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Item 7 of the provisional agenda
Regulation No. 46 (Devices for indirect vision)

Proposal for 03 series of amendments to Regulation No. 46

Submitted by the expert from the Netherlands*

The text reproduced below was prepared by the informal group on camera-monitor systems in order to objectify the requirements for the testing of camera-monitor systems of class V and VI. The modifications to the current text of the Regulation are marked in bold for new or strikethrough for deleted characters.

* 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 the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Proposal

Paragraph 2.1.2.6., delete footnote 2/ and amend to read:

"2.1.2.6. "*Critical object*" means a ~~circular~~ **cylindrical** object with **a height of 0.50 m and** a diameter ~~**of** $D_0 = 0.8$ m 2/~~ **0.30 m.**"

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 representative scale of the critical object is a multiple times larger than the smallest detail that can be perceived 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~~).

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."~~

Insert a new paragraph 2.1.2.14. to read:

"**2.1.2.14. *"Smear"* is a vertical bright bar displayed on the monitor while sun light or light from other bright light sources is directly hitting into the lens of the camera. Smear is an optical artefact.**"

Paragraph 5.2., amend to read:

"5.2. An approval number shall be assigned to each type approved. Its first two digits (at present ~~02~~ **03**,) shall indicate the series of amendments incorporating the most recent major technical amendments made to the Regulation at the time of issue of the approval. The same Contracting Party shall not assign the same number to another type of device for indirect vision."

Paragraph 6.2.2.2.1., amend to read:

"**6.2.2.2.1. 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 ratio (C=Lw/Lb) of a high contrast pattern falls**

below 2.0, shall not cover more than 15 per cent of the displayed image under the conditions of paragraph 6.2.2.2.1.1 to 6.2.2.2.1.4.

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

Insert a new paragraphs 6.2.2.2.1.1. to 6.2.2.2.1.4., to read:

"6.2.2.2.1.1. A black and white test pattern, having a minimum contrast ratio of 20 shall be positioned in front of the camera.

The test pattern shall be evenly illuminated at an illumination of 3000 ± 300 Lx

The test pattern shall be medium gray on average and cover the complete area viewed by the camera: the camera shall view no other objects than the test pattern.

6.2.2.2.1.2. The camera shall be hit by a (simulated sun) light of 40 kLx, spanning an angle between 0.6 and 0.9 degrees with an elevation angle of 10 degrees (directly or indirectly via a mirror) removed from the optical axis of the sensor.

The light source shall:

(a) have a spectrum D65 with a tolerance of ± 1500K,

(b) be homogeneous in space and time within a tolerance of 2 kLx.

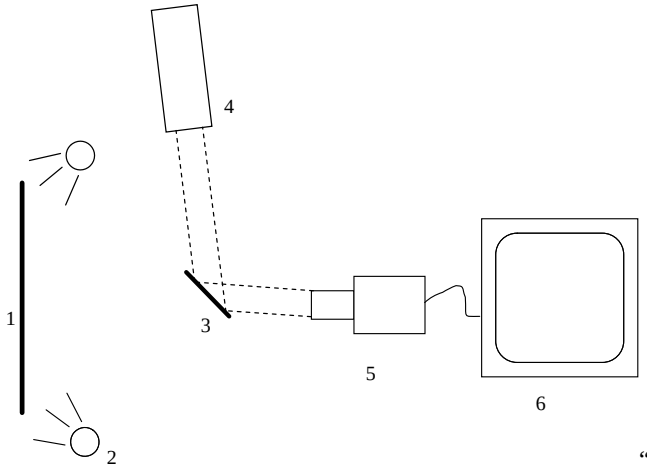
[The emission of the light source in the infrared shall be negligible.]

6.2.2.2.1.3. There shall be no ambient illumination of the monitor during the test.

6.2.2.2.1.4. An example of the set-up is given in the figure A below.

Figure A

Diagram of the blooming measurement set-up.



"

1: Black & white test pattern.
2: Lamps to make the test pattern evenly illuminated.
3: Mirror.
4: High intensity light.

5: Camera. 6: Monitor.

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:**2009**."

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 **[by the driver]** ~~within~~ **all over** the **required** ~~described~~ field of vision, taking into account the critical perception **according the procedure of Annex 10**."

Alternatively, the determination of the displayed object size shall be performed according to Annex 11."

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.~~"

Paragraphs from 21.1 to 21.8, amend to read:

"21.1. As from the official date of entry into force of the ~~02~~ **03** series of amendments to this Regulation, no Contracting Party applying this Regulation shall refuse an application for approval under this Regulation as amended by the ~~02~~ **03** series of amendments.

21.2. **As from [12 months after entry into force of the 03 series of amendments to this regulation], Contracting Parties applying this Regulation shall grant approvals to a type of devices for indirect vision only if the type meets the requirements of this Regulation as amended by the 03 series of amendments.**

21.3. **As from [18 months after entry into force of the 03 series of amendments to this regulation], Contracting Parties applying this Regulation shall grant approvals to a type of vehicle with regard to the installation of devices for indirect vision only if the type of vehicle meets the requirements of this Regulation as amended by the 03 series of amendments.**

21.4 **As from [24 months after entry into force of the 03 series of amendments to this regulation], Contracting Parties applying this Regulation may refuse to recognize approvals of a type of vehicle or type of device for indirect vision which have not been granted in accordance with the 03 series of amendments to this Regulation.**

21.5. As from 26 January 2010 for vehicles of category M_1 and N_1 and from 26 January 2007 for vehicles of other categories, Contracting Parties applying this Regulation may refuse to recognize approvals of a device for indirect vision which have not been granted in accordance with the 02 series of amendments to this Regulation.

21.6. Approvals which were granted to devices for indirect vision of Classes I or III pursuant to this Regulation in its original form (00 series) or modified by the 01 or 02 series of amendments before the date of entry into force of this series of amendments shall remain valid.

21.7. **Approvals which were granted to devices for indirect vision of Classes II, IV, V, VI or VII pursuant to this Regulation as modified by the 02 series of amendments before the date of entry into force of this series of amendments shall remain valid.***

21.8. **The provisions of this Regulation shall not prohibit the approval of a type of vehicle with regard to the mounting of devices for indirect vision pursuant to this Regulation as modified by the 03 series of amendments, if all or part of the devices for indirect vision of Classes I or III, with which it is fitted, bear the approval mark prescribed by this Regulation in its original form (00 series) or modified by the 01 or 02 series of amendments."****

Insert new paragraphs 21.9. to 21.11., to read:

"21.9. **The provisions of this Regulation shall not prohibit the approval of a type of vehicle with regard to the mounting of devices for indirect vision pursuant to this Regulation as modified by the 03 series of amendments, if all or part of the rear-view mirrors of Classes II, IV, V, VI or VII, with which it is fitted, bear the approval mark prescribed by the 02 series of amendments of this Regulation.** **

21.10. **Notwithstanding the provisions of paragraphs 21.2., 21.4. and 21.5. above, for the purpose of replacement parts, Contracting Parties applying this Regulation shall continue to grant approvals according to the 01 series of amendments to this Regulation, to devices for indirect vision of classes I to V and VII for use on vehicle types which have been approved before 26 January 2006 pursuant to the 01 series of amendments of Regulation No. 46 and to devices for indirect vision of class VI for use on vehicles which have been approved before 26 January 2007 pursuant to the 01 series of amendments of Regulation No. 46, and, where applicable, subsequent extensions to these approvals.**

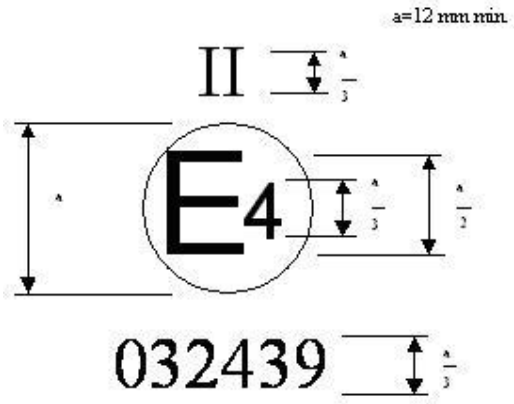
21.11. **Notwithstanding the provisions of paragraphs 21.2., 21.4. and 21.5. above, for the purpose of replacement parts Contracting Parties applying this Regulation shall continue to grant approvals according 02 series of amendments to this Regulation, to devices for indirect vision for use on vehicle types which have been approved before the date mentioned in paragraph 21.2 pursuant to the 02 series of amendments of Regulation No. 46, and, where applicable, subsequent extensions to these approvals.**"

* *Note by the secretariat*: Is paragraph 21.7. not in contradiction with paragraph 21.4.?

** *Note by the secretariat*: These transitional proposals are not in line with WP.29 guidelines on transitional proposals (TRANS/WP.29/1044).

Annex 5, amend to read:

"…



The above approval mark affixed to a device for indirect vision indicates that the mirror is a rear-view mirror, of Class II, which has been approved in the Netherlands (E 4) pursuant to Regulation No. 46 and under approval number 0~~2~~**3**2439. The first two digits of the approval number indicate that Regulation No. 46 already included the ~~02~~ **03** series of amendments when the approval was granted.…"

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

"1. Camera monitor device for indirect vision

1.1. ~~Resolution threshold of a camera~~ **Determination of the smallest discernable detail**

~~The resolution threshold of a camera is defined by the formula:~~

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

~~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~~

The smallest discernable detail of the naked eye shall be defined according to 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 test pattern and the camera D (in m) the smallest discernable detail ωc (in arcmin) is calculated as follows:

$$\omega_c = \frac{d}{D} \cdot \frac{180 \cdot 60}{\pi}$$

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. This means that, from the threshold triangle width *w* (in m) and the distance between test pattern and the camera D (in m) the smallest discernable detail ω_c (in arcmin) is calculated as follows:

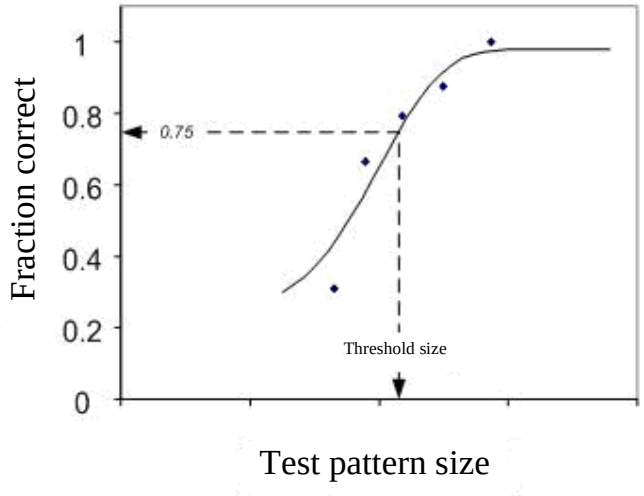
$$\omega_c = \frac{w}{4 \cdot D} \cdot \frac{180 \cdot 60}{\pi}$$

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:~~

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

~~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.~~

~~ω_{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_{mcrit} 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).

$$r_{mcrit} = \frac{\delta \cdot 60 \cdot 180}{\pi}$$

where:

r_{mcrit} : critical viewing distance of the monitor (m)

δ : size of the smallest discernable detail on the monitor (in m)"

Annex 10, paragraphs 1.3.1. and 1.3.2. amend to read:

"**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:

$$r_{dclose} = \frac{D_0 \cdot 60 \cdot 180}{\omega_c \cdot \pi \cdot f}$$

where:

r_{dclose}: detection distance (m). For the calculation of r_{dclose} for class V and VI devices a representative value of 0,30 m shall be used

D_0 : diameter of the critical object (m) according to paragraph 2.1.2.6.;

***f*: threshold increasing factor, which is equal to 8.**

ω_c: smallest discernable detail (arcmin)

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:**

$$r_{dfar} = \frac{r_{mcrit}}{r_m} \cdot r_{dclose} \quad \textbf{(m)}$$

where:

r_{dfar}: detection distance for distances larger than the critical viewing distance (m)

r_{dclose}: detection distance for distances smaller than the critical viewing distance (m)

r_m: viewing distance, i.e. distance between eye and monitor (m)

r_{mcrit}: critical viewing distance (m)"

Insert a new annex 11, to read:

"Annex 11

Determination of the displayed object size

1. Camera monitor device for indirect vision

1.1. General

Determination of the displayed object size considers the possible appearance of smear. The impact on the monitors image and consequence is the occultation of the field of view and therefore of the object. The following differentiation is made:

1.2. Case A: Smear appears

1.2.1 Step 1: Under real sun light condition: measure the width (s) of the vertical bar displayed on the monitor e.g. with a measurement microscope.

1.2.2 Step 2: Place the object at a defined distance from the camera. Measure the width of the object displayed on the monitor (b) in a situation without real sun light condition e.g. with a measurement microscope.

1.2.3 Step 3: Calculate the residual object width (α) according to the following equation:

$$\alpha['] = 60 \times 2 \times \arctan\frac{b-s}{2 \times r}$$

where:

α: residual width of the object displayed on the monitor (with smear) (minutes of arc)

b: width of the object displayed on the monitor (without smear) (mm)

s: width of the smear (mm)

r: viewing distance (mm)

1.3. Case B: Smear does not appear

1.3.1. Step 1: Place the object at a defined distance from the camera. Measure the width of the object displayed on the monitor (b) in a situation without real sun light condition e.g. with a measurement microscope.

1.3.2. Step 2: Calculate the object width (α) according to the following equation:

$$\alpha['] = 60 \times 2 \times \arctan\frac{b}{2 \times r}$$

where:

α: width of the object displayed on the monitor (without smear) (minutes of arc)

b: **width of the object displayed on the monitor (without smear) (mm)**

r: **viewing distance (mm)**

1.4. **Data supplied by the instructions for use**

In case of class V and class VI camera monitor devices the instructions for use shall include a table that shows the minimum and maximum mounting height of the camera above ground under consideration of different viewing distances. The camera must be mounted within the applicable height range. The viewing distances shall be selected from the intended context of use. The following table shows an example.

Viewing distance	**0,5 m**	**1,0 m**	**1,5 m**	**2,0 m**	**2,5 m**
Minimum mounting height	**Para. 2.2.2.**	**Para. 1.4.1.**	**Para. 1.4.1.**	**Para. 1.4.1.**	**Para. 1.4.1.**
Maximum mounting height	**Para. 1.4.2.**	**Para. 1.4.2.**	**Para. 1.4.2.**	**Para. 1.4.2.**	**Para. 1.2.2.**

1.4.1. **The value of the minimum mounting height is the same for all viewing distances as it is independent of the viewing distance. It is determined by the dimensions of the field of vision and the field of view of the camera. Use the following working steps for determination of the minimum mounting height.**

1.4.1.1. **Step 1: Draw the intended field of vision on ground.**

1.4.1.2 **Step 2: Place the camera above the field of vision in such a way that the camera is viewing the field of vision. The lateral position shall be in accordance with the intended mounting position at the vehicle.**

1.4.1.3. **Step 3: Change the height of the camera above ground in such a way, that the field of vision displayed on the monitor covers an area at least as large as the field of vision. Furthermore, the field of vision display should encompass the entire monitor screen.**

1.4.1.4 **Step 4: Measure the height between camera and ground which is the minimum mounting height. Report the result value.**

1.4.2. **The value of the maximum mounting height is different for different viewing distances as the displayed object size varies with the mounting height. Use the following working steps for determination of the maximum mounting height:**

1.4.2.1. **Step 1: Determine the minimum width bmin of the critical object displayed on the monitor for each viewing distance.**

$$b_{\min} = 2 \times r \times \tan \frac{8'}{2 \times 60}$$

where:

r: **viewing distance in mm**

bmin: minimum width of the critical object displayed on the monitor in mm

1.4.2.2. Step 2: Place the critical object inside the drawn intended field of vision in a position at which the distance between the critical object and the camera is largest. The illumination conditions shall be in such a way that the critical object is clearly visible on the monitor.

1.4.2.3. Step 3: Select the first value of the possible viewing distances.

1.4.2.4. Step 4: Change the height of the camera above ground in such a way, that the residual width B of the object displayed on the monitor is equal or larger than the minimum width allocated to that viewing distance.

$$B \geq b_{\min}$$

where:

B: residual width of the object displayed on the monitor (which is "b" in cases without smear and "b – s" in cases with smear) in mm (see paragaph 1.1 General)

1.4.2.5. Step 5: Measure the height between camera and ground which is the maximum mounting height allocated to that viewing distance. Report the result value.

1.4.2.5. Step 6: Repeat the aforementioned step 4 and 5 for the other viewing distances."

II. Justification

1. The requirements for the approval of camera-monitor systems and their installation on vehicles as given in Regulation No. 46, 02 series of amendments, 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.

Paragraph 2.1.2.6.

2. The dimensions for the critical object for Camera-Monitor systems for the class V and VI field of vision are aligned with the pole of paragraph 15.2.4.6.1.

3. Furthermore footnote 2/ can be deleted as this contains only an explanation of the size of 0,8m for the previous critical object (which might be suitable for classes I.-IV but not for classes V and VI for which camera-monitor systems are allowed).

Paragraph 2.1.2.7.

4. Adjustment of the definition of "critical perception" in order to incorporate a test method based on the Landolt-C or TOD principles.

Paragraph 2.1.2.9.

5. 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 present detection distance is measured at ground level, an editorial amendment of the definition of "detection distance" is needed.

Paragraph 2.1.2.10.

6. The words "critical field of vision" are not used in the regulation. So this definition can be deleted.

Paragraph 2.1.2.11.

7. The words "viewing reference point" are not used in the Regulation. So this definition can be deleted.

Paragraph 2.1.2.14.

8. This is a technical definition.

Paragraph 6.2.2.2.1.

9. As standard EN 12368 related to traffic signal light cannot be applied directly to cameras, the test conditions for the blooming test, which simulates the influence of low sunlight on the performance of a camera, have been redefined in paragraph 6.2.2.2.1 to 6.2.2.2.1.4. Also the area in which the contrast is below a certain value has been set on a maximum of 15 per cent of the image on a monitor. This value is based on the results of comparison test.

Paragraph 6.2.2.2.4.

10. This concerns a clarification that the measurement of the luminance contrast according ISO-standard 15008 has to be performed for a monitor only.

Paragraph 15.3.1.

11. This is to clarify that the critical object has to be seen over the entire required field of vision and not only on one point of that field. To make this provision more objective it is important that the display renders the critical object of sufficient size and sufficient detail. The procedure given in Annex 10 gives details for the determination of the detection distance and takes into account the details and size of the displayed object. Furthermore a reference to Annex 10 has been inserted for details about the determination of the detection distance.

12. A reference to a new Annex 11 has been introduced for the determination of the displayed object size.

Paragraph 15.3.3.

13. The reference to Annex 10 can be deleted as it is incorporated into paragraph 15.3.1.

Paragraph 21.

14. As the dimension of the critical object for the class V devices for indirect vision has been reduced from 80 cm to 30 cm, the new provisions should become a new series of amendments and not a supplement. This means that transitional provisions are needed to:

(a) mandate the approval authorities to grant an approval according the 03 series of amendments as from the entry into force of the new provisions (para. 21.1.);

(b) require that 12 months (respectively 18 months) after the entry into force, new system approvals (respectively new vehicle approvals) meet the new requirements, while after 24 months, Contracting Parties may refuse first registration when the new provisions are not met,

(c) permit the use of devices that are not concerned with the new provisions and

(d) copy several transitional provisions from the 02 series of amendments.

Annex 10

16. The procedure for calculating the maximum detection distance on the basis of video lines (which is an oversimplified model that should no longer be used) has been replaced by a new procedure based on ophthalmologic tests like Landolt-C or TOD (Triangle Orientation Discrimination) test. This procedure guarantees that the displayed object has sufficient detail and size.

Annex 11

17. A measurement method for determination of the displayed object size is introduced in Annex 11.