ANTI-GLARE SCREEN MEDIAN FENCE

MICHIGAN DEPARTMENT OF STATE HIGHWAYS
• AND TRANSPORTATION •
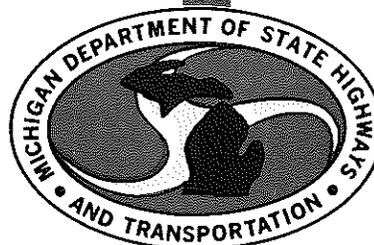
TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

ANTI-GLARE SCREEN MEDIAN FENCE

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Purpose

The intent of this research project was to evaluate the headlamp glare-reducing effectiveness of a conventional chain-link fence for roadway medians (Alcoa aluminum) and to compare the effectiveness with an expanded metal anti-glare screen manufactured by Niles Expanded Metal Co., Niles, Ohio, and currently in use (Fig. 1).

Procedure

A 3 by 4-ft section of conventional chain-link fence was stretched and secured in a wooden framework in a manner such that there were no noticeable ripples in the fence section viewed from nearly edge-on.

A similar frame containing the anti-glare screen was mounted on a goniometer capable of 360-degree rotation. A diffused 1-in. square light source illuminated one side of the screen from a distance of 2 ft. A photomultiplier mounted 100 ft from the center of rotation of the screen received the light passing through the screen.

Light transmitted by the chain-link fence and the expanded metal screen was continuously recorded during a 360-degree rotation of each screen. Light reflected by each screen was also recorded during a 360-degree rotation. In this case the light source illuminating the screen and the photomultiplier receptor were on the same side of the screen, thus simulating the light reflected from the screen by the driver's own headlamps.

Light Distribution Results

Figure 2 shows the distribution of light transmitted by the two screens. In the figure, the anti-glare screen should be visualized on a 0-180 axis. Illumination should be visualized as available from all angles from the top of the figure. The curve outline is the percentage of light at the various angles which could reach a driver's eye.

By inspection, it is apparent that the distribution of transmitted light through the chain-link fence is symmetrical while the distribution through the expanded metal fence is asymmetrical. For example, at angles out to 20 degrees on the right side of the expanded metal screen a driver's eye would receive up to 2 percent of the light available but on the left side of the screen his eye would receive up to 50 percent of the light available. This shows the necessity of orienting expanded metal anti-glare screens. Both sides of the chain-link fence would allow up to 40 percent of the available light to reach the driver's eye out to 20 degrees. Light reflected back to the driver from each type of screen was insignificant—less than 0.25 percent.

Figure 3 shows the illumination from opposing headlamps reaching the driver's eyes for both types of glare screens, for separations of approaching cars from 200 ft to 1,000 ft and for median widths of 10, 20, 30, and 40, 60, and 100 ft, respectively. The headlamp illuminance values were obtained from laboratory tests of a set of headlamps constructed to conform to SAE recommended values and aiming, and spaced to represent headlamp locations on typical automobiles surveyed in 1966.

The graphs demonstrate that the expanded metal screen cuts illumination from opposing headlamps to a negligible level for median widths down to 10 ft, whereas the chain-link fence eliminated glare causing illumination for median separations greater than approximately 25 ft for approaching automobile separations approximating 500 ft or less.

Glare Effects of Median Fence
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Since the amount of glare decreases with increases in the angle between the driver's line of sight and the opposing headlight beam, it would decrease as the lateral separation between opposing lanes of traffic becomes greater. Therefore, there should be a minimum lateral separation between opposing vehicles such that there is a barely tolerable level of headlight glare at the driver's eye.

Intolerable headlight glare may be defined as that amount of glare which will cause most drivers to be unable to see the center stripe at a sufficient distance to enable them to follow curves in the road.

Stalder and Lauer (1) have found that the average perception plus reaction time before an unwary driver in a car overtaking a reflectorized target reaches a judgment that there is decreasing distance between car and target is 1.5 seconds at speeds in excess of 30 mph.

Assuming that a driver needs the same sort of judgment time when perceiving where a center stripe is deviating from a straight line, the average driver perception-reaction time of 1.5 seconds would mean the automobile would travel over 120 ft at 55 mph before the driver could begin turning the steering wheel. We may also assume then, that it would require at least 120 ft of travel for the automobile to begin to follow a curving center stripe.

In a study of edge striping (MDOT Research Report No. R-1043), the Research Laboratory has measured the luminance of a reflectorized paint stripe at 150 ft from a set of standard headlamps, selected according to SAE recommendations. The low beam luminance was approximately 0.20 foot-Lamberts (ft-L) from the driver's eye, although there was a great amount of variability between stripes. The luminance of the concrete pavement at 150 ft was 0.05 ft-L. The driver's ability to see the paint stripe

is a function of the luminance contrast which is the ratio of the difference between the luminance of the paint stripe and the luminance of the pavement to the luminance of the background which in this case is the pavement. Thus,

$$C = \frac{B_S - B_p}{B_p}$$

where: C = contrast level (dimensionless),
$\quad\quad\quad B_S$ = brightness of paint stripe, ft-L,
$\quad\quad\quad B_p$ = brightness of pavement, ft-L.

In the example above where the shoulder brightness was 0.20 ft-L and the pavement brightness was 0.05 ft-L,

$$C = \frac{B_S - B_p}{B_p} = \frac{0.20 - 0.05}{0.05} = 3.0$$

At a given background, i.e., for a certain adaption level of the eye, the eye can see a certain minimum luminance difference or minimum contrast level (C_{min}).

Since C_{min} is at threshold, and because theoretical data eliminated factors such as lack of attention or the driver's need to search, its value should be multiplied by 10 times for certain detection (by 99 percent of driving population). Therefore, the minimum contrast necessary for certain detection, designated, C_{min}, would be 10 x C_{min}.

At a level of pavement or background luminance (B_p) of 0.05 ft-L, C_{min} = 0.05, approximately (2, p 62 and 3). Then C'_{min} = 10 x C_{min} = 0.5 for certain detection of the paint stripe. Therefore, in the example above, the paint stripe can be easily seen since the actual contrast, C = 3.0, was much greater than the theoretically necessary contrast (C'_{min}) of 0.5.

Disability glare from opposing headlights will reduce the apparent contrast between the paint stripe and pavement. Thus, intolerable disability glare is that amount of opposing headlight illumination at the driver's eye which will reduce the apparent contrast to a level below 10 x C_{min} thus obviating certain detection.

Disability veiling brightness, otherwise known as disability glare, is defined as:

$$B_V = \frac{30E}{\theta(1.5 + \theta)}$$

where: B_V = disability veiling brightness (DVB) or glare in ft-L,

E = illumination in foot-candles in a theoretical plane at the eye which is perpendicular to the line of sight,

Θ = angle in degrees of incidence of glare at the eye.

With disability glare from opposing headlights, the apparent contrast is now:

$$C = \frac{B_S - B_p}{B_p + B_V} \qquad (\underline{2}, \text{ p } 66)$$

where $B_p + B_V$ is the equivalent background brightness including the disability glare.

In this case for intolerable B_V:

$$B_V = \frac{B_S - B_p (C'_{min} + 1)}{C'_{min}}$$

where: $C'_{min} = 10 \times C_{min}$

Therefore: $B_V = \dfrac{0.20 - 0.05 \ (1.5)}{0.5}$

$B_V = 0.25$ ft-L.

The accompanying graphs (Figs. 4 through 6) show the threshold level of intolerable disability veiling glare, i.e., the borderline between intolerable and barely tolerable glare, or 0.25 ft-L for every combination of anti-glare fence angle and angle of incidence of opposing headlamp beams. Levels of glare other than the maximum tolerable level are also shown in the graphs.

Note that the value of what we have defined as maximum tolerable glare depends upon the relative brightnesses of the paint stripe and pavement. In this case the tolerable glare level, 0.25 ft-L, applies only to a typical situation where the paint stripe brightness was 0.20 ft-L and the pavement brightness at 150 ft was 0.05 ft-L.

One assumption made in constructing the graphs was that the maximum intensity beams* emitted by a pair of low beam headlamps was always directed at the driver's eyes regardless of the separation distance of the cars.

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* The value of the maximum intensity of a pair of low beam headlamps used in computation of the glare levels was 50,000 candela, the approximate average intensity found in laboratory measurements.

The assumption was reasonable since a proper combination of horizontal and vertical roadway curves could enable the on-coming driver to see the maximum beams of the other vehicle's headlamps no matter what the separation distances. Thus, the graphs depict the maximum possible glare that could enter the eyes of an opposing driver for the given separation distances.

The longitudinal separation distance is that distance between two automobiles approaching each other measured from one driver's eyes to the other driver's headlamps on a line parallel to the long axis of one car. The lateral separation distance is that distance between the eyes of one driver to the center of the headlamps of the second car measured on a line perpendicular to the long axis of one car. The driver's eyes to which the glare levels are to be applied are assumed to be looking at the roadway 150 ft in front of the car and parallel with the vehicle axis. The driver's line of sight is important since the quantity of glare experienced by a driver is dependent upon the incident angle of the light beam entering the eyes, as shown by the equation for disability glare.

Results
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Figure 4 shows typical maximum glare levels seen by a driver at the various separation distances between his vehicle and approaching low beam headlamps without an anti-glare screen in the median. Superimposed on the graph are polar coordinates which show the glare angle of incidence on the driver's eyes.

Note that without an anti-glare screen lateral separation distances of less than approximately 40 ft result in intolerable glare.

Assuming the two vehicles approaching each other are in the center of their respective lanes then the lack of an anti-glare screen would require a minimum median width of 35 ft. A 35-ft median may be feasible only in rural areas.

The chain-link fence in Figure 5 completely blocks light from opposing headlamp beams from entering the driver's eyes at incident angles less than approximately seven degrees.

For any lateral separation less than approximately 25 to 30 ft, excepting the seven-degree cutoff which would allow virtually no light to pass, the chain-link fence would allow intolerable glare for the approaching car nearer than about 100 ft.

The chain-link fence would, therefore, permit medians with a minimum 20 to 25-ft width. A 20-ft median width may not be feasible for urban expressways.

The expanded metal anti-glare screen which consists of flat metal strips yielded the results shown in Figure 6. The expanded metal anti-glare screen transmitted no light incident at less than a 20-degree angle. This screen would routinely allow 15-ft medians which would preclude 0.25 ft-L glare or greater from reaching the driver's eyes. Even narrower medians are practical with the use of an expanded metal anti-glare screen because intolerable glare would be experienced for less than 1/5 second per vehicle for vehicles passing each other at 55 mph.

Conclusions

Because of the median widths required, the chain-link fence and the expanded metal anti-glare screen would be more suitable for rural than urban anti-glare applications; however, narrow medians of from 5 to 10 ft may be practical for the expanded metal screen where the traffic volumes are low in suburban and rural areas because the time span is short during which the driver loses sight of the edge stripe.

REFERENCES

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2. Walsh, J. W. T., Photometry, Constable and Co., Ltd., 1958.

3. Illuminating Engineering Society, IES Lighting Handbook, 3rd Edition, p 2-9, 1959.

4. Fry, G. A., "Evaluating Disabling Effects of Approaching Automobile Headlights," Highway Research Board, Bulletin No. 89, 1954.
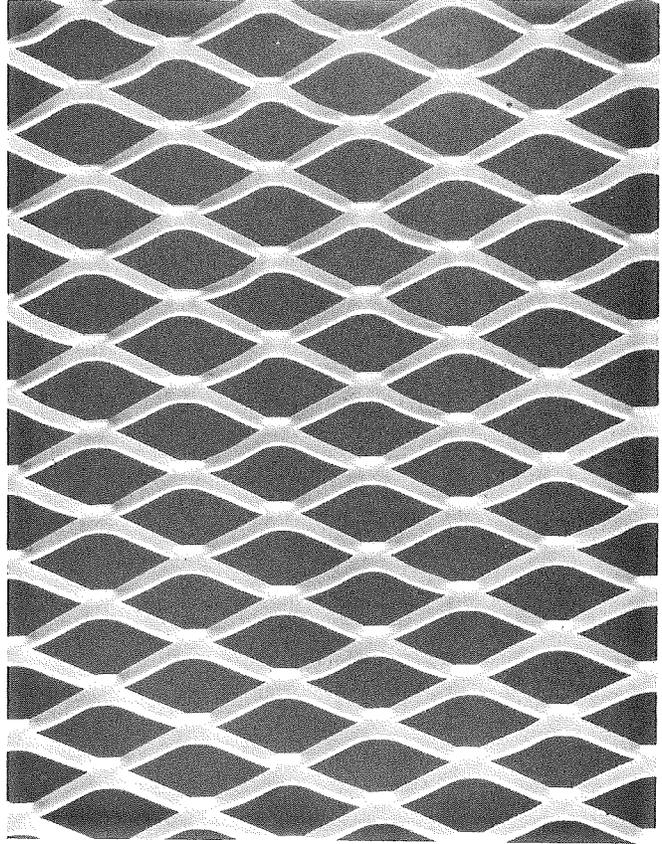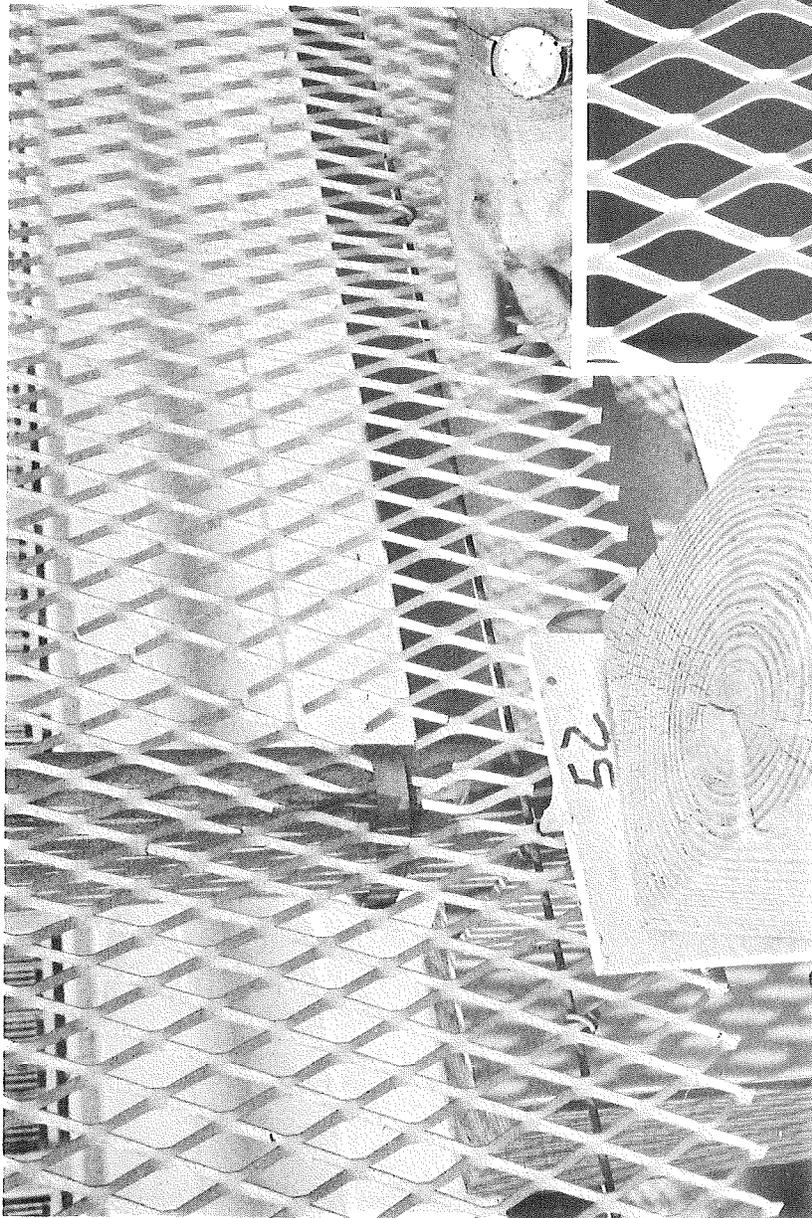
Figure 1. Niles Expanded Metal Co. anti-glare screen, installed (above) and close-up (right).
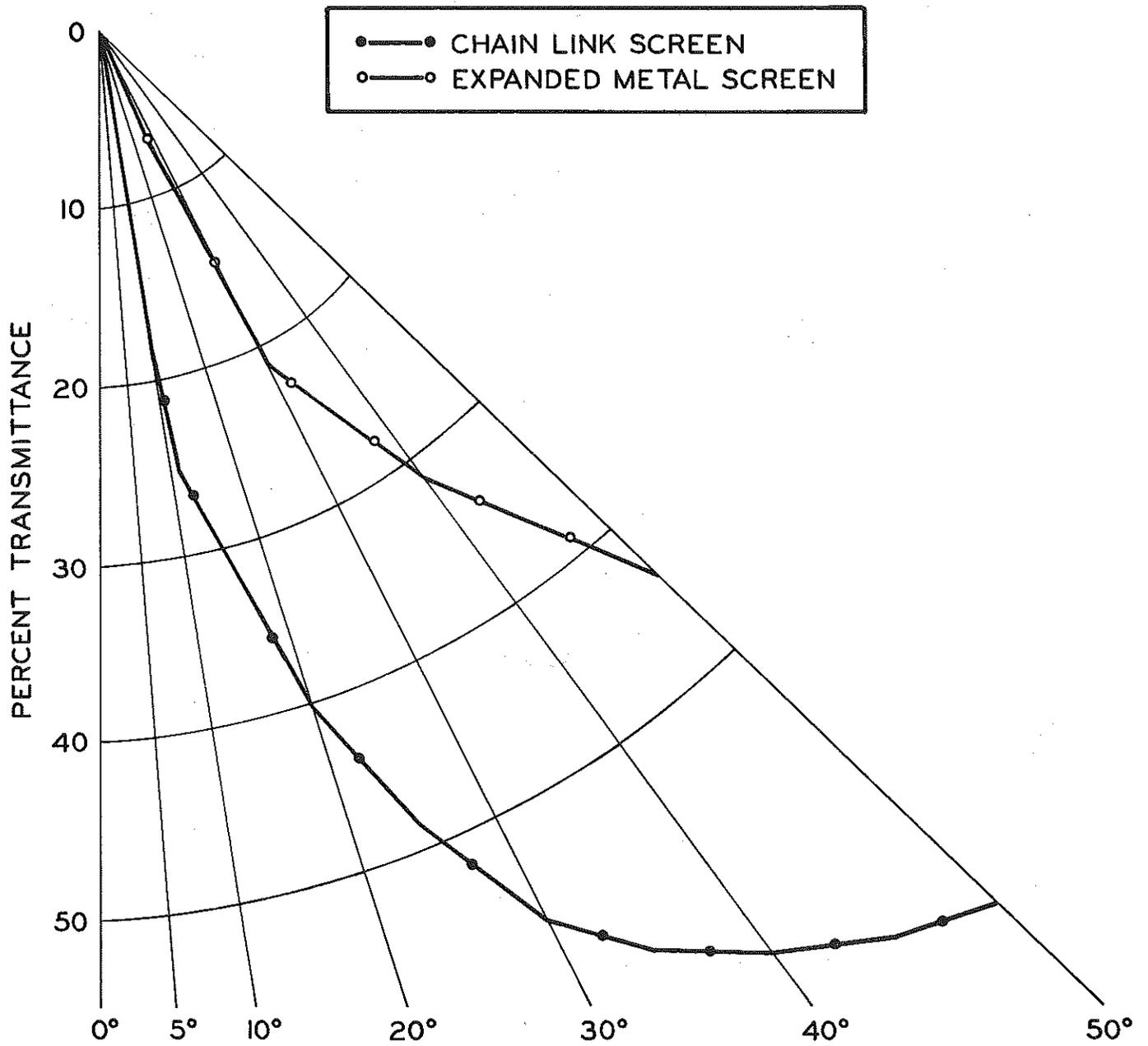
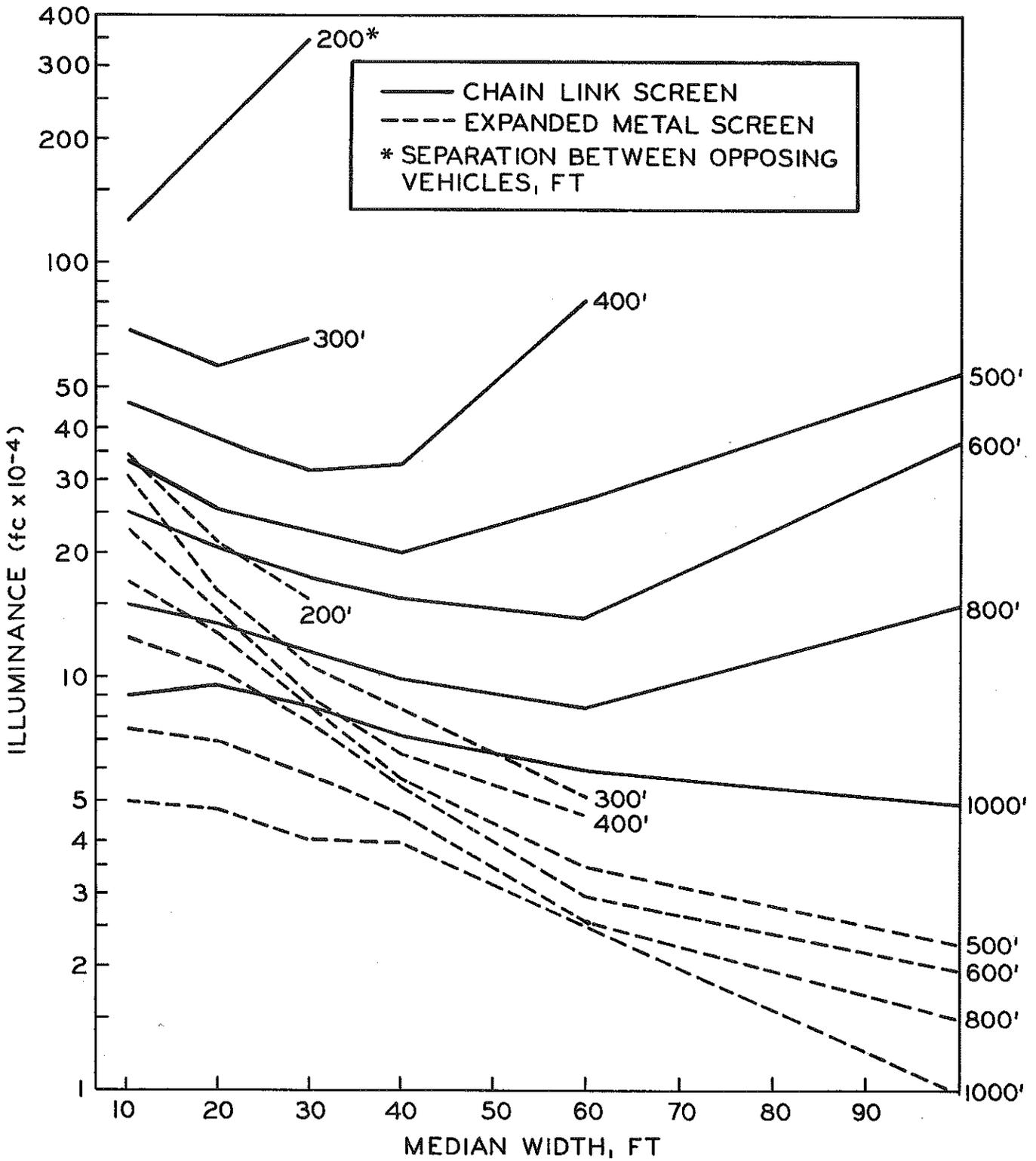Figure 2. Distribution of light transmitted by antiglare screens.

Figure 3. Antiglare screen effects on driver's eye illuminance at various distances from opposing headlights (high beam).

Figure 4 (top left)

0.25 ftL*

NO GLARE AREA

MEDIAN SEPARATION, FT

SEPARATION BETWEEN OPPOSING VEHICLES, FT

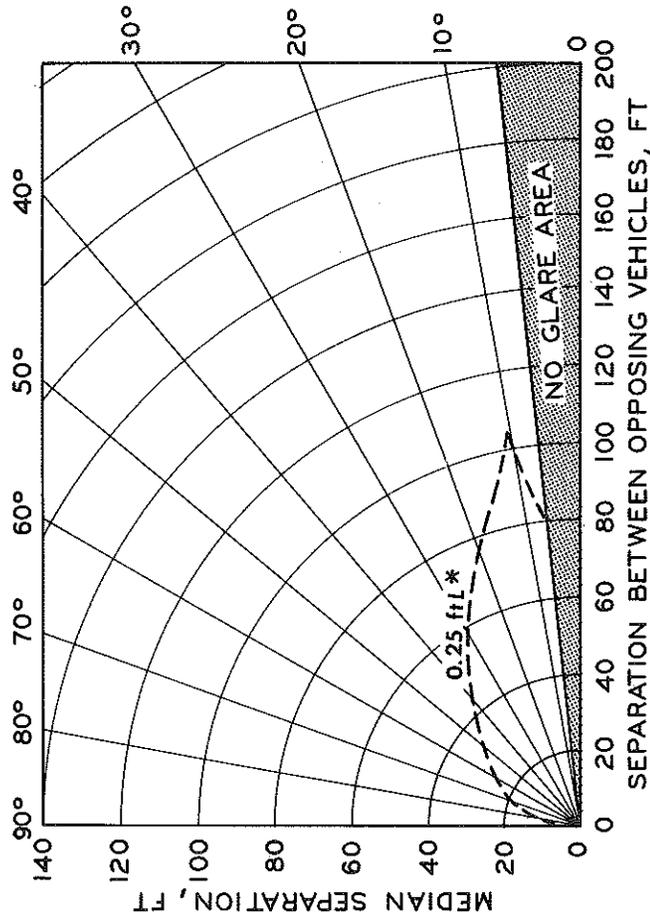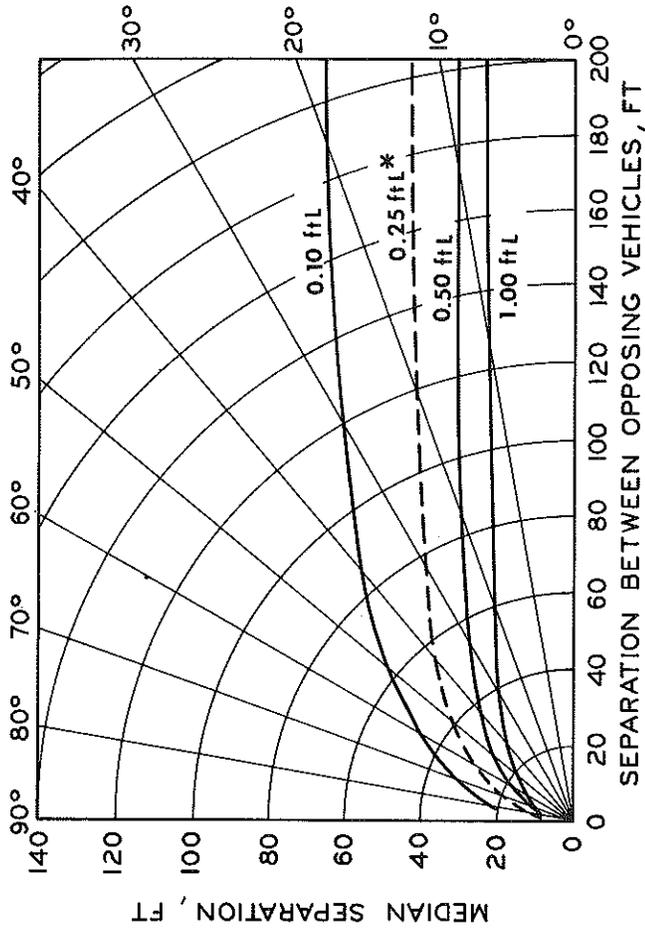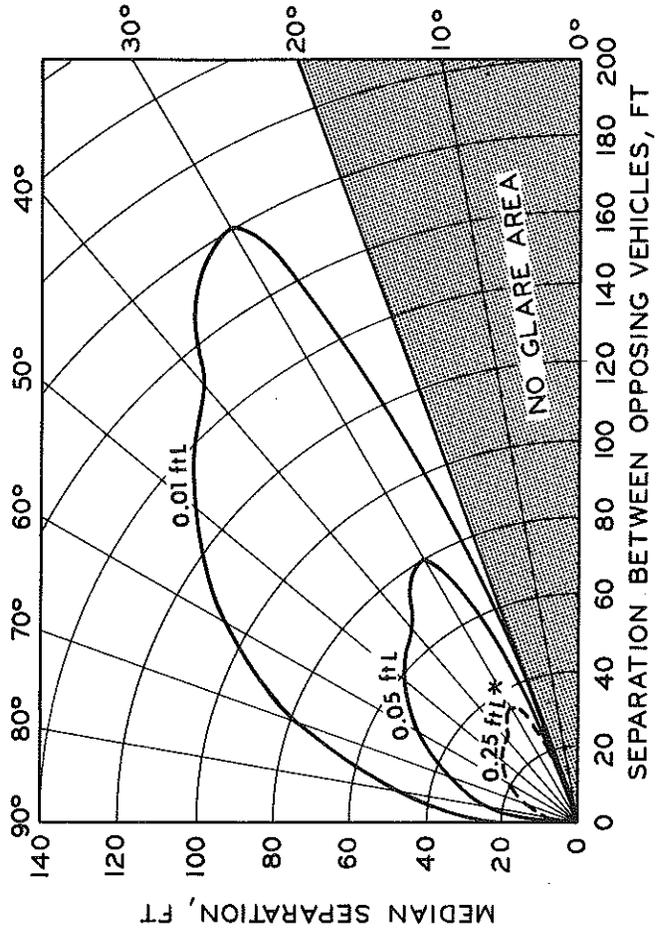Figure 4. Typical maximum glare levels with no anti-glare screen in median.

Figure 5. Glare levels with chain-link fence in median.

Figure 6. Glare levels with expanded metal anti-glare screen in median.

*BORDERLINE BETWEEN TOLERABLE AND INTOLERABLE GLARE

Figure 5 (bottom left)

0.10 ftL

0.25 ftL*

0.50 ftL

1.00 ftL

MEDIAN SEPARATION, FT

SEPARATION BETWEEN OPPOSING VEHICLES, FT

Figure 6 (bottom right)

0.01 ftL

0.05 ftL

0.25 ftL*

NO GLARE AREA

MEDIAN SEPARATION, FT

SEPARATION BETWEEN OPPOSING VEHICLES, FT