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Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures

Véhicules routiers — Aspects ergonomiques et de performance des caméras embarquées — Exigences et procédures d'essai

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 22, *Road vehicles*, Subcommittee SC 35, *Lighting and visibility*.

Introduction

The purpose of this International Standard is to give minimum safety, ergonomic, and performance requirements and test methods for Camera Monitor Systems (CMS) to replace mandatory inside and outside rearview mirrors for road vehicles (e.g. classes I to IV as defined in UN REGULATION NO. 46). This International Standard can follow updates of referred national regulations that influence the included contents.

Where possible, the requirements established for a CMS providing a specific legally prescribed field of view are based on the properties of conventional state of the art mirror systems providing that field of view.

The CMS is treated as a functional system in regards to requirement definitions and performance tests.

This International Standard outlines general requirements and test methods regarding the basic aspects of CMS; e.g. intended use, operating readiness, field of view, magnification, etc.

Furthermore, this International Standard outlines requirements and test methods regarding the necessary object size and resolution provided by the CMS. Besides the properties of the mirror system to be replaced, those requirements are also based on physical aspects of the human operator (e.g. visual acuity).

The given requirements follow the assumption, that the CMS provides an ideal mapping of the real world scene. To correspond to reality, this International Standard also provides requirements and test methods for all relevant parameters that worsen the ideal mapping (e.g. isotropy or artefacts).

Finally, this International Standard gives requirements and test methods regarding the aspects of time behaviour and failure behaviour.

All requirements are established to be as generic as possible, i.e. that these are possible to apply to any of the covered rearview mirrors. If additional or specific information is required for certain mirrors, these are provided in separate annexes.

This International Standard declares that CMS replacing legally prescribed mirrors have to be considered as safety-relevant systems and therefore, relevant safety standards (e.g. ISO 26262) have to be considered.

Road vehicles — Ergonomic and performance aspects of Camera Monitor Systems — Requirements and test procedures

1 Scope

This International Standard gives minimum safety, ergonomic, and performance requirements for Camera Monitor Systems to replace mandatory inside and outside rearview mirrors for road vehicles (e.g. classes I to IV as defined in UN REGULATION NO. 46). It addresses Camera Monitor Systems (CMS) that will be used in road vehicles to present the required outside information of a specific field of view inside the vehicle. These specifications are intended to be independent of different camera and display technologies unless otherwise stated explicitly. ADAS Systems (such as parking aid) are not part of this International Standard.

NOTE 1 Mirror classes V and VI (as defined in UN REGULATION NO. 46) are not in scope of this International Standard since the requirements are already defined in UN REGULATION NO. 46.

NOTE 2 The definitions and requirements in this International Standard are formulated with regard to a system structure, where one camera captures one legally prescribed field of view and one monitor displays one legally prescribed field of view. Of course, also other system structures (e. g. with one monitor displaying two legally prescribed fields of view) are within the scope of this International Standard. For those systems, either the system supplier or the vehicle manufacturer has to prove that the resulting system fulfils the requirements given in Clause 6.

NOTE 3 Whenever the phrases “field of view” or “field of vision” are used, then both have the same meaning and are to be used in parallel.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2813, *Paints and varnishes — Determination of gloss value at 20 degrees, 60 degrees and 85 degrees*

ISO 9241-302:2008, *Ergonomics of human-system interaction — Part 302: Terminology for electronic visual displays*

ISO 9241-305:2008, *Ergonomics of human-system interaction — Part 305: Optical laboratory test methods for electronic visual displays*

ISO 9241-307:2008, *Ergonomics of human-system interaction — Part 307: Analysis and compliance test methods for electronic visual displays*

ISO 12233:2014, *Photography — Electronic still picture imaging — Resolution and spatial frequency responses*

UN REGULATION NO. 46, *Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regards to the installation of these devices (ECE homologation)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1 Vehicle related terms and definitions

3.1.1
vehicle
vehicle with a combustion engine and/or electric driving motor, intended for use on the road, with or without external body components added, having a permissible maximum mass of at least 400 kg and a maximum design speed equal to or exceeding 50 km/h

Note 1 to entry: Vehicles of categories M1, M2, M3, N1, N2 and N3 (see UN-ECE REGULATION NO. 46).

[SOURCE: ISO 13043, definition 3.1]

3.1.2
vehicle coordinate system
positive x-axis pointing into the opposite of the forward movement direction of the vehicle, the z-axis being orthogonal to the ground plane pointing upwards and the y-axis pointing to the right seen in forward movement direction thus forming a right handed coordinate system

3.1.3
driver's ocular points
points that are uniquely defined for each vehicle

Note 1 to entry: See Figure 1.

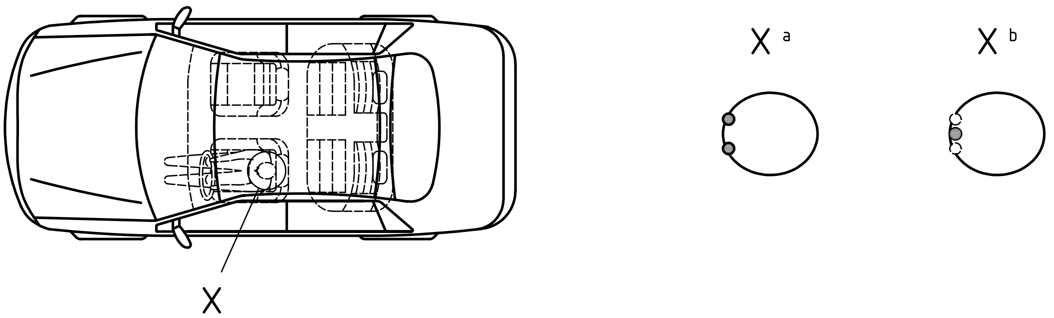
Note 2 to entry: These points are related to data given by the vehicle manufacturer following definitions of the responsible national body.

EXAMPLE "The driver's ocular points" means two points 65 mm apart and 635 mm vertically above point *R* of the driver's seat as defined in Annex 8. The straight line joining these points runs perpendicular to the vertical longitudinal median plane of the vehicle. The centre of the segment joining the two ocular points is in a vertical longitudinal plane which has to pass through the centre of the driver's designated seating position, as specified by the vehicle manufacturer."

3.1.4
driver's ocular reference point
middle point between the two ocular points of the driver

Note 1 to entry: See Figure 1.

Note 2 to entry: The abbreviation ORP can be used for this point.



Key

a ocular points

b ocular reference point

Figure 1 — Driver's ocular reference point

EXAMPLE The two ocular points of the driver uses 635 mm vertically above point *R* as shown in the example given in 3.1.3.

3.2 Mirror related terms and definitions

3.2.1
mirror
device with a reflective surface mounted to the bodywork of a vehicle

Note 1 to entry: It is used to see the required outside information of a specific field of view by indirect vision.

Note 2 to entry: The definitions in the subclauses from 3.2.2 to 3.2.28 assume an ideal mirror and do not deal with artefacts like low quality surface, dirt, etc.

3.2.2
mirror distance to driver ocular reference point
distance from the driver's ocular reference point to the centre of the mirror

Note 1 to entry: See Figure 2.

Note 2 to entry: It is denoted as a_{mirror} and is measured in metres.

Note 3 to entry: The mirror distance to driver ocular reference point influences the resolution and the magnification requirements for a CMS replacing a mirror. The designed resolution and magnification of a CMS should take into account that this distance is usually lower than the maximum values given in the following subclauses.

3.2.3
maximum mirror distance to driver ocular reference point (driver side)
maximum value for a_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $a_{mirror/driver/max}$ and is measured in metres:

— for class I UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,05 m;

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,7 m;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,2 m;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/driver/max}$ = 1,7 m.

Note 2 to entry: The above values represent the maximum distances for MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: See B.6.2 for more information on the values for class II and class IV mirrors.

3.2.4
maximum mirror distance to driver ocular reference point (passenger side)
maximum value for a_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $a_{mirror/passenger/max}$ and is measured in metres:

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/passenger/max}$ = 2,6 m;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/passenger/max}$ = 1,9 m;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $a_{mirror/passenger/max}$ = 2,6 m;

— for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is defined as $a_{mirror/passenger/max}$ = 2,5 m;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to the Japanese REGULATION NO. 44, this value is defined as $a_{mirror/passenger/max}$ = 2,5 m.

— for vehicle category of Japanese REGULATION refer to Japanese REGULATION NO. 44.

Note 2 to entry: The above values represent the maximum distances for MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: See B.6.3 for more information on the values for class II and class IV mirrors.

Note 4 to entry: Japanese REGULATION main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle".

3.2.5
mirror viewing angle
total angle between the ray leaving the eye-point and reaching an object after being reflected from the mirror surface, i.e. two times the angle between the driver's line of sight and the surface normal of the mirror

Note 1 to entry: See Figure 3.

Note 2 to entry: It is denoted as β_{mirror} and is measured in degrees.

3.2.6
minimum mirror viewing angle (driver side)
minimum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $\beta_{mirror/driver/min}$ and is measured in degrees:

— for class I UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/min}$ = 20 °;

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/min}$ = 55 °;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/min}$ = 30 °;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/min}$ = 55 °.

Note 2 to entry: The above values represent the minimum angles for MY 2013 mass produced vehicles (based upon 2013 survey) regarding the required field of view.

3.2.7
maximum mirror viewing angle (driver side)
maximum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $\beta_{mirror/driver/max}$ and is measured in degrees:

— for class I UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/max}$ = 65 °;

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/max}$ = 75 °;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/max}$ = 65 °;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/driver/max}$ = 125 °.

Note 2 to entry: The above values represent the maximum angles for today's vehicles in the market based on the required field of view.

3.2.8
minimum mirror viewing angle (passenger side)
minimum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $\beta_{mirror/passenger/min}$ and is measured in degrees:

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/min}$ = 80 °;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/min}$ = 55 °;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/min}$ = 80 °;

— for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is defined as $\beta_{mirror/passenger/min}$ = 54 °;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Japanese REGULATION NO. 44, this value is defined as $\beta_{mirror/passenger/min}$ = 50,5 °.

— for vehicle category of Japanese REGULATION refer to Japanese REGULATION NO. 44.

Note 2 to entry: The above values represent the minimum angles for MY 2013 mass produced vehicles (based upon 2013 survey) regarding the required field of view.

Note 3 to entry: Japanese REGULATION main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle".

3.2.9
maximum mirror viewing angle (passenger side)
maximum value for β_{mirror} as found in existing homologated vehicles for the given mirror class on the passenger side

Note 1 to entry: It is denoted as $\beta_{mirror/passenger/max}$ and is measured in degrees:

— for class II UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 95 °;

— for class III UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 85 °;

— for class IV UN REGULATION NO. 46 mirrors, this value is defined as $\beta_{mirror/passenger/max}$ = 150 °;

— for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is defined as $\beta_{mirror/passenger/max}$ = 111 °;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Japanese REGULATION NO. 44, this value is defined as $\beta_{mirror/passenger/max}$ = 64 °.

— for vehicle category of Japanese REGULATION refer to Japanese REGULATION NO. 44.

Note 2 to entry: The above values represent the maximum angles for MY 2013 mass produced vehicles (based upon 2013 survey) regarding the required field of view.

Note 3 to entry: Japanese REGULATION main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle".

3.2.10
distance from mirror to object
distance from the mirror to an object being viewed by the driver

Note 1 to entry: See Figure B.14.

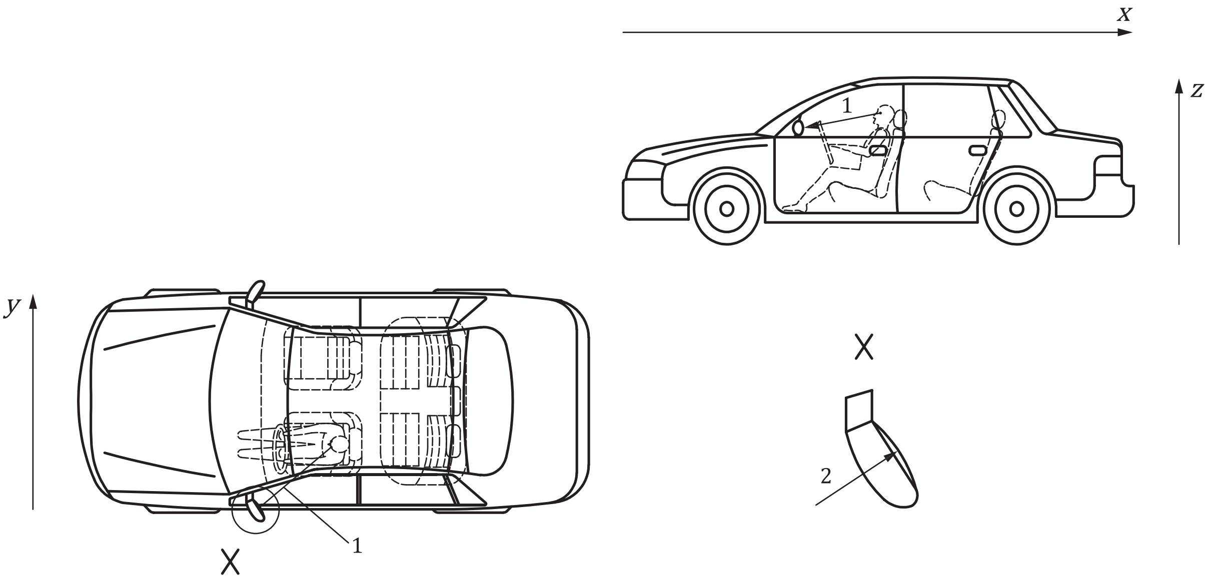
Note 2 to entry: It is denoted as d_{object} and is measured in meters.

3.2.11
mirror radius of curvature
radius of the sphere that specifies the shape of a spherical mirror surface

Note 1 to entry: See Figure 2.

Note 2 to entry: For convex spherical mirrors with the reflective layer on the convex surface, this value is positive.

Note 3 to entry: It is denoted as r_{mirror} and is measured in metres.



Key

1 a_{mirror}

2 r_{mirror}

Figure 2 — Mirror radius of curvature

3.2.12
mirror minimum allowed radius of curvature
minimum allowed value for r_{mirror} as defined by the responsible national body

Note 1 to entry: It is denoted as $r_{mirror/min}$ and is measured in metres.

Note 2 to entry: The values given below are examples:

— for class I UN REGULATION NO. 46 spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for class II UN REGULATION NO. 46 spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for class III UN REGULATION NO. 46 spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 1,2 m;

— for class IV UN REGULATION NO. 46 spherical convex mirrors, this value is defined as $r_{mirror/min}$ = 0,3 m;

— for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is defined as $r_{mirror/min}$ = 0,6 m;

— for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Japanese REGULATION NO. 44, this value is defined as $r_{mirror/min}$ = 0,6 m;

— for vehicle category of Japanese REGULATION refer to Japanese REGULATION NO. 44;

— FMVSS 111 only allows for plane mirrors where $r_{mirror/min}$ is infinite on the driver side; however, on the passenger side of the vehicle, FMVSS 111 defines a spherical convex mirror with a minimum radius of $r_{mirror/min}$ = 0,889 m.

Note 3 to entry: Japanese REGULATION main mirror means “Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle”.

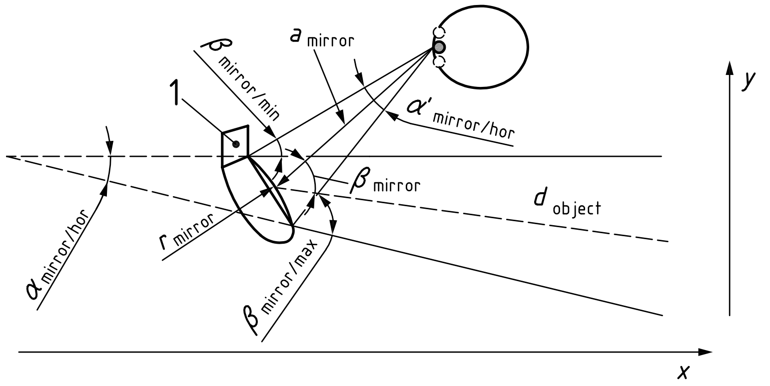
3.2.13
mirror angular size
angle under which the driver perceives the mirror

Note 1 to entry: See 3.2.14 and 3.2.15 for details and differentiation between horizontal and vertical direction.

3.2.14
mirror horizontal angular size
angle between the lines from the ORP to the left and right edge (in y-direction) of the reflective mirror surface

Note 1 to entry: See Figure 3.

Note 2 to entry: It is denoted as $\alpha'_{mirror/hor}$ and is measured in degrees.



Key

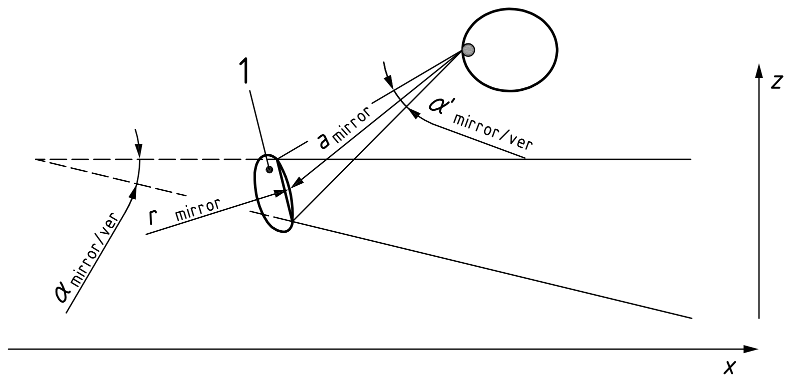
1 mirror

Figure 3 — Mirror horizontal angular size (bird's eye view)

3.2.15
mirror vertical angular size
angle between the lines from the ORP to the top and bottom edge in (z-direction) of the reflective mirror surface

Note 1 to entry: See Figure 4.

Note 2 to entry: It is denoted as $\alpha'_{mirror/ver}$ and is measured in degrees.



Key

1 mirror

Figure 4 — Mirror vertical angular size (side view)

3.2.16
field of view
space defined by all rays of light (lines from object points to the reflective mirror surface) that are still reflected into the driver's imaginary monocular eye point at the ORP

Note 1 to entry: This space can be approximated by a pyramid with its base lying in the y-z-plane.

3.2.17
horizontal field of view
angle between the leftmost and the rightmost ray of the field of view projected to the x-y-plane

Note 1 to entry: It is denoted as $\alpha_{mirror/hor}$ and is measured in degrees.

3.2.18
minimum horizontal field of view
minimum allowed value for $\alpha_{mirror/hor}$ as defined by the responsible national body

Note 1 to entry: It is denoted as $\alpha_{mirror/hor/min}$ and is measured in degrees.

Note 2 to entry: Information on $\alpha_{mirror/hor/min}$ for different mirror classes is given in B.2.1.

3.2.19
vertical field of view
angle between the topmost and the bottommost ray of the field of view projected to the x-z-plane

Note 1 to entry: It is denoted as $\alpha_{mirror/ver}$ and is measured in degrees.

3.2.20
minimum vertical field of view
minimum allowed value for $\alpha_{mirror/ver}$ as defined by the responsible national body

Note 1 to entry: It is denoted as $\alpha_{mirror/ver/min}$ and is measured in degrees.

Note 2 to entry: Information on $\alpha_{mirror/ver/min}$ for different mirror classes is given in B.2.2.

3.2.21
mirror magnification factor
relationship between the correct size of an object and its perceived size when seen through the mirror

Note 1 to entry: It is dependent on the distance from the ORP to the mirror a_{mirror} (see 3.2.2), the radius of the mirror r_{mirror} (see 3.2.11), the distance to the object d_{object} (see 3.2.10), and the mirror viewing angle β_{mirror} (see 3.2.5). It is denoted as $M_{mirror.}$

Note 2 to entry: For convex spherical rearview mirrors, the magnification factor is below 1, i.e. objects in a rearview mirror appear smaller than they really are. For plane mirrors with unit magnification, the magnification factor is equal to 1, i.e. there is no magnification.

Note 3 to entry: For a formula describing the magnification factor variation over the mirror, refer to B.3.

3.2.22
mirror average magnification factor
average value for the magnification based on a mirror with minimum radius $r_{mirror/min}$ and maximum distance to the ORP $a_{mirror/max}$

Note 1 to entry: It is denoted as $M_{mirror/avg}$.

Note 2 to entry: It is derived as the average over the relevant range of viewing angles β_{mirror} at the horizontal centre line of the mirror and distances d_{object}.

Note 3 to entry: See 3.2.23 and 3.2.24 for details and differentiation between driver and passenger side.

3.2.23
mirror average magnification factor (driver side)
average magnification factor for M_{mirror} as found in existing homologated vehicles for the given mirror class on the driver side

Note 1 to entry: It is denoted as $M_{mirror/driver/avg}$:

- for class I UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,33;
- for class II UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,23;
- for class III UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,31;
- for class IV UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/avg}$ = 0,065;
- for an FMVSS 111 plane driver mirror, this value is $M_{mirror/driver/avg}$ = 1.

Note 2 to entry: The above values were derived from MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.

3.2.24
mirror average magnification factor (passenger side)
average magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the passenger side

Note 1 to entry: It is denoted as $M_{mirror/passenger/avg}$:

- for class II UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,15;
- for class III UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,20;
- for class IV UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/avg}$ = 0,036;
- for an FMVSS 111 passenger mirror, this value is defined as $M_{mirror/passenger/avg}$ = 0,17;
- for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is $M_{mirror/passenger/avg}$ = 0,088;
- for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Japanese REGULATION NO. 44, this value is $M_{mirror/passenger/avg}$ = 0,10;
- for vehicle category of Japanese REGULATION refer to Japanese REGULATION NO. 44.

Note 2 to entry: The above values were derived from MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.

Note 5 to entry: Japanese REGULATION main mirror means “Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle”.

3.2.25
mirror minimum magnification factor
minimum value for the magnification based on a mirror with minimum radius $r_{mirror/min}$ and maximum distance to the ORP $a_{mirror/max}$; it is derived from the maximum viewing angle $\beta_{mirror/max}$ at the horizontal centre line of the mirror within the relevant range and the distance $d_{object} = \infty$

Note 1 to entry: It is denoted as $M_{mirror/min}$.

Note 2 to entry: See 3.2.26 and 3.2.27 for details and differentiation between driver and passenger side.

3.2.26
mirror minimum magnification factor (driver side)
minimum magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the driver side

Note 1 to entry: It is denoted as $M_{mirror/driver/min}$:

- for class I UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/min}$ = 0,31;
- for class II UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/min}$ = 0,21;
- for class III UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/min}$ = 0,29;
- for class IV UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/driver/min}$ = 0,037;
- for an FMVSS 111 plane driver mirror, this value is $M_{mirror/driver/min}$ = 1.

Note 2 to entry: The above values were derived from MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.2.

3.2.27
mirror minimum magnification factor (passenger side)
minimum magnification factor for M_{mirror} as found in existing homologated vehicles for the given class on the passenger side

Note 1 to entry: It is denoted as $M_{mirror/passenger/min}$:

- for class II UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/min}$ = 0,13,
- for class III UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/min}$ = 0,19;
- for class IV UN REGULATION NO. 46 mirrors, this value is defined as $M_{mirror/passenger/min}$ = 0,014;
- for an FMVSS 111 passenger mirror, this value is defined as $M_{mirror/passenger/min}$ = 0,17;
- for main mirrors on cab-over-engine type trucks according to Japanese REGULATION NO. 44, this value is $M_{mirror/passenger/min}$ = 0,061;
- for main mirrors on motor vehicles with a passenger capacity of 11 persons or more according to Japanese REGULATION NO. 44, this value is $M_{mirror/passenger/min}$ = 0,094.

Note 2 to entry: The above values were derived from MY 2013 mass produced vehicles (based upon 2013 survey).

Note 3 to entry: For detailed information how these values were derived, refer to B.3.

Note 4 to entry: For additional recommendations concerning commercial vehicles, refer to A.3.3.2.

Note 5 to entry: Japanese REGULATION main mirror means "Those mirrors used mainly for observing obstacles showing up around the rear portion on the left side of the vehicle".

3.2.28
mirror angular resolution
parameter that describes the ability of a mirror to resolve small details in a reflected scene

Note 1 to entry: In principle, a mirror can resolve an unlimited amount of detail. Nevertheless, in combination with the human eye, the angular resolution of a driver seeing through the rear view mirror of a vehicle is limited by the angular resolution of the human eye. The smaller the angular resolution of the human eye, the smaller the details can be that are still resolved by the driver, i.e. in contrast to the pixel resolution of cameras smaller values for the angular resolution indicate a higher quality vision.

3.2.29
visual acuity of the human eye
ability of the human eye and human visual system to resolve small details; it is different for each person and usually degrades with increasing age of the person

Note 1 to entry: It is measured using a Landolt C test (see ISO 8596:2009) at an optician, denoted as V_{eye} and measured in [1/arcmin].

Note 2 to entry: Usually, national bodies define a minimum visual acuity for acquiring a driver's license. A visual acuity of 1 is reached if a test person has correctly identified the direction of 60 % of the Landolt C openings, assuming that the Landolt C openings are of a size such that the openings are visible (from the test person's eye position) under an angle of 1 arcmin (see Figure 5).

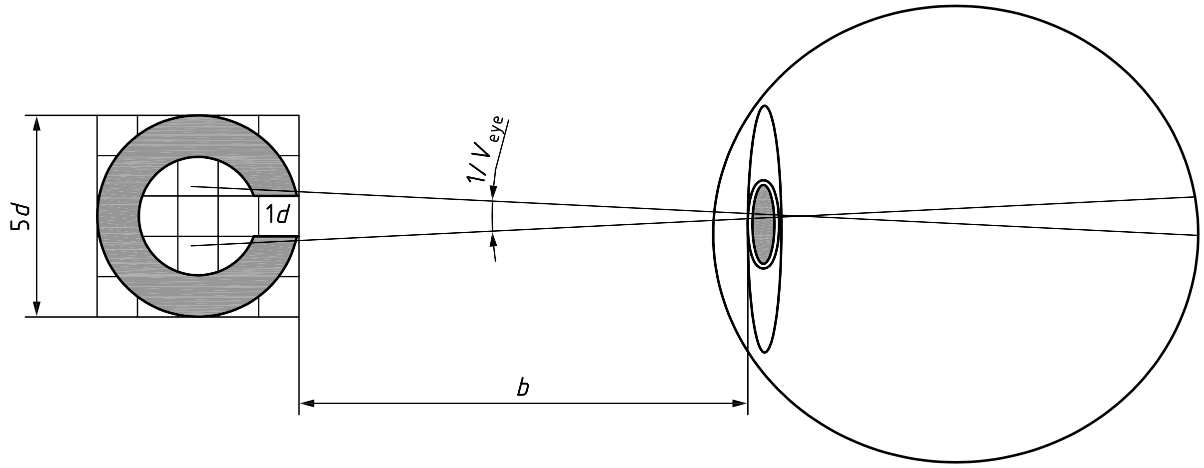


Figure 5 — Visual acuity of the human eye, e.g. tested with Landolt C ring

3.2.30
minimum visual acuity of the human eye
minimum value of V_{eye}

Note 1 to entry: It is denoted as $V_{eye/min}$:

— for UN REGULATION NO. 46 class I mirrors, this value is defined as $V_{eye/min}$ = 0,7;

— for UN REGULATION NO. 46 class II mirrors, this value is defined as $V_{eye/min}$ = 0,8;

— for UN REGULATION NO. 46 class III mirrors, this value is defined as $V_{eye/min}$ = 0,7;

— for UN REGULATION NO. 46 class IV mirrors, this value is defined as $V_{eye/min}$ = 0,8.

Note 2 to entry: FeV, the German requirements for acquiring drivers licenses for passenger vehicles, Appendix 6 §1.1 defines a minimum visual acuity of 0,7. Japan defines 0,7, Netherlands defines 0,5, and Sweden defines 0,5.

Note 3 to entry: In Sweden, Germany, Japan, and Netherlands, driving licenses for C/CE (heavy truck/heavy truck with trailer), D/DE (heavy bus/heavy bus with trailer) type of vehicles, as well as for taxis; minimum 0,8 in binocular acuity is required. Glasses or contact lenses may be used to achieve this acuity.

Note 4 to entry: There may be differences depending on the market where the vehicle is to be driven.

3.3 Camera related terms and definitions

3.3.1
camera
device used to capture colour images of a specific field of view; it mainly consists of two relevant items: imager and lens

Note 1 to entry: The following definitions assume an ideal camera and do not deal with artefacts like image blur, wrong focus, lens distortion, etc. The tests defined in 7.8 make sure that these artefacts are reduced to a minimum.

3.3.2
camera optical axis
virtual line that defines the path along which light propagates through the system; for a system composed of simple lenses, the axis passes through the centre of curvature of each surface, and coincides with the axis of rotational symmetry

3.3.3
camera reference orientation
the orientation of a camera of a CMS where the optical axis of the camera is pointing along the positive x-axis of the vehicle [the camera is looking backwards with the imager (see 3.3.7) lying in the y-z-plane] and the camera's upper side normal is parallel to the positive z-axis of the vehicle

Note 1 to entry: It helps to simplify the definition of further parameters of the camera (see Figure 6). See also 3.1.2 for coordinate convention used.

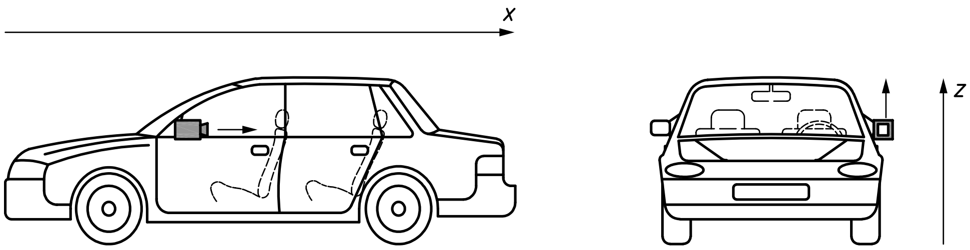


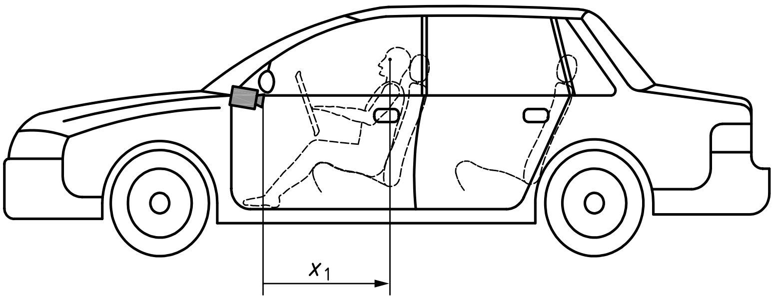
Figure 6 — Camera reference orientation

3.3.4
camera distance to driver ocular reference point in x-direction
distance from the centre of the *entrance pupil of the camera* (3.3.13) to the *driver's ocular reference point* (3.1.4) in x-direction when mounted to the vehicle; it is specific for each vehicle, even if the camera itself is the same for each vehicle

Note 1 to entry: See Figure 7.

Note 2 to entry: It is denoted as x_{camera} and is measured in metres.

Note 3 to entry: For camera positions forward of the ORP, x_{camera} has to be a positive value while for camera positions rear of the ORP, x_{camera} has to be a negative value.



Key

X_1 x_{camera}

Figure 7 — Distance to driver ocular reference point in x-direction

3.3.5
camera distances in y-direction

displacement from the outermost point of the same side of the vehicle to the entrance pupil of a camera replacing side mirrors in y-direction is denoted as y_{camera}, and displacement from the longitudinal centre x-z-plane to the entrance pupil of a camera replacing the interior centre mirror in y-direction is denoted as y'_{camera}

Note 1 to entry: Distances are measured in metres (see Figure 8).

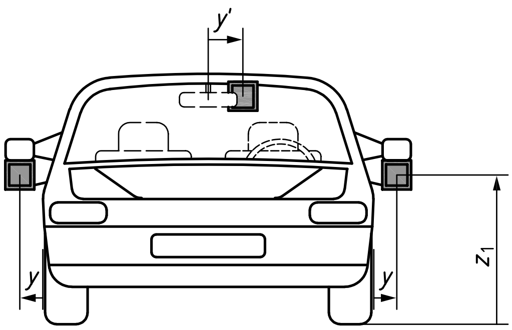
Note 2 to entry: For camera positions located outboard of the outermost point of the vehicle, y_{camera} has to be a positive value while for camera positions located inboard of the outermost point of the vehicle, y_{camera} has to be a negative value.

Note 3 to entry: For camera positions located in positive y-direction, y'_{camera} has to be a positive value while for camera positions located in negative y-direction, y'_{camera} has to be a negative value.

3.3.6
camera height above road surface

distance from the road surface to the centre of the *entrance pupil of the camera* (3.3.13) in z-direction when mounted to the vehicle; it is specific for each vehicle, even if the camera itself is the same for each vehicle

Note 1 to entry: It is denoted as z_{camera} and is measured in metres.



Key

y y_{camera}

y' y'_{camera}

Z_1 z_{camera}

Figure 8 — Height above road surface