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Transport information and control systems — Manoeuvring Aids for Low Speed Operation (MALSO) — Performance requirements and test procedures

Systèmes d'information et de commande des transports — Aides à la conduite pour manoeuvre à vitesse réduite (MALSO) — Exigences de performance et modes opératoires

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 17386 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

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Introduction

Today's aerodynamically shaped vehicles often result in restricted rear and front visibility. Manoeuvring aids for low speed operation enhance safety and driver convenience during parking or manoeuvring situations at very low speed, e.g. in narrow passages. Drivers can avoid collisions with obstacles that cannot be seen but can be detected by the system and they can make more effective use of limited parking space.

Manoeuvring Aids for Low Speed Operation (MALSO) are detection devices with non-contact sensors which assist the driver during low speed manoeuvring. MALSO systems indicate to the driver the presence of front, rear or corner objects when squeezing into small parking spaces or manoeuvring through narrow passages. They are regarded as an aid to drivers for use at speeds of up to 0,5 m/s, and they do not relieve drivers of their responsibility when driving the vehicle.

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Transport information and control systems — Manoeuvring Aids for Low Speed Operation (MALSO) — Performance requirements and test procedures

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1 Scope

This International Standard for Manoeuvring Aids for Low Speed Operation addresses light-duty vehicles, e.g. passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded) equipped with such MALSO systems. It specifies minimum functionality requirements which the driver can generally expect of the device; i.e., detection of and information on the presence of relevant obstacles within a defined (short) detection range. It defines minimum requirements for failure indication as well as performance test procedures; it includes rules for the general information strategy but does not restrict the kind of information or display system.

MALSO systems use object-detection devices (sensors) for ranging in order to provide the driver with information based on the distance to obstacles. The sensing technology is not addressed; however, technology affects the performance-test procedures set up in this International Standard (refer to Clause 7). The current test objects are defined based on systems using ultrasonic sensors, which reflect the most commonly used technology at the time of editing this International Standard. For other sensing technologies possibly coming up in the future, these test objects shall be checked and changed if required.

Visibility-enhancement systems like video-camera aids without distance ranging and warning are not covered by this International Standard.

Reversing aids and obstacle-detection devices on heavy commercial vehicles are not addressed by this International Standard; requirements for those systems are defined in ISO/TR 12155.

2 Normative references

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

ISO 2575, *Road vehicles — Symbols for controls, indicators and tell-tales*

ISO 15006, *Road vehicles — Ergonomic aspects of transport information and control systems — Specifications and compliance procedures for in-vehicle auditory presentation*

ISO 15008, *Road vehicles — Ergonomic aspects of transport information and control systems — Specifications and compliance procedures for in-vehicle visual presentation*

ISO 16750 (all parts), *Road vehicles — Environmental conditions and testing for electrical and electronic equipment*

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3 Terms and definitions

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

3.1
audible information and warning
acoustical signal (e.g. pulses, speech) which is used to present information about relevant obstacles to the driver

NOTE Acoustical pulses can be coded mainly by carrier frequency, repetition rate and position of sound generator (refer to Figure 2 sub-functions).

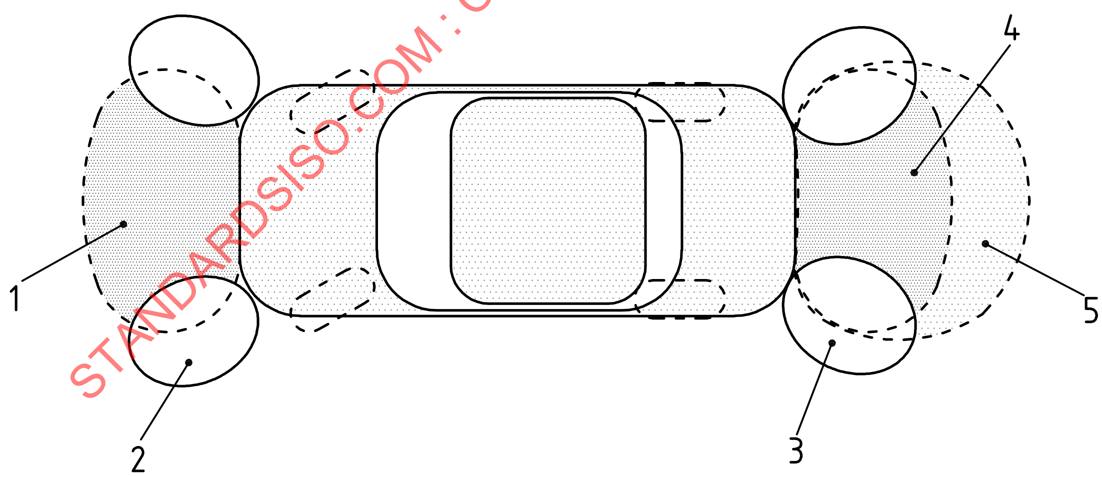
3.2
evaluation for information and advice
information about detected obstacles which, when the system is activated, will be evaluated to warn and advise the driver in order to help with the current low speed manœuvre

NOTE Refer to Figure 2 sub-functions.

3.3
manoeuvring aid for low speed operation
system which, at low speeds (< 0,5 m/s), is capable of informing the driver of the presence of stationary obstacles in particular areas in close proximity to the subject vehicle, mainly during parking and manoeuvring in narrow passages

3.4
monitoring range
m. r.
specific three-dimensional space around the vehicle which is divided into rear and front corner m. r., front, rear-1 and rear-2 m. r.

NOTE Refer to Figure 1. The covered monitoring ranges depend on the intended use of the system (refer to Clause 4).



Key

1 front
2 front corner
3 rear corner
4 rear-1
5 rear-2

Figure 1 — Monitoring ranges (plan view)

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3.5
reversing detection system
system which gives an indication to the driver, when the reverse gear is selected, of whether there are objects in the monitoring range

3.6
sensor
component which detects objects in the monitoring range

NOTE There are a variety of sensor principles listed below which could be used.

— The most common principle is the flight time measurement (e.g. RADAR, LIDAR, SONAR). Active sensor elements create a pulsed or continuously modulated field of microwaves, (infra-red) light, or ultrasonic sound. The reflected energy due to an object in the detection area is received, and the distance to the object is measured. The lateral position of the object is estimated based on the beam or field directional characteristics, or based on the timing relationships between sensors with overlapping coverage areas.

— Alternative principles include distance measurement by triangulation principle and passive sensor systems using image processing.

3.7
system activation
action of transitioning the system operation from a quiescent mode to an active one in which the system is monitoring the monitoring ranges, evaluating the objects detected and generating appropriate feedback to assist the driver

3.8
test object
object with a specific material, geometry and surface for testing the monitoring range, and which should give comparable results for the relevant sensor types

3.9
visual information and warning
optical signal (e.g. a telltale or display) which is used to present information about relevant obstacles to the driver

NOTE Visual information may be coded, e.g. by colour, repetition rate, symbols or text. The driver may be warned by continuous or pulsating signalling of possibly coloured telltales. Information may be graphical or alphanumeric (refer to Figure 2 sub-functions).

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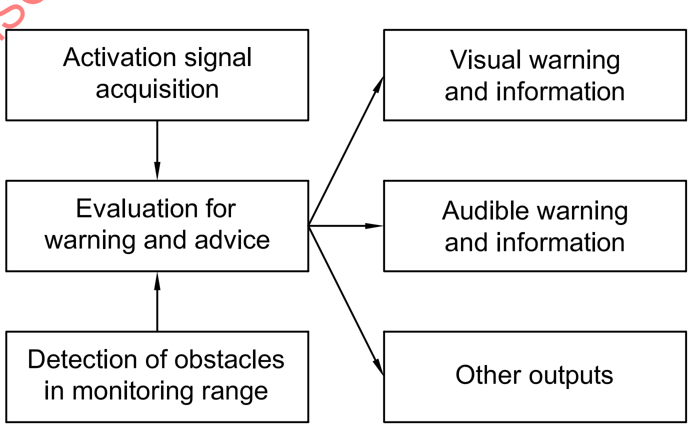

Figure 2 — Block diagram of the potential sub-functions of a manoeuvring aid for low-speed operation.

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3.10
warning levels
progressive critical levels of audible/visual/tactile/kinaesthetic information or feedback to the driver regarding the hazard environment

4 Classification

The MALSO system classification reflects the diversity of driving behaviour and market demand in different regions of the world. For example, in certain countries, drivers manoeuvre within a very tight area and have come to rely on warnings given at very short range. In other regions, drivers expect warnings to be given at a relatively longer range. A manufacturer may select the most suitable system parameters based on the driving style and expectations of the target driver population.

The manoeuvring aids for low-speed operation are classified according to their capability of covering the different monitoring ranges. Each monitoring range corresponds to a particular part of the vehicle boundary to prevent colliding with an obstacle (refer to Figure 1). The class of the system is indicated by an abbreviation corresponding to the monitoring ranges covered.

Table 1 — Classification of manoeuvring aids for low speed operation — Abbreviations of monitoring ranges

Monitoring Range	Abbreviation	Detection distance m	Maximum driving speed m/s
rear-1	R1	0,6	0,3
rear-2	R2	1,0	0,5
rear corner driver side	Rcd	0,5	0,3
rear corner passenger side	Rcp	0,5	0,3
front	F	0,6	0,3
front corner driver side	Fcd	0,5	0,3
front corner passenger side	Fcp	0,5	0,3

Any combination of monitoring ranges may be used, if it is beneficial for the intended use of the system.

The corner-type systems have monitoring ranges restricted to particular corners of the vehicle and are mainly intended to assist the driver while driving through narrow passages.

For convenience and most efficient use of the manoeuvring aid, the driver shall be informed about the type of system the vehicle is equipped with, according to the classification above.

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5 Functional and performance requirements

5.1 System activation

5.1.1 Systems with manual activation

The system is turned ON and OFF by the driver with a switch or push-button. After activation, the system shall indicate readiness for service acoustically or visually. This indication shall be clearly distinguishable from distance information about obstacles.

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5.1.2 Systems with automatic activation

The system is activated/deactivated automatically according to the driving situation. The possible monitoring ranges (refer to Clause 4) may be activated separately in order to avoid nuisance signals. After each automatic activation, readiness for service shall be clearly indicated to the driver. There may be an ON/OFF switch or push-button to override automatic (de)activation.

Activation criteria are **[reverse gear selected]** on the one hand and **[speed below a specified limit v_{on}]** on the other hand. Deactivation criteria may be **[gear other than reverse is selected, speed beyond a specified limit v_{off}]** or **[distance moved since last system activation greater than x_{off}]**. The speed limits v_{on} and v_{off} and the distance limit x_{off} may be defined appropriately to the sensor technology and the intended use of the system; however, v_{on} and v_{off} shall be $\geqslant$ 0,5 m/s or $\geqslant$ 0,3 m/s, depending on the monitoring range under consideration (refer to Table 1), since these are the maximum velocities supported by the system.

Table 2 shows how the different existing monitoring ranges should be activated.

Table 2 — System activation/deactivation criteria

monitoring range	Reverse gear selected	gear other than reverse is selected	
		$v < v_{on}$	$v \geqslant v_{off}$ **or** $x > x_{off}$
front	o [a]	+ [b]	— [c]
front corners	o [a]	+ [b]	— [c]
rear	+ [b]	o [a]	— [c]
rear corners	+ [b]	o [a]	— [c]

[a] "o" indicates optional.

[b] "+" indicates active.

[c] "—" indicates inactive.

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5.2 Driver interface and information strategy

5.2.1 General information presentation

For the driver interface, at least the audible information channel shall be used. Visual information and warning may be used as a supplement. A standardized information strategy will be the basis for the development of both types of information components, as this makes the use in different vehicles easier and safer. The most relevant information for the driver is the distance, i.e. the clearance, between the vehicle boundary and an obstacle. The location of the obstacle relative to the vehicle may be indicated as additional information. Failures shall be indicated to the driver as well.

A general information strategy cannot be established because of the following reasons.

— There are many different ways of coding the information.

— Each car manufacturer will integrate the manoeuvring aids into its driver-information system with its specific driver interface.

The following subclauses may be regarded as guidance in the implementation of an information strategy.

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5.2.2 Audible information

The audible information shall be presented in accordance with ISO 15006.

The following basic code is recommended for the audible information channel.

a) Distance shall be coded into at least two levels. These zones may be represented by different repetition rates, with the basic rule that a high repetition rate or a continuous sound corresponds to short distances. If a different or an additional code is used it should not interfere with the basic rule.

b) The different areas may be represented by different carrier frequencies (e.g. high frequency for the front, low frequency for the back of the vehicle). In this case, not more than two different areas/carrier frequencies should be used. Synthesized or recorded voice messages may also be used.

c) The activation/deactivation of the system and the indication of failure/disturbance may be presented by an audible signal, clearly distinguishable from the other signals.

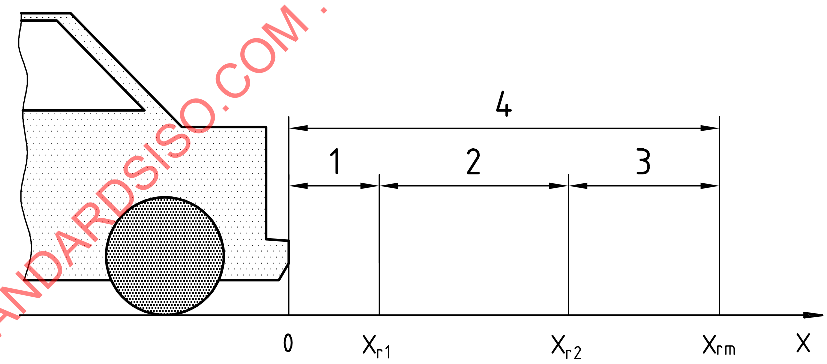
5.2.3 Visual information

The visual information shall be presented in accordance with ISO 15008.

If the visual information channel is used as a supplement to the audible channel, the following basic code is recommended.

a) The information shall be coded into at least two levels, represented by different colours: red for level 1 (imminent collision level) and yellow or green for level 2 (attention level). If a different code or an additional advisory level is used, it should not interfere with these basic code elements. The two levels may be subdivided by using more than one display element with the same colour, e.g. a bar-graph with three red and three yellow bars, allowing for six sub-levels.

   Figure 3 shows the warning levels for the rear monitoring range.



Key

X distance to an obstacle

1 level 1
2 level 2
3 advisory level
4 rear monitoring range

Figure 3 — Warning levels for rear monitoring range

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b) The display should be located so as to minimize the likelihood of inducing drivers to change their direction of vision. For example, it is recommended to place the display for the rear monitoring range in the rear part of the passenger compartment, because this allows drivers to watch the display while simultaneously looking through the rear mirror or over their shoulder directly through the rear window. For the same reason, it is recommended to locate the display for the front monitoring range in the dashboard.

c) It is recommended to indicate the activation/deactivation and malfunction of the system by a telltale or a symbol in all active displays of the system. These symbols shall be in accordance with ISO 2575.

5.2.4 Combination of visual and audible information

A combination of visual and audible information may be used to improve the system performance or to reduce the possibility of annoying the driver and passengers, taking into account the specific advantages of both information channels.

Level 1 (imminent collision level) information shall be given audibly and may additionally be given visually; level 2 (attention level) information may, however, be given by the visual or the audible channel only.

If the intensity of the audible information presentation can be reduced by the driver, e.g. from a menu of the onboard human-machine interface (HMI) system, there should be a note in the user manual or a message in the dialog with the HMI system, stating that warnings may not be perceived in time if the volume is set too low.

5.2.5 Duration of signalling

In general, the signalling of an obstacle shall be maintained as long as the obstacle is detected and shall cease when the obstacle is no longer detected.

In the case of an audible warning only, the acoustical signal may be automatically switched off temporarily after a certain time (to be defined by the manufacturer). The system, however, shall remain in the active state.

As soon as the distance to the obstacle decreases, the audible signal shall be switched on automatically again. In the case of an increasing distance to the obstacle, the audible signal may remain switched off.

If a visual display supplements the audible information channel, the acoustical signal may be switched off temporarily. The visual signalling, however, should be maintained. This measure helps to avoid annoying acoustical signals to the driver.

The driver may select temporary suppression of the acoustical signal. In this case, the acoustical signal shall remain suppressed until the driver switches it on again; however, the acoustical signal shall be automatically reinstated when the system is activated the next time.

5.3 Dynamic performance of object detection

5.3.1 Relative velocity of objects

The system shall be able to detect stationary objects while the vehicle itself is either stationary or moving at a speed up to 0,3 m/s. Systems classified R2 (refer to Clause 4) shall be able to detect stationary objects in the rear monitoring range b while moving at a speed up to 0,5 m/s.

5.3.2 Maximum time delay for the detection of an obstacle

After the activation of the system, the time interval between the indication of “readiness for service” and the first presentation to the driver of the correct information about a relevant obstacle already present in the monitoring area shall be no more than 600 ms.

As long as the system is active, the time delay between appearance of a relevant obstacle and presentation of the correct information to the driver shall not exceed 350 ms in all monitoring ranges. This capability is proved by a suitable test procedure with an accuracy better than one-tenth of the measured time delay.

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For reference, examples of test procedures are given in Annex A.

The delay is calculated as the arithmetic mean of at least 10 tests. The mean delay to indication within these tests shall not exceed 350 ms and no single value shall exceed 500 ms.

5.4 Monitoring range coverage

5.4.1 Sections of the monitoring range

According to Clause 3, the total monitoring range is divided into seven monitoring ranges (refer to Figure 1). Each monitoring range is characterised by horizontal and vertical areas of relevance.

5.4.2 Horizontal areas of relevance

The horizontal areas of relevance are the two-dimensional projections of the monitoring ranges onto the driveway. The minimum detection distances as measured from the vehicle boundary are defined in Table 1.

The first 0,2 m starting from the vehicle boundary (refer to Figure 4) shall not be tested, because state-of-the-art sensing technology cannot guarantee detection in this close proximity.

In order to perform the operational test described in Clause 7, the relevant monitoring range shall be scanned horizontally with test object H, vertically with test object V. Each detected grid position is represented by a covered square with edge lengths of dx and dy (dx = 0,1 m; dy = 0,1 m for testing the horizontal coverage) and its centre at the position of the longitudinal axis of the standard obstacle.

The coverage ratio is defined as the ratio of the covered area to the total area of relevance.

EXAMPLE For a total area of relevance of 96 cells with a covered area of 88 cells, the average coverage ratio is 91,7 %. The area of a single detection hole is defined as the square dx^2 corresponding to a “not detected” standard obstacle.

NOTE The small error due to the overestimation of the area by the integer number of cells can be neglected.

For the evaluation of the performance tests, the monitoring range is divided into a near range, A1, that extends from the vehicle boundary up to 0,6 m, and A2 which covers the range beyond 0,6 m. These sub-areas are not related to the warning-level ranges (refer to Figure 3). An example is shown in Figure 4 for the rear horizontal area of relevance. The coverage ratio shall be determined separately for each of the two sub-areas.

5.4.3 Rear horizontal area

In order to simplify the performance test procedure, the rear horizontal area of relevance is represented by a rectangle that begins 0,2 m off the rear vehicle boundary and extends to the maximum detection distance, which is 0,6 m for R1 and 1,0 m for R2.

The width of the rectangle is equal to the vehicle width, measured along the rear axle. The dimensions shall be rounded up to the nearest 0,1 m.

5.4.4 Front horizontal area

The front horizontal area of relevance is represented by a rectangle that begins 0,2 m off the front vehicle boundary and extends to the maximum detection distance, which is 0,6 m. The width of the rectangle is equal to the vehicle width, measured along the front axle. The dimensions shall be rounded up to the nearest 0,1 m.

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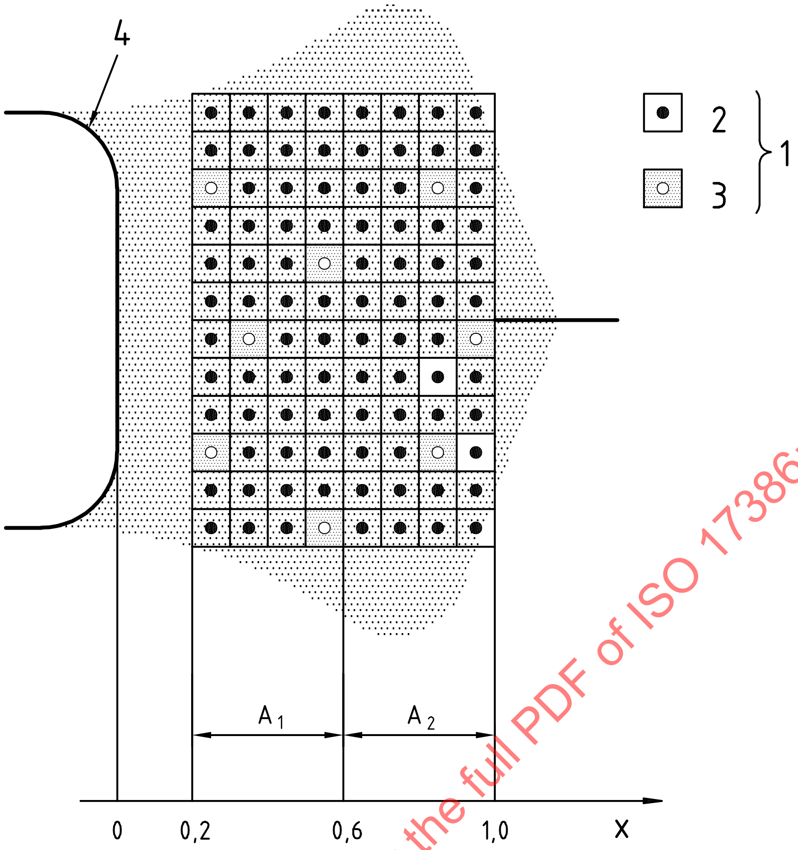

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Key

X distance from the vehicle boundary, in metres

1 test object

2 detected

3 not detected

4 rear boundary of vehicle

A_1, A_2 sub-areas

Figure 4 — Example determination of the rear horizontal coverage ratio

5.4.5 Corner horizontal areas

For the definition of the corner horizontal areas of relevance, the following “brick definition” method shall be used.

1) Draw a rectangular box close around the vehicle outline.

2) Draw lines from each box corner to the vehicle at an angle of 45°.

3) The intersections of these lines and the vehicle boundary are the vehicle corners.

4) The elliptical areas at each corner indicate the horizontal areas of relevance to be evaluated in the test procedure using 7 square grid positions with dx = dy = 0,1 m (refer to Figure 5).

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Dimensions in metres

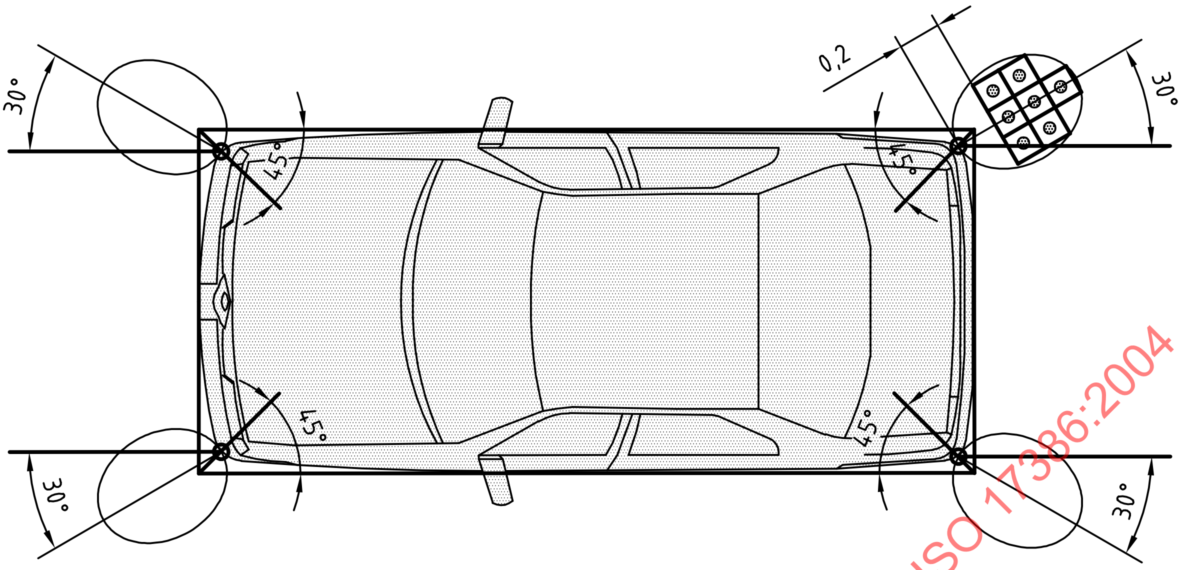

Figure 5 — “Brick definition” of vehicle corners and minimum corner detection ranges

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5.4.6 Minimum coverage ratios

The minimum required coverage ratios for the front and rear horizontal areas of relevance are as follows:

— 90 % in A1;

— 87 % in the rear-2 area of A2.

The minimum coverage ratios for corner areas of relevance shall be 100 %.

Within the whole monitoring range, there shall be no more than two contiguous detection holes in a straight line, either horizontally, vertically or diagonally in the horizontal plane.

5.4.7 Vertical areas of relevance

In order to simplify the performance test procedure, the vertical areas of relevance are represented by rectangles that begin 0,2 m off the vehicle boundary and extend to the maximum detection distance in the particular monitoring range (refer to Clause 4). In the front and the rear monitoring range, the test shall be carried out using test object V placed in a vertical plane coinciding with the longitudinal axis of the vehicle. Refer to the horizontal monitoring ranges, shown in Figure 5, for the inclination of the corner vertical areas of relevance with respect to the vehicle boundary.

For testing the vertical coverage, it is sufficient to use a 0,2 m grid ($dx = dy = 0{,}2$ m), since the capability of covering the whole area without excessive holes is already proven by the test of the horizontal areas. The height of the rectangles is 0,6 m, corresponding to three lines of grid squares.

An example for the rear monitoring range is depicted in Figure 6.

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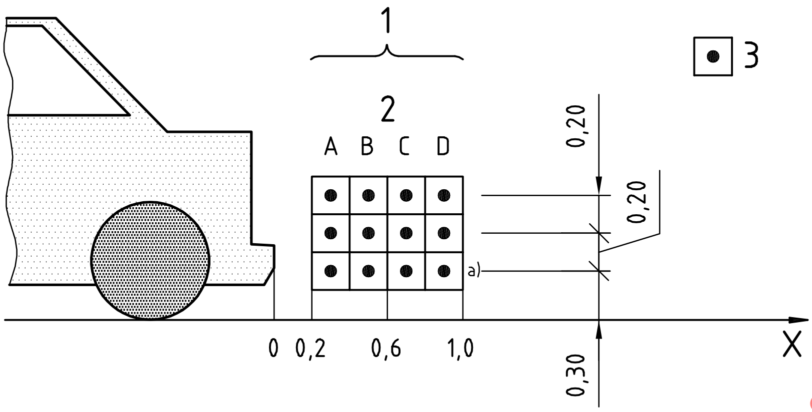
Dimensions in metres



Key

X distance from the vehicle boundary, in metres

1 rear vertical area of relevance

2 column

3 test object grid position

a The centre of the lower line shall be 0,30 m above ground.

Figure 6 — Determination of the rear vertical area coverage ratio by the test procedure

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In order to allow for the angular detection characteristics and different installation height of common sensors, at least one cell in column A (nearest to the bumper) shall be covered.

The minimum coverage shall be as defined in Table 3. Refer to Table 1 for the detection distances within the different monitoring ranges.

Table 3 — Vertical coverage (minimum number of covered cells)

Monitoring ranges	Column			
	A	B	C	D
rear-2	1	2	2	1
rear-1 and front	1	2	0	0
rear and front corner	1	1	0	0

5.5 Self-test capabilities and failure indication

The system shall provide the following self-test functions (at least after each system activation):

a) electronic circuit and wiring — The self-test unit shall check the function of the electronic components of the system.

b) sensor components — The self-test unit shall check whether there is any damage to the sensor elements which would lead to a malfunction of the system.

The procedures a) and b) described above shall

— be executed automatically to detect faults leading to a failure of the system function;

— generate a warning signal [refer to 5.2.2 c) and 5.2.3 c)] whenever a fault condition is detected.

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5.6 Operation with trailers

5.6.1 Trailer-hitch handling

A trailer hitch mounted on the host vehicle may affect the proper function of the sensors on one hand and may extend the rear boundary of the vehicle on the other hand.

Especially if a detachable trailer hitch is used, particular care shall be taken that the mounting of the hitch will not result in poor coverage of the rear monitoring range. It shall be taken into account that the hitch will most probably protrude beyond the bumper and will thus determine the vehicle boundary.

If proper functioning with the hitch mounted cannot be effected, either the system shall automatically shut off when a hitch is mounted or a manual override cut-off switch shall exist. The user manual of the vehicle shall describe the appropriate operation in these cases.

5.6.2 System operation with trailers

For systems that do not have a manual override cut-off switch, the electrical circuit of the vehicle shall be designed in such a way that the reversing detection system will automatically be suspended as soon as the electrical connection between towing and trailing vehicle is in operation. However, if the trailer is fitted with compatible sensors, these should now inform the driver of obstacles whilst reversing.

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6 Requirements and tests for components

The system components shall be designed according to specific automotive requirements. This shall be proved by standardized tests defined by the automobile manufacturer. As an alternative to automobile manufacturer's specific test procedures, ISO 16750 (all parts) may be the basis for component test procedures.

7 Operational test of obstacle detection

7.1 Test object

The geometry, reflection and absorption properties of the standard test obstacle should lead to easy testability and good representation of a real obstacle. Of course, the standard obstacle should not favour one of the physical principles and should represent the most relevant objects in real manoeuvring situations.

Within this standardized framework, different systems will be made comparable in order to fulfil the minimum performance requirements expected by the driver.

Reflectivity measurements for ultrasonic waves on relevant objects have been performed and it has been proven that the following tubular test objects are suitable representations of real objects when testing systems with ultrasonic sensors:

— test object H for horizontal test plastics tube, grey, ∅ 75 mm, length 1 000 mm;

— test object V for vertical test plastics tube, grey, ∅ 75 mm, length 1 000 mm.

NOTE Such plastics tubes are available commercially for domestic installation.

If systems are tested that use sensing technologies other than ultrasonic sensors, it should be verified that these tubes produce equivalent echoes for the sensor technologies in question (e.g. RADAR, LIDAR, electrostatic or video/image processing); otherwise, suitable reference objects will need to be developed. If possible, they should have a tubular shape.

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7.2 General ambient conditions

While testing, the wind speed shall not exceed 5,4 m/s (wind force 3). Temperature shall be within (23 ± 5) °C and the relative air humidity (60 ± 25) % (refer to 7.4). The test location shall be on a flat, dry, asphalt or concrete surface. The tests shall not be affected by reflections, neither of sonic nor of electromagnetic waves from walls in the environment, auxiliary test equipment or other objects.

7.3 Test procedure

7.3.1 Test setup

Perform the operational test on a vehicle or test structure which allows the installation conditions of the selected vehicle model or selected vehicle range to be reproduced. In case a vehicle is used to perform the test, it shall have curb weight. A tolerance of + 5% may be allowed. If the ride height is adjustable, it shall be set to normal driving conditions for paved roads.

Sensor surfaces shall be visibly clean and free of contamination.

Depending on the class of the manoeuvring aid (refer to Clause 4), the detection performance shall be tested in the rear monitoring range, the front monitoring range and the corner monitoring ranges.

7.3.2 Test 1 — Coverage of horizontal areas of relevance

7.3.2.1 Test

Position test object H perpendicularly on the ground in the monitoring range in such a way that its longitudinal axis is positioned rigidly in the grid positions in accordance with 5.4.2. If the horizontal area of relevance depends on the steering angle, the test shall be performed with the steering in a neutral (straight-ahead) position.

7.3.2.2 Evaluation

Check the coverage ratio for each sub-area of the horizontal area of relevance. Detection shall take place unambiguously with an uninterrupted sequence of the signal corresponding to the warning level. The minimum coverage ratio as defined in 5.4.2 shall be attained in each sub-area.

7.3.3 Test 2 — Coverage of vertical areas of relevance

7.3.3.1 Test

Secure the test object V in a rigid horizontal position in the monitoring range with its three-dimensional centre located on the appropriate grid-positions (the grid has to cover the vertical area of relevance in accordance with 5.4.7).

7.3.3.2 Evaluation

Refer to 7.3.2.2.

7.4 Specific ambient conditions

7.4.1 General

In addition to the tests under general ambient conditions described in 7.2, the system shall be tested at specific ambient conditions.

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7.4.2 Tests at extreme temperatures

Perform the test in a climate chamber. Position test object H perpendicularly on the ground in the monitoring range at a distance to the vehicle boundary that corresponds to approximately 80 % of the specified maximum detection distance at 25 °C. Choose the exact position so that the test object is detected faultlessly at normal ambient temperature. The sensors may be mounted on a test fixture that reproduces the vehicle boundary.

Then heat up the climate chamber to (60 ± 2) °C and hold the maximum temperature for at least 30 min.

Cool down the chamber to (– 25 ± 2) °C and hold the minimum temperature for at least 30 min. Precautions shall be taken against icing of sensor surfaces that may affect the object-detection performance. Ice should not be visibly present on the surface of the sensors.

The system shall operate during the whole test procedure and object detection shall be indicated without interruption.

NOTE An alternative laboratory test is acceptable if its equivalence can be demonstrated.

7.4.3 Tests at different lighting levels

If the system function may depend on the lighting level, e.g. for video sensors, the object detection shall be tested at different lighting levels to assure that the minimum performance requirements are fulfilled under both daytime and nighttime conditions. The test should be conducted in an area with no lighting except for the test vehicle's own lighting, for example, head, tail and reverse lights.

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