period "had been drinking." Reduced contrast sensitivity and increased reaction time of the drinking or fatigued driver undoubtedly contribute to the number of rear-end collisions, the most prevalent motor vehicle accident type as reported by the National Safety Council.

The problem of rear-end collisions as related to night visibility has been fully recognized by industry and safety authorities for years. The automobile industry has improved headlighting on several occasions. It has adopted two taillights, lighted rear plates, turn signals, improved fusing, higher voltages, indicating circuitry, larger and more effective taillights, and reflectors. Both mandatory and voluntary forms of vehicle inspection have been adopted to real advantage in a number of states and locales. Yet, following the voluntary national safety check held in May 1955, the parti-

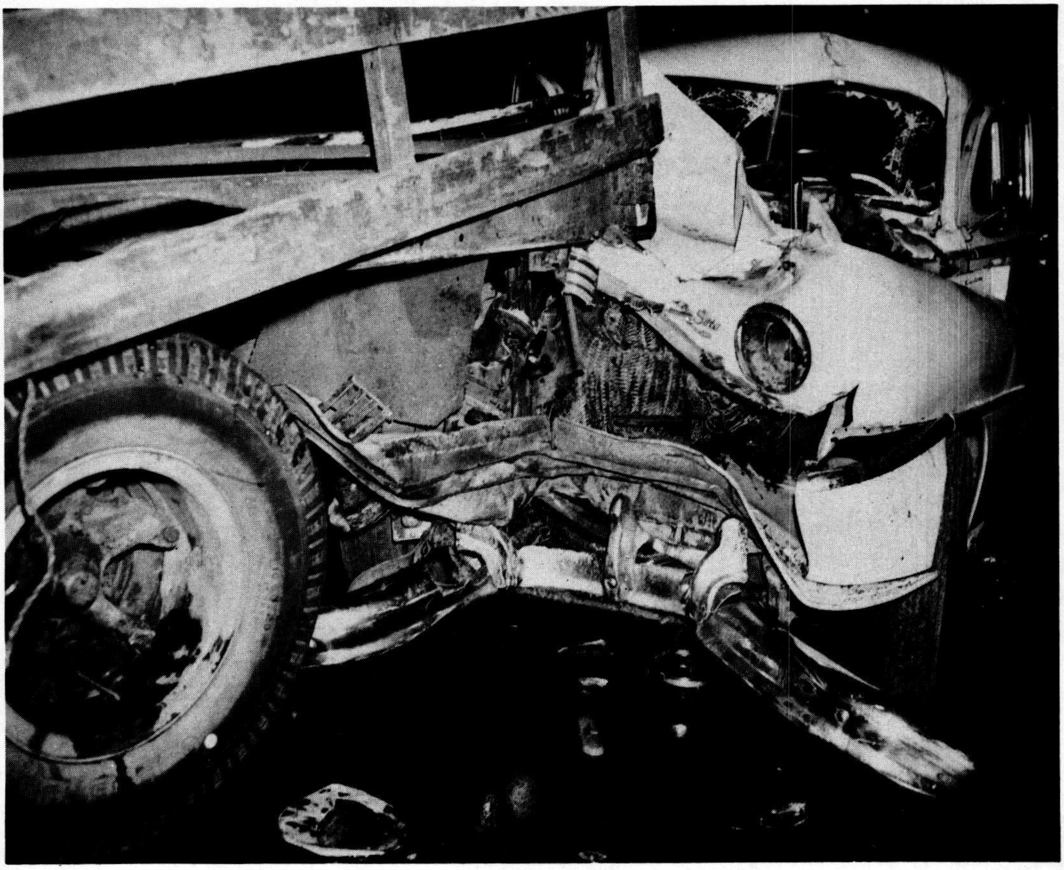

Figure 1. Typical rear end collision.

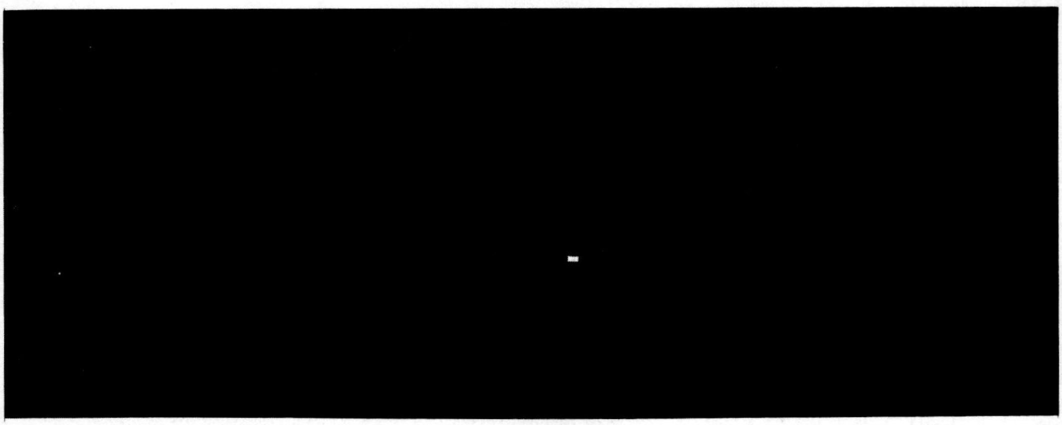

Figure 2. Comparison of painted and reflectorized plates on two vehicles viewed from 200 ft.

cipating organizations reported that rear lights accounted for 26. 6 percent of all defects. In spite of very considerable and progressive efforts of the automobile industry and enforcement agencies, over-aged, damaged, neglected, or improperly equipped vehicles are a continuing hazard to the motorist and a constant challenge to safety leaders.

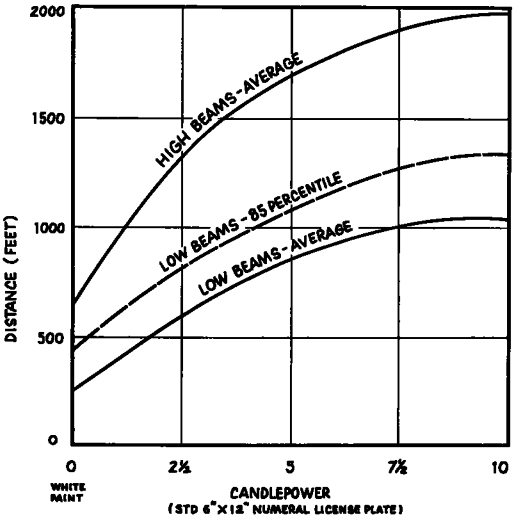

Figure 3. Average detection distance of painted and reflectorized license plates of varying brilliance, viewed with high and low beams.

Reflectorized license plates have been adopted in recent years by a number of states as a safety measure designed to reduce the threat of vehicles otherwise inadequately protected. These damage-resistant registration plates protect against collision in the case of lighting failures, damage to conventional plastic or glass taillight-reflector assemblies, or combination reflector assemblies inoperative as a result of dust and dirt collection on the rear surface. Routine maintenance and cleaning has all too frequently been shown not to include disassembly and cleaning of these units. On the other hand, simple washing normally restores reflective plate performance. Thus, because registration is required of every vehicle on a public road and because registration plates are issued by the state at regular intervals, the reflectorized license plate offers the first universal opportunity and practical enforcement device for maintenance of minimum protection.

A series of observations have shown that unlighted, dark-colored vehicles with damaged or ineffectual rear reflectors are first visible from 400 ft to the overtaking motorist using high beams. This distance is reduced to a mere 150 ft with low beams. Painted, clean white license plates viewed with low beams increase this distance to 250 ft; vehicles equipped with reflectorized plates are visible up to 1,000 ft (Figure 2).

Figure 3 shows the relative visibility of painted and reflectorized license plates of varying brilliance, viewed with high and low beams. Under ideal viewing conditions it is evident that marked increases in visibility are possible with reflectorized license plates. Completed 6- by 12-in. license plates with a reflective brilliance of 10 c.p. per incident foot-candle, measured in accordance with photometric procedures of the Society of Automotive Engineers, at 0 deg. divergence, may be seen an average of two-fifths of a mile on high beams. The level of reflective brilliance required is dependent on visibility demands of the motorist, in turn dependent on his physical requirements, vehicle limitations, and driving conditions. Minimum visibility requirements, therefore, under most driving conditions must be equal to or greater than total stopping distance.

A number of studies of vehicle braking and stopping distances have been published in recent years. A particularly comprehensive study was presented by Normann (5). Although this study was primarily concerned with vehicle braking distance on a dry concrete surface, measurement of driver reaction times and distances were made. Because the drivers were aware approximately when the stop was to be made, these reaction times, averaging ¾ sec. (Figure 4), were considered absolute minimums and more in the nature of a byproduct of braking distance tests.

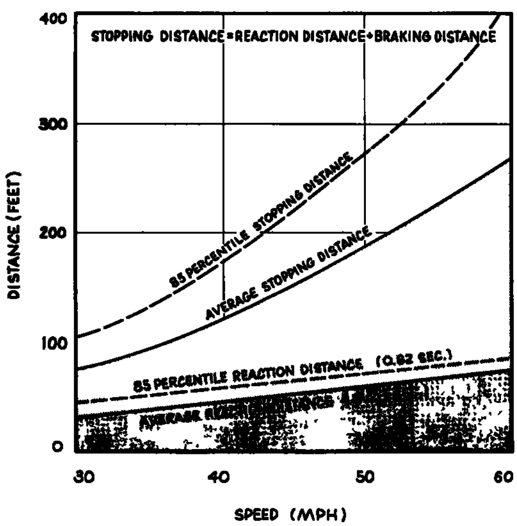

Figure 4. Average reaction and braking distances (from Ref. 5).

To be realistic, reaction times must consider the total elapsed time from the instant of hazard detection by the unwary motorist until application of brakes. Because recognition and discrimination of relative motion is required at threshold visibility levels, it is logical to employ allowances for reaction time based on studies of perception of relative motion at such illumination levels. Stalder and Lauer have presented such a study (6).

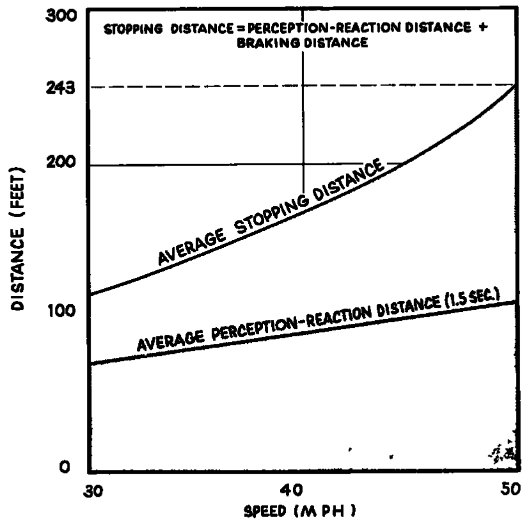

Figure 5. Mean perception and braking distance.

This report showed mean perception time before reaching a judgment to be 1½ sec. for two reflectorized target forms at overtaking speeds in excess of 30 mph. This interval was found to be true regardless of whether high beams were used or whether low beams and low opposing lights were employed. Under these conditions a third target form consisting of a point source of illumination resulted in mean perception times in excess of 2 seconds. From the manner of test it can be assumed that perception time included reaction time, although the observer's voice actuated the timing mechanism rather than his right foot the brake.

In Figure 5, speed is plotted against mean perception and braking distance calculated from Stalder and Lauer's 1½-second minimum perception-judgment time with Normann's average braking distance superimposed. It is apparent from these data that 243-ft visibility is the minimum requirement for the average motorist and vehicle at 50 mph if a rear-end collision with a stationary vehicle is to be avoided. This minimum visibility must be assured in the most common, adverse circumstances, which in themselves do not demand significant speed reduction.

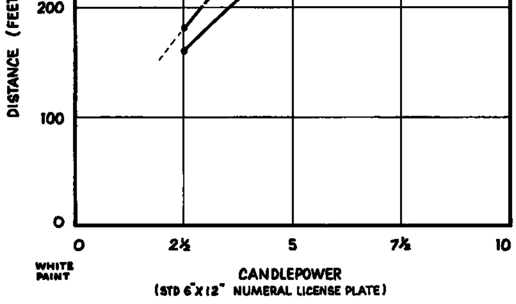

Figure 6. Average detection distance of an unlighted vehicle protected by reflectorized license plates of varying brightness and viewed with low beams and low opposing lights.

OPPOSING HEADLIGHTS

The problem of visibility in the face of opposing headlights has been regarded by a number of agencies and investigators as common enough to require the establishment of standards of performance based on these conditions. Correspondingly, the same visibility tests were conducted of standard over-all reflectorized license plates varying from 2½ to 10 c.p. per incident foot-candle. These were attached to an unlighted vehicle and viewed with low beams. Maximum veiling effects were observed when the vehicle approaching in the left lane was located at any point 30 ft beyond the target vehicle to 100 ft ahead. Tests were conducted with vehicles stopped opposite one another separated by a conventional 4 to 5 ft. The average of a number of observers and viewing vehicles is illustrated in Figure 6, from which it can be determined that completed plates capable of reflecting 5 c.p. per incident foot-candle, on the average

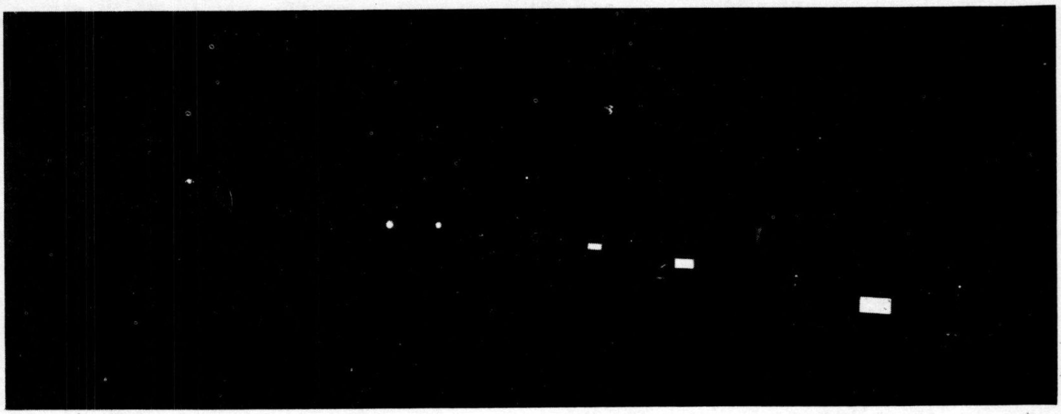

Figure 7. Reflective license plates provide effective delineation of parked cars.

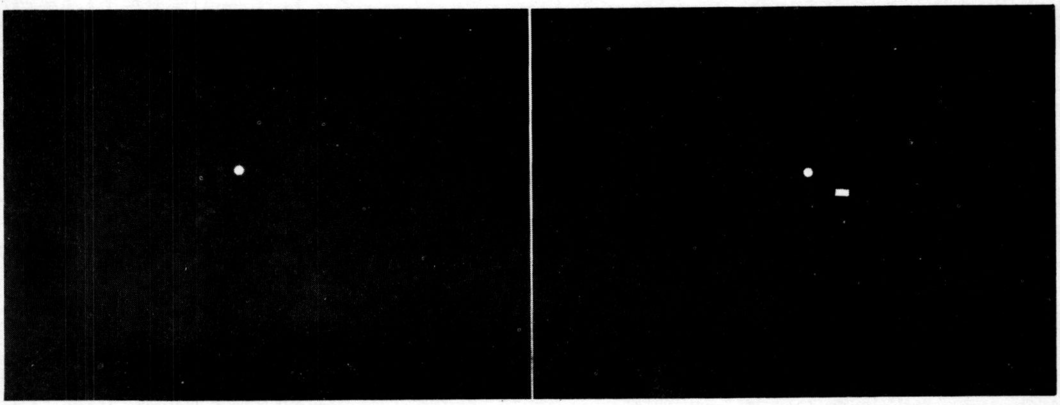

Figure 8. Photograph from 200 ft illustrates the benefit of reflectorized front plates in providing delineation of approaching one-eyed vehicles.

and under these conditions, provide the minimum brilliance for requisite warning at 50 mph.

OTHER REQUIREMENTS

More typical requirements necessarily include need for rain performance. The National Safety Council has pointed out that one out of every four accidents occurred under conditions which reduce visibility (such as haze, mist, smoke, rain, hail, dust, snow, or combinations of these). The same tests conducted on a misty night revealed that average visibility of the 5-c.p. plate dropped to 100 ft, the minimum requirement at speeds appropriate to these conditions, 25 mph or less. However, such marginal visibility does not provide more than marginal safety.

The physical condition of the road surface is another factor that may increase the basic requirements for braking distance. Braking distance is increased up to ten times on glare ice as compared to dry concrete, up to five times on packed snow or gravel. Wet pavements, dependent on composition, can increase this distance as much as glare ice. Thus, a stopping distance requirement of 243 ft for 50 mph on dry concrete must be recognized as a point of departure rather than absolute. This is not the "safe" stopping distance, but rather the absolute minimum for the average motorist in ideal weather conditions.

Correspondingly, these became basic considerations when the State of Minnesota adopted reflectorized license plates. To provide a more adequate margin of safety, required candle power was doubled and performance was required at all times relatively unaffected by rain. Each Minnesota license plate initially provided at least 10 c.p. per incident foot-candle. After one year of use and before cleaning, rear plates have retained an average of two-thirds the required brilliance, even after a series of recent snowfalls and thaws. This value increased to 85 percent of the original requirement after normal washing.

Practical considerations demand reflective materials for license plates which may be simply cleaned with materials and methods normally used to clean automobile finishes. Effective and enduring performance as a safety device is required even though plates may be damaged, bent, or mutilated in normal use. It is equally essential to require that such treated plates provide adequate indication when a vehicle, disabled or otherwise, is positioned at an angle to the roadway or oncoming traffic.

Among the common motoring situations in which reflective license plates have been shown to operate effectively are delineation of parked cars (Figure 7) prevalent in residential areas; warning of damaged, stalled, or parked and unlighted cars and trucks in the road, as well as on shoulders of rural roads; supplementary warning for motorists approaching from the rear at higher relative speed; and effective protection in case of taillight failure unknown to the motorist. It has been particularly well recognized that reflective front plates assure positive delineation of approaching "one-eyed" vehicles by indicating the relative position of the vehicle on the road.

Where adequate contrast and brilliance have been provided, law enforcement, especially in apprehension of stolen vehicles, has been greatly aided by permitting enforcement officers to read registration numbers nearly as easily at night as during the day. Reflectorized license plates have been demonstrated to increase night legibility distance by 50 percent. In fact, the front license plate, normally obscured by the opposing headlights of an approaching vehicle, is legible for the first time. Because enforcement officers are able to read the registration numbers of vehicles approaching in the opposite direction, the number of plates checked is greatly increased. This, of course, is also to the advantage of the average motorist in increasing apprehension and recovery of stolen vehicles, as well as deterring the traffic violator.

At a time when traffic accidents are increasing at an alarming rate, any responsible program of accident prevention must include full consideration of every enforcement technique and safety contribution. Because each state requires vehicle registration and periodically renews license plates, a universal opportunity is provided to adopt a particularly effective safety and enforcement device through license plate reflectorization.

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