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INLAND TRANSPORT COMMITTEE

World Forum for Harmonization of Vehicle Regulations

Working Party on General Safety Provisions

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Item 6 of the provisional agenda

REGULATION No. 46
(Devices for indirect vision)Proposed amendments to the RegulationSubmitted by the expert from the Netherlands^{*/}

The text reproduced below was prepared by the expert from the Netherlands, in order to get more objective requirements for camera monitor systems in the Regulation. It is based on informal document No. GRSG-93-05 distributed during the ninety-third session of the Working Party on General Safety Provisions (GRSG) (ECE/TRANS/WP.29/GRSG/72, para. 22). The

^{*/} In accordance with the programme of work of the Inland Transport Committee for 2006-2010 (ECE/TRANS/166/Add.1, programme activity 02.4), the World Forum will develop, harmonize and update Regulations in order to enhance performance of vehicles. The present document is submitted in conformity with that mandate.

modifications to the current text of the Regulation are marked in **bold** or ~~strikethrough~~ characters.

A. PROPOSAL

Paragraph 2.1.2.4., amend to read:

"2.1.2.4. **"Luminance contrast"** ~~contrast~~ means the ~~brightness ratio~~ **luminance difference** between an object and its immediate background/surrounding **divided by the luminance of the background** that allows the object to be distinguished from its background/surroundings."

Paragraph 2.1.2.6., amend to read:

"2.1.2.6 **"Critical object"** means a ~~circular~~ **spherical** object with a diameter ~~$D_0 = 0.8 \text{ m}$~~ ^{2/}
 $D_0 = 0.3 \text{ m}$."

Footnote 2/ to paragraph 2.1.2.6., should be deleted.

Paragraph 2.1.2.7., amend to read:

"2.1.2.7. **"Critical perception"** means the level of perception that **can just be obtained under critical conditions via the viewing system that is used. This corresponds to the situation in which the diameter of the critical object is a multiple times larger than the smallest detail that can be via the viewing system** ~~the human eye is generally capable of achieving under various conditions. For traffic conditions the limiting value for a critical perception is eight arc-minutes of visual angle.~~"

Paragraph 2.1.2.9., amend to read:

"2.1.2.9. **"Detection distance"** means the distance measured ~~at ground level~~ **from the centre of the lens of the camera** ~~viewing reference point~~ to the ~~extreme point~~ at which a critical object can just be perceived **(as defined by the critical perception** ~~the limiting value for a critical~~ ~~perception~~ ~~just~~ ~~barely~~ ~~achieved).~~"

^{2/} A system for indirect vision is intended to detect relevant road users. The relevancy of a road user is defined by his or her position and (potential) speed. More or less in proportion with the speed of the pedestrian-cyclist-moped driver, the dimensions of these road users increase as well. For detection purposes a moped driver ($D = 0.8 \text{ m}$) at 40 m distance would be equal to a pedestrian ($D = 0.5 \text{ m}$) at a distance of 25 m. Considering the speeds, the moped driver would be selected as the criterion for the detection size; for that reason an object with a size of 0.8 m shall be used for determining the detection performance.

Paragraph 2.1.2.10., amend to read:

"2.1.2.10. **(reserved)** ~~Critical field of vision~~" means the area in which a critical object has to be detected by means of a device for indirect vision and that is defined by an angle and one or more detection distances."

Paragraph 2.1.2.11., amend to read:

"2.1.2.11. **(reserved)** ~~Viewing reference point~~" means the point linked to the vehicle to which the prescribed field of vision is related. This point is the projection on the ground of the intersection of a vertical plane passing through the driver's ocular points with a plane parallel to the median longitudinal plane of the vehicle situated 20 cm outside the vehicle."

Paragraph 6.2.2.2.1., amend to read:

"6.2.2.2.1. The camera should function well under low sunlight conditions. The camera shall provide a luminance contrast of at least 1:3 under low sun condition in a region outside the part of the image where the light source is reproduced (condition as defined in EN 12368: 8.4). The light source shall illuminate the camera with 40,000 lx. The angle between the normal of the sensor plane and the line **The camera shall function well in conditions in which sunlight falls on the camera. The saturated area (defined as the area in which the luminance contrast of a high contrast pattern falls below 0.2 shall be limited. In the representative test case with a (simulated sun)light of 40000 lx on the camera, a background illumination of 3000 lx ($\pm 25\%$) and a light source spanning an angle of 5° ($\pm 10\%$), which is displayed at the centre of the monitor, the saturated area shall be less than 10% of the image. A description of a test method is given in Annex 9. A test method other than prescribed in Annex 9 may be used but evidence must be furnished that it is equivalent.**

[To do:

- * investigate relationship between exit port and blooming area
- * geometric test setup and alignment between camera and light source (elevation angle, exit port angle)
- * description of light source: spectrum (eg D65), illuminance uncertainty, homogeneity of illumination in space and time
- * background pattern reflectivities + pattern size
- * illumination of the monitor (NO)

Paragraph 6.2.2.2.4., amend to read:

"6.2.2.2.4. The measurements for the luminance contrast **of the monitor** shall be carried out according to ISO 15008:2003."

Paragraph 15.3.1., amend to read:

"15.3.1. A device for indirect vision shall give such performances that a critical object can be observed ~~within~~ **all over** the **required described** field of vision, taking into account the critical perception **according the procedure of Annex 10.**"

Paragraph 15.3.3., amend to read:

"15.3.3. (reserved) For the determination of the detection distance in case of camera-monitor devices for indirect vision, the procedure of Annex 10 shall be applied."

Annex 9, amend to read:

"Annex 9

(reserved)

Test for the determination of the saturated area of the camera under the conditions mentioned in paragraph 6.2.2.2.1

Measurement set-up

A high-intensity light (e.g., theatre spotlight) is reflected into the image using a small mirror (see Figure 1). The illuminance of the camera by the light reflected from the mirror shall be 40,000 lx. The light source is depicted in the centre of the camera: the light enters the camera from the normal direction. A high contrast black and white pattern (e.g. a checkerboard pattern) is illuminated by a set of lamps to create an even illumination of 3000 ($\pm 25\%$) lx.

The glare source should extend an angle (diameter) of 5° ($\pm 10\%$). A schematic drawing of the set-up is given in Figure 1.

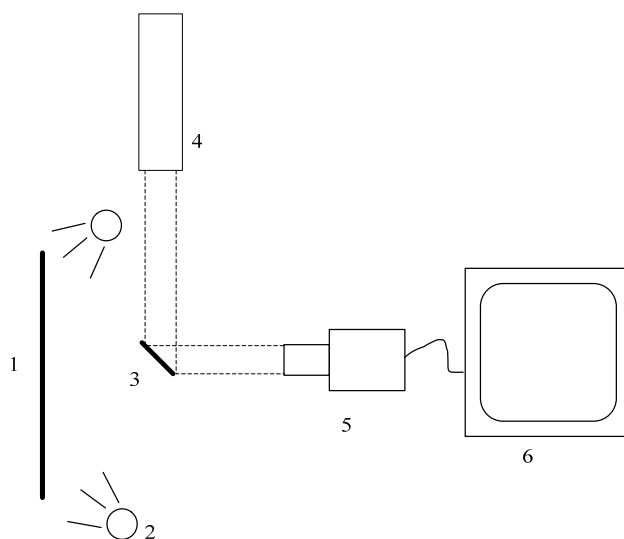


Figure 1 Diagram of the blooming measurement set-up. 1: Black & white background. 2: Lamps to make the background evenly illuminated. 3: Mirror. 4: high intensity light. 5: Camera. 6: Monitor.

The mirror shall be placed such that its image is positioned in the middle of the pattern. The luminance contrast between the white and black areas in the display image can be

measured. The saturated area is defined by the area in which the contrast of a high contrast test pattern falls below 0.2. The contrast (C) is defined by the difference in luminance between the bright (L_w) and dark (L_b ; black) and regions divided by the luminance of the bright (white) regions:

$$C = \frac{L_w - L_b}{L_w}$$

The saturated area shall not cover more than 10% of the display area.

In case the camera system shows dynamical changes in the blooming area during the test the maximum blooming area should fulfill the requirement."

Annex 10, paragraphs 1.to 1.2., amend to read:

"1.CAMERA MONITOR DEVICE FOR INDIRECT VISION

- 1.1. ~~Resolution threshold of a camera~~
The resolution threshold of a camera is defined by the formula:

[EQUATION TO BE DELETED!]

$$\omega_c = 60 \frac{\beta_c}{2N_c}$$

where:

~~ω_c – resolution threshold of the camera (arc min)~~

~~β_c – angle of vision of the camera (°)~~

~~N_c – number of video lines of the camera (#)~~

~~The manufacturer shall supply the values for β_c and N_c~~

Determination of the smallest discernable detail. The smallest discernable detail of the naked eye shall be defined according standard ophthalmologic tests like the Landolt C test or the TOD test. The smallest discernable detail at the centre of the viewing system can be determined using the Landolt C test or the TOD test. In the rest of the viewing area the smallest discernable detail may be estimated from the centrally determined smallest discernable detail and the local image deformation. For instance, in the case of a digital camera the smallest discernable detail at a given pixel location (in the monitor) scales inversely with the solid angle of the pixel.

- 1.1.1. Landolt-C test In the Landolt-C test test symbols are judged by the subject under test. In accordance with this test the smallest discernable detail is defined as the visual angle of the gap size of the Landolt C symbol at threshold size and is expressed in arcmin. The threshold size corresponds to the size at which the subject judges the orientation correctly in 75 per cent of the trials. The smallest discernable detail is determined in a test involving a human observer. A test chart containing test

symbols is placed in front of the camera and the observer judges the orientation of test symbols from the monitor. From the threshold gap size of the Landolt C test symbol d (in m) and the distance between the camera D (in m) the smallest discernable detail ω_c (in arcmin) is calculated as follows:

$$\omega_c = \frac{d}{D} \cdot \frac{180 \cdot 60}{\pi} \quad [\text{arcmin}]$$

1.1.2. TOD test

The TNO Landolt C test can be used to determine the smallest discernable detail of the camera-monitor system. However, for sensor systems it is more suitable to use the TOD (Triangle Orientation Discrimination) method which is similar to the Landolt C method, but involves equilateral triangular test patterns. The Triangle Orientation Discrimination method is described in detail by Bijl & Valeton (1999), who provide practical guidelines on how to perform a TOD measurement. In the method, triangular test patterns (see Figure 1) are viewed through the viewing system under test. Each triangle can have one out of four possible orientations (apex up, left, right or down) and the observer indicates/guesses for each triangle its orientation. When this procedure is repeated for many (randomly oriented) triangles of different sizes the fraction of correct responses can be plotted (see Figure 2), and increases with test pattern size. The threshold is defined as the point at which the fraction correct crosses the 0.75 level and can be obtained by fitting a smooth function through the data (see Bijl & Valeton, 1999). Critical perception is reached when the critical object diameter equals two times the width of the triangle at threshold size. The smallest discernable detail (ω_c) is equal to 0.25 times the width of the triangle at threshold size.

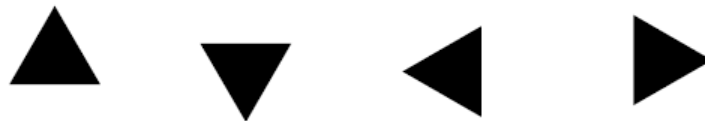


Figure 1 Triangular test patterns used in the Triangle Orientation Discrimination (TOD) method

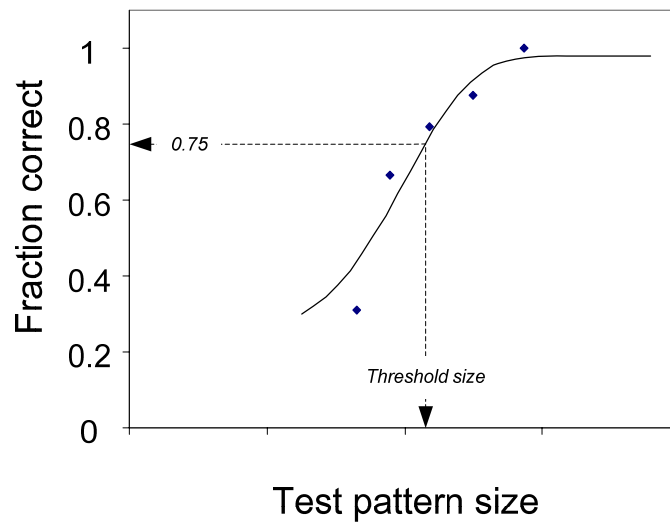


Figure 2 Typical relationship between the size of the triangle and the fraction of correct responses.

1.2. Determination of the critical viewing distance of the monitor

For a monitor having certain dimensions and properties, a distance to the monitor can be calculated within which the detection distance is dependent only on the performances of the camera. This critical viewing distance $r_{m,c}$ is defined by:

$$r_{m,c} = \frac{H_m}{N_m \cdot 2 \cdot \tan\left(\frac{\omega_{eye}}{2.60}\right)}$$

[EQUATION TO BE DELETED!]

where:

$r_{m,c}$ — critical viewing distance (m)

H_m — height of the monitor image (m)

N_m — number of video lines of the monitor (-)

ω_{eye} — resolution threshold of the observer (minutes of arch)

The number 60 is for conversion from minutes of arches to degrees.

The manufacturer shall supply the values for H_m and N_m .

$$\omega_{eye} = 1$$

For a monitor having certain dimensions and properties, a distance to the monitor can be calculated within which the detection distance is dependent only on the performances of the camera. The critical viewing distance $r_{m,crit}$ is defined

as the distance at which the smallest discernable detail displayed on the monitor spans 1 arcmin measured from the eye (the acuity threshold of a standard observer).

$$r_{m_{crit}} = \frac{\delta \cdot 60 \cdot 180}{\pi} \quad [\text{m}]$$

where:

$r_{m_{crit}}$ - critical viewing distance of the monitor (m)
 δ - size of the smallest discernable detail on the monitor (in m)"

Paragraphs 1.3.1. and 1.3.2. should be deleted.

Insert the following new paragraphs 1.3.1 and 1.3.2.

"1.3.1. Maximum detection distance within the critical viewing distance where, due to the installation, the distance eye-monitor is less than the critical viewing distance, the maximum attainable detection distance is defined as:

$$r_{d_{close}} = \frac{D_0 \cdot 60 \cdot 180}{\omega_c \cdot \pi \cdot f} \quad [\text{m}]$$

where:

$r_{d_{close}}$ - detection distance [m]
 D_0 - diameter of the critical object [m] which is equal to 0.3 m according to paragraph 2.1.2.6
 f - threshold increasing factor, which is equal to 8.
 ω_c - smallest discernable detail [arcmin] (see paragraph 1.1.)

1.3.2. Detection distance greater than the critical viewing distance. Where, due to the installation, the distance eye-monitor is more than the critical viewing distance, the maximum obtainable detection distance is defined as:

$$r_{d_{far}} = \frac{r_{m_{crit}}}{r_m} \cdot r_{d_{close}} \quad [\text{m}]$$

where:

$r_{d_{far}}$ - detection distance for distances larger than the critical viewing distance [m]
 $r_{d_{close}}$ - detection distance for distances smaller than the critical viewing distance [m]
 r_m - viewing distance, i.e. distance between eye and monitor [m]
 $r_{m_{crit}}$ - critical viewing distance [m], see paragraph 1.2."

B. JUSTIFICATION

The requirements for the approval of camera-monitor systems and the installation on vehicles seem to be unclear, like the provisions for low sunlight conditions and the visibility of critical object. The tests need objectivity in order to reduce different interpretations and to improve reproducibility.

- 2.1.2.4. Correction of a typographic error. In addition the definition needs to be amended as the used test method is based on another definition of contrast.
- 2.1.2.6. For convenience reasons it is better to use a spherical critical object as its shape does not depend on the viewing angle. The diameter of 0,3 m is representative of the object mentioned in paragraph 15.3.5.2.
- Finally footnote 2/ can be deleted as this contains only an explanation of the size of 0,8m of the previous critical object (which is suitable for classes I.-IV but not for classes V and VI for which camera-monitor systems are allowed).
- 2.1.2.7. Adjustment of the definition of "critical perception" in order to incorporate a test method based on the Landolt-C or TOD methods.
- 2.1.2.9. The detection distance will be based on a measurement of the smallest discernable detail using Landolt-C or TOD procedures and will be expressed as a distance between the camera and the required field of vision. As the present detection distance is measured on ground level an editorial amendment of the definition of "detection distance" is needed.
- 2.1.2.10. The words "critical field of vision" is not used in the regulation, so this definition can be deleted.
- 2.1.2.11. The words "viewing reference point" is not used in the Regulation, so this definition can be deleted.
- 6.2.2.2.1. As standard EN 12368, related to traffic signal light, cannot be applied directly to camera's the test conditions for the blooming test, which simulates the influence of low sunlight on the performance of a camera, have been redefined. Also the area in which the contrast is below a certain value has been set on a maximum of 10% of the image on a monitor. The details of the test are specified in Annex 9; as the described test is just a possible test, also equivalent tests are permitted.
- 6.2.2.2.4. This concerns a clarification that only the measurement of the luminance contrast of a monitor has to be performed according ISO-standard 15008.
- 15.3.1. Clarification that the critical object has to be seen all over the required field of vision and not only on one point of that field. Furthermore a reference to Annex 10 has been inserted for details about the determination of the detection distance.
- 15.3.3. The reference to Annex 10 can be deleted as it is incorporated in paragraph 15.3.1.

Annex 9

This new annex contains a detailed measuring set-up for the test in which low sunlight falling on the camera is simulated.

Annex 10

The procedure for calculating the maximum detection distance on the basis of video lines has been replaced by a new procedure based on ophthalmologis tests like Landolt-C or TOD (Triangle Orientation Discrimination).
