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Vision Factors Considerations in Rear View Mirror Design

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The Engineering Society For Advancing Mobility Land Sea Air and Space ®
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HIGHWAY VEHICLE REPORT

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VISION FACTORS CONSIDERATIONS IN REAR VIEW MIRROR DESIGN

1. INTRODUCTION:

The design and location of rear viewing mirrors or systems, and the presentation of the rear view to the driver can best be achieved if the designer and the engineer have adequate references available on the physiological functions of head and eye movements and on the perceptual capabilities of the human visual system. The following information and charts are provided for this purpose. For more complete information of the relationship of vision to forward vision, see "Visual Considerations of Man: the Vehicle, and the Highway," SAE SP-279.

2. VISION FACTORS CONSIDERATIONS IN REAR VIEW MIRROR DESIGN:

2.1 Introduction: The design and location of rear view mirrors to provide adequate driver rear vision can best be performed when a basic knowledge of the physiological and perceptual capabilities of the driver's visual system are understood.

2.2 Field of View: The field of view of each eye of the driver extends in the horizontal meridian 90 deg to the outside and 60 deg to the inside of the driver's forward line of sight. (It is assumed that the driver's forward line of sight is directly in line with the longitudinal axis of the vehicle and the highway.) It can be seen from Fig. 1 that the fields of view overlap each other to the extent of approximately 60 deg, thus providing a binocular field of view of 120 deg in the horizontal meridian. The vertical extent (Fig. 2) of the binocular field of view is approximately 50-55 deg above the primary line of sight. The vertical extent of the field of view below the primary line of sight is 60-70 deg.

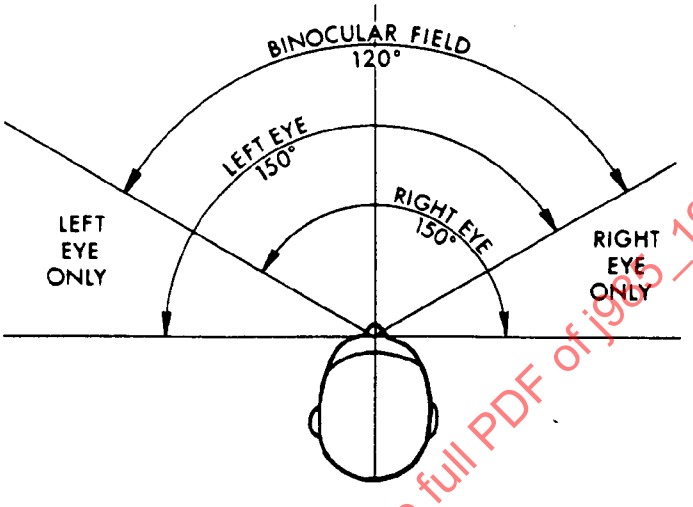

FIGURE 1 - Horizontal Extent of the Binocular Visual Field

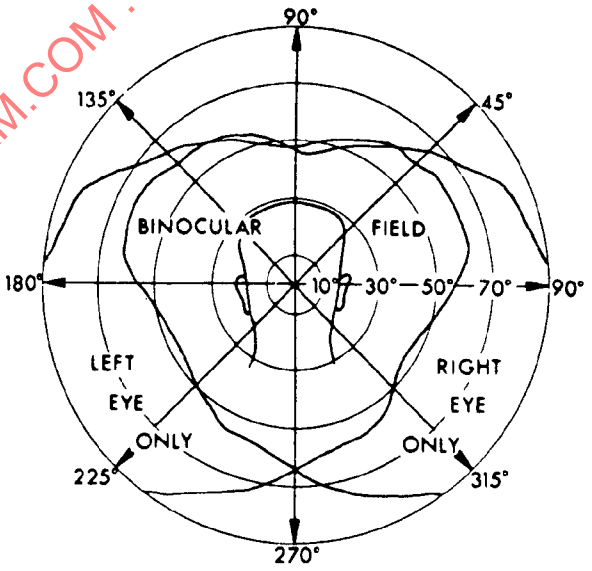

FIGURE 2 - Binocular Visual Field with Head and Eyes Fixed

2.3 Visual Fields with Head and Eye Movement: In the design and engineering of rear view mirrors and mirror systems, every effort should be made to allow the driver to maintain his visual attention ahead in the area on or surrounding the axis of his vehicle. Driver eye attention away from the road ahead should be kept at a minimum. Eye and head movement are two factors affected by the placement of rear view mirrors and must be considered.

Optimal eye rotation in the horizontal meridian is 15 deg to the left and 15 deg to the right (Fig. 3). However, the eyes can turn 30 deg to the right in one rapid, smooth movement.[1] Easy head movement is 45 deg to the left and 45 deg to the right. Maximum head movement is 60 deg left and 60 deg right. Optimal eye rotations in the vertical meridian are 15 deg upward and 15 deg downward (Fig. 4). Maximum eye movement upward is 45 deg and downward, 65 degrees. Easy head movement in the vertical meridian is 30 deg up and 30 deg down and maximum head movement is 50 deg up and 50 deg down.

To reduce driver fatigue and improve visual efficiency, the entire rear vision mirror is best located within the area 60 deg to the left or 60 deg to the right of the driver's forward field of view (45 deg easy head movement plus 15 deg optimal eye rotation). A mirror in this location is in the field of view of both eyes while the driver looks straight ahead. For the same reason, visual effciency will be at its highest when the rear vision mirror is placed within an area 45 deg above the forward line of sight and 45 deg below the forward line of sight (30 deg easy head movement plus 15 deg optimal eye movement). If necessary, the horizontal limit of head and eye movement may be extended 75 deg to the left and 75 deg to the right of the forward line of sight to view the mirror (45 deg easy head movement plus 30 deg eye movement).

A driver can combine head and eye movement that exceeds the above limits, but he should not be required to do so repeatedly or for long periods of time.

2.4 Perceptual Characteristics of the Eyes: The ability of the eye to perceive detail, form, color, and motion is highest in the area of central vision immediately surrounding the primary line of sight. The perception of these functions is reduced outside of the central vision area. The perception of traffic events and the presence of cars to the rear is reduced when a mirror is placed away from the forward line of sight. Beyond a given area, a rear view mirror may cease to stimulate the driver's visual system sufficiently to alert him to the presence of traffic activity to the rear. Under these conditions, an alert driver must monitor the rear vision mirror in order to determine the traffic activity and vehicle presence to the rear. The farther a mirror is placed away from the forward line of sight, the poorer the driver's perception of the forward traffic events while he is looking into the rear view mirror.

[1]The human eye does not rotate around a single point. Thus, upon temporal (outward) gaze the eye moves rearward approximately 0.5 mm and in nasal (inward) gaze, the eye moves forward approximately 0.6 mm.

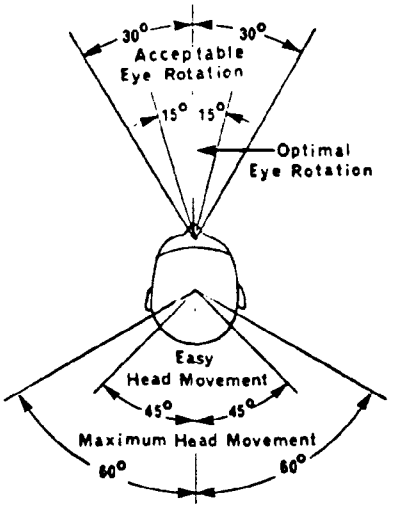

FIGURE 3 - Horizontal Extent of Head and Eye Movement

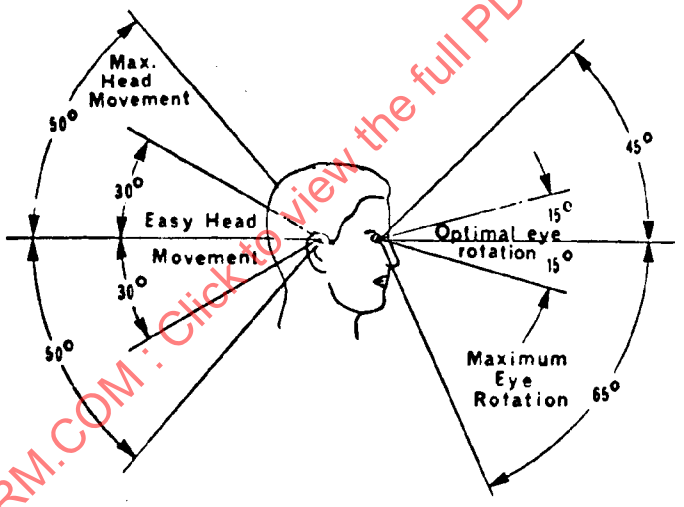

FIGURE 4 - Vertical Extent of Head and Eye Movement

2.5 Enhancement of Visual Perception: Visual perception (perception of happenings to the rear of the vehicle) is enhanced when rear vision mirrors are placed within the binocular field of view. Rear traffic activity, reflected in the rear vision mirror, stimulates the retina of each of the driver's eyes and he is, thus, provided with a stronger image, a higher degree of motion perception of the image, and a reduced reaction time to turn his eyes and observe the image directly in the mirror. A rear vision mirror provides better visual perception when its width allows the driver to view the images in the mirror with both eyes simultaneously. This means the effective aperature (opening or width) of the mirror must be sufficiently wide to allow both right and left line of sight to view the mirror while the eyes are parallel. Interpupillary distance is the distance between the lines of sight and is approximately 64 mm (2.5 in). It is desirable that the mirror should be sufficiently wide to allow binocular view with reasonable changes in the lateral position of the driver's eyes.

2.5 (Continued):

The vertical dimension of a rear view mirror or system should adequately provide for changes in the vertical position of the driver's eyes. Insufficient vertical mirror dimension restricts a driver's "eye freedom" and often a physical eye and head adjustment must be made to use the mirror.

Better space and motion perception results when the object perceived is seen within the context of its highway environment. More accurate localization of cars seen in the mirror will result when a portion of the observer's car is seen in the mirror, serving as a reference cue.

2.6 Illumination and Visual Perception: When highway and street illumination falls to levels experienced at twilight and dawn, visual perception suffers. Brightness contrast of the vehicles and objects on the highway is greatly reduced. The contrast approaches zero (no contrast) shortly before dark descends. For best visual perception of rear traffic events, a rear view mirror should have as high (bright) a reflection as possible so that the driver will be provided with a rear view that is similar to the brightness of his forward view. The brightness of the view to the rear as reflected in the mirror should remain as high as possible until darkness actually descends. Low-transmittance mirrors reduce the driver's seeing ability during the low-illumination hours of dusk and dawn. This is partly due to the difficulty the eyes have in adapting to a reflected image brightness greatly lower than the brightness of the forward highway scene. A lowered brightness image results in a longer viewing time of the mirror - a condition to be avoided. The illumination needed to see well increases with age. A 60-year-old driver may require three times more light to see than a 20-year-old driver.

2.7 Vision in Night Driving: Seeing during night driving is handicapped by the presence of glare or reflected glare sources within the driver's field of view. Headlight glare from oncoming vehicles can reduce forward visibility. Overhead roadway lighting glare can also reduce driver visibility. Likewise, glare from following vehicle headlights reflected by the rear view mirror into the driver's eyes can reduce driver visibility of the roadway ahead. All of these glare sources are additive in their effect on driver visibility and every effort should be made to minimize or eliminate such glare. Glare sources may be a cause of both irritation and fatigue to drivers at night.

The closer a rear vision mirror is placed to the driver's forward line of vision at night, the greater may be the reduction in forward visibility and the greater may be the discomfort from the glare source. The reduction of the glare is possible with low-transmittance rear view mirrors. The use of such mirrors is advised when the glare sources may be disabling to vision and discomforting to the driver. The age of a driver is generally related to the degree that glare affects vision. Older drivers are more susceptible to glare discomfort and visibility loss. After glare, a driver 60 years of age may require two times as long to recover from glare as a 20-year-old driver.

2.7 (Continued):

Day-night mirrors that provide both high- and low-image brightness should be easily activated by the driver and used only when the glare source is high. The mirror should quickly be returned to full transmittance whenever the glare source is not high, in order that the driver can perceive the vehicles to the rear in the context of the highway on which they are traveling. In this way, full knowledge of the speed characteristics and the lateral placement characteristics of the following vehicles can best be determined.

2.8 Adjustability of Mirrors: The variation and position in driver eye positions can be ascertained from an SAE paper (Ref. 5). However, once a driver has adjusted his mirror, his eye position may change considerably vertically and horizontally throughout the duration of a single trip. The vertical mirror dimension is most critical. It must allow the driver's eye to move up or down without having the line of sight encroach upon the upper or lower edge of the mirror. The driver should not be required to make unnecessary physical or psychological adjustment in order to use the mirror once it is adjusted. Too narrow a mirror can create such adjustment needs.

3. REFERENCES FOR VISION FACTORS IN REAR VISION MIRROR DESIGN:

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