
**Intelligent transport systems — Devices
to aid reverse manoeuvres — Extended-
range backing aid systems (ERBA)**

*Systèmes intelligents de transport — Dispositifs d'aide aux manœuvres
de marche-arrière — Système d'aide à la marche-arrière à gamme de
distances étendue (ERBA)*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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 22840 was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

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Introduction

Extended-range backing aids (ERBA) are detection devices with non-contact sensors that assist the driver during low- to mid-speed backing manoeuvring. These systems detect and warn the driver of objects in the pathway of the vehicle. In comparison to low-speed-only devices whose main purpose is assisting in parking manoeuvres (e.g. ISO 17386), the purpose of the ERBA is to assist in higher-speed backing manoeuvres associated with traversing longer distances.

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Intelligent transport systems — Devices to aid reverse manoeuvres — Extended-range backing aid systems (ERBA)

1 Scope

This International Standard for extended-range backing aids (ERBA) addresses light-duty vehicles [e.g. passenger cars, pick-up trucks, light vans and sport utility vehicles (motorcycles excluded)] equipped with such ERBA systems. This International Standard establishes minimum functionality requirements that the driver can expect of the system, such as the detection of and information on the presence of relevant obstacles within a defined detection range. This International Standard also sets minimum requirements for failure indication as well as performance test procedures. This International Standard includes rules for the general information strategy but does not restrict the kind of information or display system.

ERBA systems are intended to provide backing aid functionality over an extended area located aft of the subject vehicle. ERBA systems are not intended for short-range detection of obstacles located immediately behind the vehicle. If a short-range detection system is needed, either in lieu of or in addition to an ERBA system, reference can be made to ISO 17386.

This International Standard does not include reversing aids and obstacle-detection devices for use on heavy commercial vehicles. Requirements for those systems are defined in ISO/TR 12155. This International Standard does not include visibility-enhancement systems, such as video-camera aids that do not have distance ranging and warning capabilities.

ERBA systems use object-detection devices (sensors) for detection and ranging in order to provide the driver with information based on the distance to obstacles. The sensing technology is not addressed; however, technology does affect the performance test procedures defined in this International Standard. The test objects are defined based on systems using ultrasonic and radar sensors, which are the most commonly used detection technology for long-range applications at the time of publication of this International Standard.

ERBA systems are intended to supplement the interior and exterior rear view mirrors, not eliminate the requirement for such mirrors. Automatic actions (e.g. applying brakes to prevent a collision between the subject vehicle and the obstacle) are not addressed in this International Standard. Responsibility for the safe operation of the vehicle remains with the driver.

ERBA systems calculate a dynamic estimate of collision danger [e.g. perhaps using a time-to-collision, (TTC) algorithm] and warn the driver that immediate attention is required in order to avoid colliding with the detected obstacle. A dynamic warning is necessary for the higher vehicle speeds that occur in backing events where the relative closing velocities between the vehicle and the obstacle are greater as compared to low-speed situations, such as parking. The purpose of this dynamic warning is to deliver a more urgent warning to the driver in order for the driver to take timely action. Distance indications are optional, but if so included, it is recommended that reference be made to ISO 15008 for requirements.

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 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 test procedures for in-vehicle visual presentation*

3 Terms and definitions

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

3.1
extended-range backing aid (ERBA) system
system capable of warning a driver of the presence of obstacles in an area behind the vehicle and issuing a warning to indicate immediate driver action is required

3.2
system activation
process of transitioning the system's operation from a quiescent mode to an active mode

NOTE In an active mode, the system is monitoring the zone of regard. It is evaluating the objects detected and is generating the appropriate indications and/or warnings to the driver.

3.3
audible information and warning
acoustical indication or signal used to convey information to the driver about obstacles in the zone of regard

NOTE For examples, see Annex A.

3.4
visual information and warning
optical indication or signal used to convey information to the driver about obstacles in the zone of regard

NOTE For examples, see Annex A.

3.5
tactile information and warning
physical stimulus used to convey information to the driver about obstacles in the zone of regard

NOTE For examples, see Annex A.

3.6
zone of regard
specific area behind the vehicle that is monitored by the ERBA system as defined in this International Standard

3.7
sensor
component that detects the obstacle(s) in the zone of regard, independent of the technology used

3.8**test object**

standard test target used for testing a system

NOTE The test object is comprised of a specific material, geometry and surface for standardized testing of obstacles within the system's zone of regard. It is expected that the test object yield comparable results for different sensor types. See 7.1.

3.9**warning levels**

intensity of the warnings conveyed to the driver about the threat of obstacles in the zone of regard

NOTE For examples, see Annex A.

3.10**closing speed**

relative velocity between the subject vehicle and the detected obstacle, regardless of whether one or both is/are stationary or moving

NOTE For examples, see Annex A.

3.11**distance indication**

provides the driver information on the specific distance between the subject vehicle and the obstacle

3.12**presence warning**

information provided to the driver on the presence of an obstacle in the zone of regard

NOTE The purposes of this warning are to

- alert the driver of objects located in the zone of regard before releasing the brake and moving the subject vehicle;
- alert the driver of objects located in the zone of regard that have not exceeded the threshold for a dynamic warning (see 3.13).

3.13**dynamic warning**

urgent indication to the driver of an imminent threat (collision) with an obstacle

NOTE For examples, see Annex A.

3.14**steering angle**

angle between the straight-ahead position and the current position (heading) of the wheels relative to the longitudinal axis of the vehicle

3.15**readiness-for-service indication**

indication presented to the driver that the ERBA system has completed its state transition from OFF (or standby) to ON and is now ready for operational use

NOTE The method of presentation of this indication may be visual or audible or any combination so desired by the system designer.

4 Symbols and abbreviated terms

B_{edge}	backing area, edge
B_{far}	backing area, far
B_{middle}	backing area, middle
B_{near}	backing area, near
B_{out}	backing area, out
B_{side}	backing area, side
$^{\circ}\text{C}$	degrees Celsius
cm	centimetre
dx	change in x
dy	change in y
e.g.	<i>exempli gratia</i> (for example)
etc.	<i>et cetera</i> (and the rest)
HMI	human-machine interface
i.e.	<i>id est</i> (that is)
m	metre
max.	maximum
ms	millisecond
m/s	metres per second
min.	minimum
RCS	radar cross-section
s	second
$\varnothing$	outside diameter

5 Functional and performance requirements

IMPORTANT — The ERBA system as described in this International Standard is intended to detect typical objects in the reversing path of a vehicle in order to help protect it from damage. It is not intended to reliably detect pedestrians or animals. It is recommended that the vehicle operator's handbook (owner's manual) include an advisory note that clearly indicates this limitation.

5.1 Steering angle

As a minimum requirement, the ERBA system shall support straight backing manoeuvres. The azimuth zone-of-regard definition (3.6) in this International Standard relates to this primary-use case. See Figure 1.

ERBA systems may adapt to the steering angle for better detection of obstacles in the path of travel in curves; however, this International Standard does not include performance requirements for systems that adapt to steering angle. The requirements of this International Standard shall be fulfilled during backing events with the steering in the neutral position.

5.2 Detection range

ERBA systems shall detect targets located in the 1,0 m to 5,0 m range located behind the vehicle's rear bumper in a region called the zone of regard. See Figure 1.

ERBA systems may detect targets closer than 1,0 m, however, this International Standard does not include performance requirements for this range.

NOTE It is proposed that systems that can detect targets closer than 1,0 m comply with ISO 17386.

5.3 Minimum performance requirements

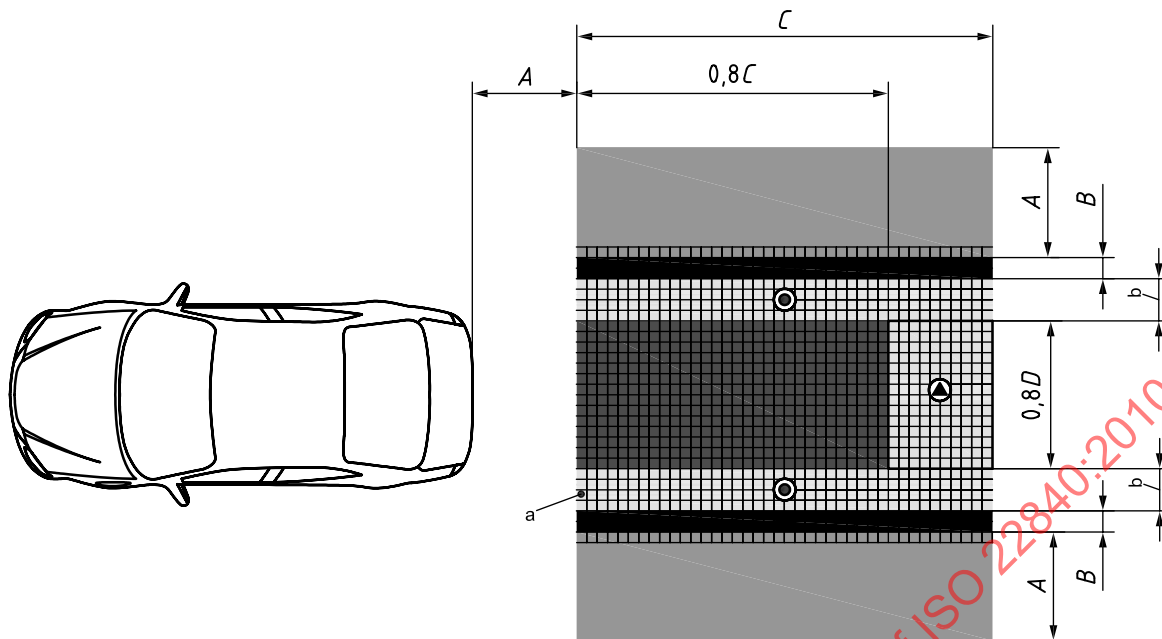
The minimum performance requirements for an ERBA system shall be in accordance with Table 1.

The column labelled "Detection range" specifies a "Near (max.);" range of 1,0 m and a "Far (min.);" range of 5,0 m. These requirements require that the ERBA system begin detecting objects at a maximum of 1,0 m from the host vehicle, and continue detecting targets to a minimum of 5,0 m from the vehicle. The vehicle's rear bumper or fascia shall be used as the reference point for this measurement; see Figure 1.

The column labelled "Closing speed" specifies the minimum range of closing speeds over which the ERBA shall detect objects. It is acceptable that the ERBA be capable of functioning at closing speeds greater than 3,0 m/s.

Table 1 — Performance requirements

Detection range m		Closing speed m/s	Detection latency ms		Warning type			Detection performance (using standard ISO target)				
Near max.	Far min.		Mean	Max.	Distance indication	Presence warning	Dynamic warning	B _{near} % min.	B _{edge} % min.	B _{far} % min.	B _{side} % max.	B _{out} % max.
1,0	5,0	0,0 to 3,0	150	250	optional	optional	required	90	60	60	60	10



Key

Detection areas

A 1,0 m

B 0,25 m

C detection range

D bumper width

min. 90 % B_{near}

min. 60 % B_{edge} 

B_{far} 

max. 60 % B_{side}

max. 10 % B_{out}

a $\square$ 10 cm $\times$ 10 cm.

b 0,1 m to 0,25 m beyond.

Figure 1 — Azimuth zone of regard

5.4 Detection latency

5.4.1 Start-up detection latency

5.4.1.1 Detection latency is defined as the response time of the ERBA system.

NOTE In case other vehicle systems (such as a navigation display) are used to display ERBA information, the appearance of the start-up screen on the display system is treated as the ERBA readiness-for-service indication.

5.4.1.2 For systems with no visual or audible readiness-for-service indication, the response time is measured from the moment when the reverse lamps of the vehicle are lit after the ignition has been set to ON to the moment when the ERBA system issues a warning for a pre-existing object located in the zone of regard. The average response time shall not exceed 450 ms, with no single measurement value exceeding 550 ms. This time includes typical manufacturer delays for reverse-gear activation to suppress unwanted flickering of displays when the lever is shifted (e.g. from “neutral” to “park” via “reverse”, or from “park” to “drive” via “reverse”).

5.4.1.3 For systems with only a visual readiness-for-service indication, the response time is measured from the moment when the readiness-for-service indication is presented to the moment when the ERBA system issues a warning for a pre-existing object located in the zone of regard. The average response time shall not exceed 150 ms, with no single measurement value exceeding 250 ms.

5.4.1.4 For systems with only an audible readiness-for-service indication, the response time is measured from the moment when the readiness-for-service indication ends to the moment when the ERBA system issues a warning for a pre-existing object located in the zone of regard. The average response time shall not exceed 500 ms. The increased response time allows for a period of silence between the audible sound of the readiness-for-service tone and the audible sound of the ERBA warning tone.

5.4.1.5 For systems with both visual and audible readiness-for-service indications, the provisions of 5.4.1.4 shall apply.

5.4.2 Delay of indications and warnings

As long as the system is active, the time delay between the appearance of a relevant obstacle in the zone of regard and the presentation of indications shall not exceed 150 ms on average, with no single measurement value exceeding 250 ms.

Detection latency shall be proved using a suitable test procedure with accuracy better than one-tenth of the measured time delay. The delay is calculated as the arithmetic mean of at least ten tests.

5.5 Driver interface and information strategy

5.5.1 General information presentation

The driver interface shall be capable of presenting at least audible information. Visual information may be used as a supplement. A general information strategy should be the basis for the development of these types of information components, as this makes the use in different vehicles easier and safer. However, a specific information strategy cannot be established because, for example,

- there are many different ways of codifying the information;
- each car manufacturer wants flexibility to integrate the backing aid into its driver-information system such that it is in harmony with the overall vehicle design.

5.5.2 Audible information

Audible information shall be presented in accordance with ISO 15006.

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

- a) Distance indications, if used, may be presented either audibly or visually. If presented, they shall be codified into at least two zones (for example, near and far). These zones may be represented by different repetition rates (or perhaps a variable frequency), with the basic rule that a high repetition rate or a continuous sound or high frequency corresponds to short distances. If a different or an additional code is used, it should not interfere with the basic rule. Synthesized or recorded voice messages may also be used. In general, the warning of an obstacle shall be maintained as long as the obstacle is detected and shall cease when the obstacle is no longer detected. The audible information 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.
- b) Presence warnings may be presented to the driver, either audibly or visually or both. They shall be codified in a manner to clearly notify the driver of objects in the zone of regard. It is permissible to combine presence warnings and distance indications. Synthesized or recorded voice messages may also be used. In general, the warning of an obstacle shall be maintained as long as the obstacle is detected and shall cease when the obstacle is no longer detected. The audible information may be automatically switched off temporarily after a minimum of 1 s. 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.

- c) Dynamic warnings shall be presented audibly and may be presented visually. They shall be codified in a manner to cause the driver to focus immediately on the warning. These warnings shall be unique from distance indications and presence warnings and should be of a nature to prompt the driver to take immediate action. Synthesized or recorded voice messages may also be used.
- d) System enabled/disabled status indications and/or the indication of failure/disturbance may be presented audibly and visually, and shall be clearly distinguishable from the other signals. Synthesized or recorded voice messages may also be used. In general, the status indication 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.
- e) A manufacturer may permit the driver to manually select temporary suppression of the audible warnings. In this case, the audible warnings shall remain suppressed until the driver switches it on again; however, audible warnings shall be automatically reinstated when the system is enabled the next time; see 5.6.
- f) This International Standard does not establish an exact algorithm for use for state transitions between the audible-alert types (distance, presence and dynamic). However, a general rule for transitions is that they should be designed to provide smooth and intuitive changes between the audible states. Hysteresis is recommended to reduce "flickering" (oscillations) between the alert types. This is especially important for the dynamic-warning alert.
- g) In the case where presence warnings are not presented over the entire 5 m range of the system or are presented for less than 3 s, a special diagnostic mode shall be made available for the purposes of compliance testing. While in the diagnostic mode, the system shall issue presence warnings over the full 5 m range of the system. Warnings shall be presented for a minimum of 3 s (uninterrupted). It is intended that this mode be available only to the service technician for the purpose of confirming that the system meets the detection requirements of this International Standard; it is not intended that this mode be available to the driver of the vehicle. No specific requirements on how this mode is entered or exited are imposed or implied.

5.5.3 Visual information

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

The following basic code is recommended for the visual-information channel.

- a) Visual information shall be codified into at least two levels, represented by multiple colours: for example, red for level 1 (imminent collision level) and yellow or green for level 2 (attention level). If a different or an additional advisory level is used, it should not interfere with the basic rule. 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 or green bars, allowing for six sublevels. If a monochromatic element is used instead of multiple colours, the two levels may be represented by a combination of continuous and flashing illumination or a display consisting of incremental bars.
- 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 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.
- c) It is recommended to indicate the activation/deactivation and malfunction of the system by a tell-tale or a symbol in all active displays of the system. Reference should be made to ISO 2575 for the recommended symbols.

5.5.4 Combination of visual and audible information

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

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 about the HMI system stating that the warnings might not be perceived in time if the volume is set too low.

Visual warnings should be maintained under conditions when the audible warnings may have been suppressed. This measure helps to remind the driver that objects are in the zone of regard and differentiate this situation from a “no target” condition.

5.6 System activation

The system is activated (enabled) automatically as soon as reverse gear is selected as a minimum requirement. Additional activation methods are permissible to the designer (such as a manual ON/OFF switch or activation based on detected wheel speeds). Operation in the neutral gear is also permissible for the case when the vehicle is rolling backward.

5.7 System deactivation

The system may be deactivated according to the designer's preferences. No specific requirements for deactivation are imposed by this International Standard.

5.8 Operation with trailers

5.8.1 Trailer-hitch handling

A trailer hitch mounted on the subject vehicle can affect the proper functioning of the ERBA system and can also extend the rear boundary of the vehicle.

Especially if a detachable trailer hitch is used, particular care shall be taken to ensure that the mounting of the hitch does not result in poor coverage of the rear monitoring range. The fact that the hitch most probably protrudes beyond the bumper and, thus, determines the vehicle boundary shall be taken into account.

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.

5.8.2 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 ERBA system is automatically deactivated as soon as the electrical connection between towing and trailing vehicles is in operation. However, if the trailer is fitted with compatible sensors, these should now inform the driver of obstacles while reversing.

5.9 Presence detection requirements

5.9.1 Description of the azimuth zone of regard — Presence

The azimuth area of relevance is the two-dimensional projection of the zone of regard onto the roadway; see Figure 1.

This azimuth area is composed of eight smaller zones defined as follows:

- a) B_{near} zone: a near backing zone centred on the vehicle's longitudinal centreline. It covers 80 % of the bumper width, extending longitudinally from 1,0 m rearward of the bumper to at least 4,0 m rearward of the bumper, as shown in Figure 1.

- b) B_{edge} zones: two backing edge zones located adjacent to the B_{near} and B_{far} zones. Each B_{edge} zone begins at the edge of the B_{near} and B_{far} zones and extends laterally to 0,25 m past the rear bumper side edge as shown in Figure 1. Each B_{edge} zone extends longitudinally from 1,0 m rearward of the bumper to at least 5,0 m rearward of the bumper.
- c) B_{far} zone: a far backing zone aft of the B_{near} zone centred on the vehicle longitudinal centreline. It covers 80 % of the of the bumper width, extending longitudinally from at least 4,0 m (80 % of the required 5,0 m minimum backing range) to at least 5,0 m (100 % of the required 5,0 m minimum backing range) as shown in Figure 1.
- d) B_{side} zones: two backing side zones located adjacent to the B_{edge} zones. The purpose of the B_{side} zones is to restrict the detection of objects (e.g. parallel-parked vehicles) in this region in order to minimize nuisance warnings. Each B_{side} zone begins at the edge of the B_{edge} zone and extends laterally 0,25 m beyond the rear bumper lateral (side) edge as shown in Figure 1. Each B_{side} zone extends longitudinally from 1,0 m rearward of the bumper to at least 5,0 m rearward of the bumper (100 % of the required 5,0 m minimum backing range).
- e) B_{out} zones: two backing out zones located adjacent to the B_{side} zones. The purpose of the B_{out} zones is to restrict the detection of objects far outside the path of the subject vehicle (e.g. adjacent-lane vehicles) in order to minimize nuisance warnings. Each B_{out} zone begins at the edge of the B_{side} zone and extends laterally for 1,0 m as shown in Figure 1. Each B_{out} zone extends longitudinally from 1,0 m rearward of the bumper to at least 5,0 m rearward of the bumper (100 % of the required 5,0 m minimum backing range).

5.9.2 Azimuth detection requirements — Presence

The following azimuth presence detection requirements shall be achieved by the ERBA system when tested according to the test procedures (see 7.4.2) using a test object:

- Zone B_{near} : a minimum of 90 % detection for the area defined as B_{near} . The detection ratio is defined as the ratio of the detected area to the total area of relevance.

EXAMPLE Given a total area of relevance of 480 cells, the system detected an area of 445 cells. The detection ratio is $445/480 = 93\%$.

NOTE Round to the nearest whole percentage.

- Zone B_{edge} , Zone B_{far} : a minimum of 60 % detection for the areas defined as B_{edge} and B_{far} zones, respectively. The detection ratio is defined as the ratio of the detected area to the total area of relevance.
- Zone B_{side} : a maximum of 60 % detection for the area defined as each B_{side} zone. The detection ratio is defined as the ratio of the detected area to the total area of relevance.
- Zone B_{out} : a maximum of 10 % detection for the area defined as each B_{out} zone. The detection ratio is defined as the ratio of the detected area to the total area of relevance.

5.9.3 Description of the elevation zone of regard — Presence

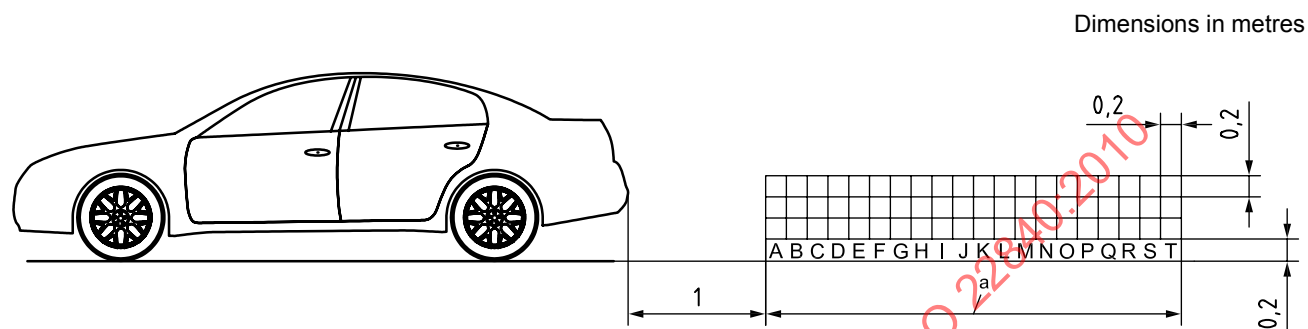
The elevation area of relevance is a two-dimensional projection of the elevation zone of regard onto a flat vertical imaginary surface; see Figure 2. A grid of rectangular cells 20 cm $\times$ 20 cm in size defines the vertical projection of the elevation zone of regard. The height of the rectangles is 0,6 m corresponding to three rows of grid cells. This collection of cells begins 1,0 m from the rear bumper edge and extends longitudinally to at least 5,0 m rearward of the bumper (100 % of the required 5,0 m minimum backing range). The lower surface of elevation zone of regard shall be positioned 0,2 m above the ground.

For testing the elevation coverage, it is sufficient to use a 20 cm grid ($dx = dy = 20$ cm), since the capability of covering the whole area without excessive holes is already proven by the test of the azimuth areas.

5.9.4 Elevation detection requirements — Presence

The following elevation presence detection requirement shall be achieved by the ERBA system when tested according to the test procedures (see 7.4.3) using a test object:

- a minimum of two cells per column for columns A to O, and a minimum of one cell per column for columns P to T; see Figure 2.



^a Detection range (4 m min.).

Detection requirement	Column																			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Detected cells (min.)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1

Figure 2 — Elevation zone of regard

5.10 Dynamic detection requirements

5.10.1 Description of azimuth zone of regard — Dynamic

The dynamic azimuth zone of regard description is the same as the presence azimuth zone of regard description; see 5.9.1.

5.10.2 Azimuth warning requirements — Dynamic

The following azimuth dynamic warning requirement shall be achieved by the ERBA system when tested according to the test procedures (see 7.5.2) using a test object:

- A warning shall be issued by the system.

5.10.3 Description of the elevation zone of regard — Dynamic

The dynamic elevation zone of regard description is the same as the presence elevation zone of regard description; see 5.9.3.

5.10.4 Elevation detection requirements — Dynamic

The following elevation dynamic detection requirement shall be achieved by the ERBA system when tested according to the test procedures (see 7.5.3) using a test object:

- A warning shall be issued by the system in at least 2 of 3 rows.

5.11 Self-test capabilities and failure indications

The system shall provide the following self-test functions (as a minimum on each system-enabled event).

- a) Electronic circuit and wiring: the system shall check the function of the electronic components of the system.
- b) Sensor components: the system shall check whether there is any damage to the sensor element(s) that can lead to a malfunction of the system.

The procedures a) and b) above shall

- be executed automatically in order to detect faults leading to a failure of the system function;
- generate a warning signal whenever a fault condition is detected.

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 used as the basis for component test procedures.

7 Test requirements

7.1 Test objects

7.1.1 Definition of a standard test object

The purpose of 7.1 is to define the requirements of the standard test objects being used when testing a system's obstacle detection capability.

If certain sensing technologies require a different standard, this shall be investigated and evaluated. The plastic pipe for ultrasonic-based systems was chosen because it is commercially available, inexpensive, easily replaced in case of loss or damage and easily transportable. The metal pipe for radar-based systems is chosen for similar reasons, and also because it provides a consistent radar cross-section, RCS, signature over a wide range of radar frequencies, unlike the plastic pipe.

It is recognized that these test objects represent different echo characteristics to different sensors, but this is true for any object chosen. The intention is to keep the same test object that is representative of at least some of the expected real-world application objects (i.e. a round wooden, metal or concrete pole).

The geometry, reflection and absorption properties of the test object should lead to easy testability and good representation of a real obstacle. The standard obstacle should not favour one of the physical principles and should represent the most relevant objects in real manoeuvring situations. The test object is the same for both horizontal and vertical detection tests. The intention of standardizing the test object is so that embodiments (systems) from various suppliers can be designed and manufactured with comparable performance to ensure that the minimum performance expectations of the driver are fulfilled.

7.1.2 Ultrasonic-based systems

Reflectivity measurements of ultrasonic waves on relevant objects have been conducted. Experiments have shown that the reflection of ultrasound does not significantly change for different materials, as long as the surface is smooth and "hard" for sound. For instance, metal and wooden poles exhibit the same sonic reflectivity as plastic poles of the same diameter. It should be kept in mind that for use as a test object, metal poles are more rigid and can be more accurately manufactured.

Table 2 — Test object, ultrasonic-based systems

Zone of regard		Material	Diameter $\varnothing$, mm	Length
Azimuth	$B_{\text{middle}}, B_{\text{far}}$ $B_{\text{edge}}, B_{\text{side}}$	Wood, metal or hard plastic	75	$1^{+0,2}_0$ m
	B_{out}	Wood, metal or hard plastic	150	$1^{+0,2}_0$ m
Elevation		Wood, metal or hard plastic	75	Length equal to width of test vehicle bumper plus 20 % to 40 %

For the azimuth, the pole is placed in the test position with a vertical orientation. For the elevation, the pole is suspended in a horizontal position (parallel relative to the ground) and parallel to the vehicle rear bumper.

7.1.3 Radar-based systems

Reflectivity measurements of radar waves on relevant objects have been conducted. The results of this testing proved that the following tubular test object is suitable as a representation of real objects that were detectable by systems using radar-based sensors.

Table 3 — Test object radar-based systems

Zone of regard		Material	Diameter $\varnothing$, mm	Length
Azimuth	$B_{\text{middle}}, B_{\text{far}}$ $B_{\text{edge}}, B_{\text{side}}$	Metal	25	$1^{+0,2}_0$ m
	B_{out}	Metal	50	$1^{+0,2}_0$ m
Elevation		Metal	25	Length equal to width of test vehicle bumper plus 20 % to 40 %

For the azimuth, the pole is placed in the test position with a vertical orientation. For the elevation, the pole is suspended in a horizontal position (parallel relative to the ground) and parallel to the vehicle rear bumper.

7.2 Ambient conditions — General

The wind speed shall not exceed 5,4 m/s (wind force 3) during testing. Temperature shall be 5 °C to 30 °C and non-precipitating conditions (not raining, sleeting, snowing, etc.). Testing shall be conducted on a flat, dry surface. Walls, auxiliary test equipment and other non-test objects (clutter) shall be removed from the test area in order to eliminate interference caused by their reflections (sonic and/or electromagnetic).

7.3 Response time for object detection

The exact test method for measuring detection latency (see Table 1) is not specified herein, but the test procedure and test equipment shall be capable of accurately measuring system latency to within 0,01 s. It is recommended that at least 1,5 s be allowed for vehicle power systems and electronic control units (ECU) to settle after ignition voltage is switched ON before conducting this test.

7.4 Test requirements — Presence warning

7.4.1 General

The general requirements necessary for determining compliance of a candidate system to the functional requirements of this International Standard are given in paragraph 2 of this subclause. It is the responsibility of the manufacturer to establish a detailed test procedure.

Perform the operational tests on a real vehicle or a representative test structure that simulates the installed condition of the device on the real vehicle. In the case where a vehicle is used to perform the test, it shall have a normal curb weight. A tolerance of $\pm 5\%$ may be allowed. If the ride height is adjustable, it shall be set to normal driving condition on paved roads.

7.4.2 Azimuth zone of regard — Presence warning

Carry out the procedure as follows.

- Construct a grid in accordance with Figure 1.
- If the system-under-test's detection capability depends on the steering angle of the subject vehicle, the test shall be performed with the steering in a neutral (straight-ahead) position.
- If the system-under-test's capability to detect targets over the full 5 m zone of regard or for warnings being presented for a minimum of 3 s depends on being in a diagnostic mode, then place the system in this mode.
- Position the test object perpendicular to the ground in the centre of a grid square in the azimuth zone of regard.
- Enable the system-under-test and record whether or not the test object is detected. Detection shall be unambiguous with an uninterrupted reporting of the test object for at least 3 s.
- Repeat this procedure for all grid squares.

It shall be the prerogative of the tester to leave the system enabled throughout the test procedure or to disable and then re-enable the system for each successive grid square. If the system is enabled for the duration of the test, the tester shall ensure that no latch-ups, or results from previously tested grid squares, are being reported by the system. The results from each grid square test shall be fully independent of the test result of any other grid square.

7.4.3 Elevation zone of regard — Presence warning

Elevation testing shall take place after the azimuth performance has been determined.

Carry out the procedure as follows.

- Construct a grid in accordance with Figure 2.
- If the system-under-test's detection capability depends on the steering angle of the subject vehicle, the test shall be performed with the steering in a neutral (straight-ahead) position.
- If the system-under-test's capability to detect targets over the full 5 m zone of regard or for warnings being presented for a minimum of 3 s depends on it being in a diagnostic mode, then place the system in this mode.
- Position the test object parallel to the ground in the centre of a grid square, parallel to the subject vehicle.

- Enable the system-under-test and record whether or not the test object is detected. Detection shall be unambiguous with an uninterrupted reporting of the test object for at least 3 s.
- Repeat this procedure for all grid squares.

It shall be the prerogative of the tester to leave the system enabled throughout the test procedure or to disable and then re-enable the system for each successive grid square. If the system is enabled for the duration of the test, the tester shall ensure that no latch-ups, or results from previously tested grid squares, are being reported by the system. The results from each grid square test shall be fully independent of the test result of any other grid square.

7.5 Test requirements — Dynamic warning

7.5.1 General

The following general requirements are necessary for determining compliance of a candidate system to the functional requirements of this International Standard. It is the responsibility of the manufacturer to establish a detailed test procedure.

- Perform the operational tests on a real vehicle or a representative test structure that simulates the installed condition of the device on the real vehicle. In the case where a vehicle is used to perform the test, it shall have normal curb weight. A tolerance of $\pm 5\%$ may be allowed. If the ride height is adjustable, it shall be set to normal driving condition on paved roads.
- Care should be exercised in the design of all test-object anchoring devices to ensure that only the test object is detectable during the operational tests.

7.5.2 Azimuth zone of regard — Dynamic warning

Carry out the procedure as follows.

- Construct a grid in accordance with Figure 1.
- If the system-under-test's detection capability depends on the steering angle of the subject vehicle, the test shall be performed with the steering in a neutral (straight-ahead) position.
- The test shall be conducted by positioning the test object in the zone of regard at each of the positions shown in Figure 3. The tester shall ensure that the test object moves only within each successive region (e.g. B_{side}) and does not enter any other region (e.g. B_{middle}) during the test.
- Enable the system-under-test, conduct the test, and record whether or not a dynamic warning is issued. Detection shall be unambiguous.
- Repeat this procedure for each of the locations shown in Figure 3.
- Finally, measure and record the system-under-test's detection latency using a suitable test procedure. Reference can be made to ISO 17386:2004, Annex A, for an example of a suitable test procedure.

It shall be the prerogative of the tester to leave the system enabled throughout the test procedure or to disable and then re-enable the system for each successive grid square. If the system is enabled for the duration of the test, the tester shall ensure that no latch-ups, or results from previously tested grid squares, are being reported by the system. The results from each grid square test shall be fully independent of the test result of any other grid square.

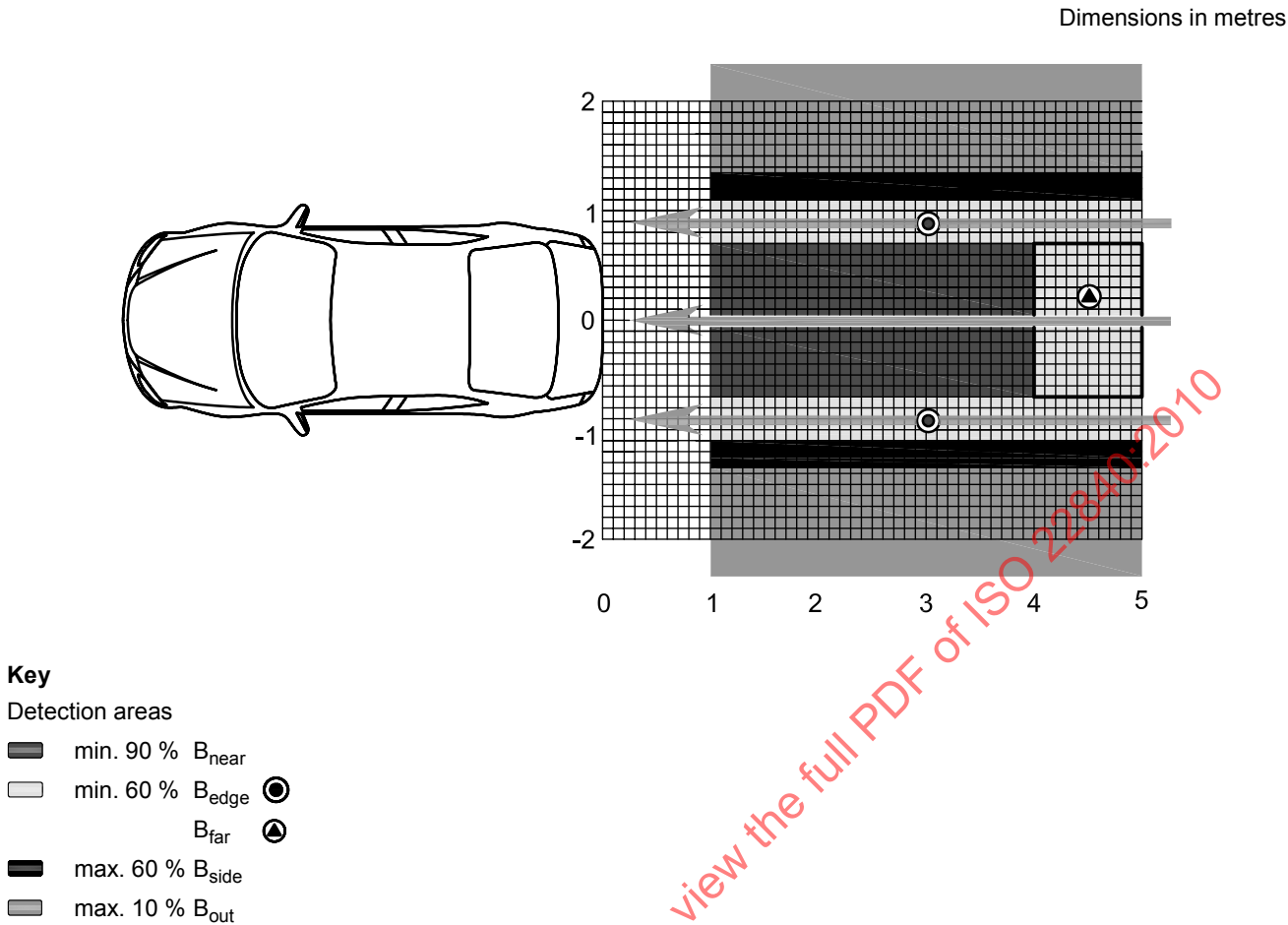


Figure 3 — Azimuth zone of regard — Dynamic warning test

Table 4 — Azimuth zone of regard — Dynamic warning test

Zone of regard	Location	Speed m/s
Right B_{edge}	Anywhere in right B_{edge}	$3,0 \pm 0,3$
B_{near} , B_{far}	Vehicle centreline	$3,0 \pm 0,3$
Left B_{edge}	Anywhere in left B_{edge}	$3,0 \pm 0,3$

7.5.3 Elevation zone of regard — Dynamic warning

Carry out the procedure as follows.

- Construct a grid in accordance with Figure 4.
- If the system-under-test's detection capability depends on the steering angle of the subject vehicle, the test shall be performed with the steering in a neutral (straight-ahead) position.
- The test shall be conducted by positioning the test object in the zone of regard at each of the row positions shown in Figure 4. The tester shall ensure that the test object moves only within each successive row and does not enter any other row during the test.

- Enable the system-under-test, conduct the test, and record whether or not a dynamic warning is issued. Detection shall be unambiguous.
- Repeat this procedure for each of the rows.

It shall be the prerogative of the tester to leave the system enabled throughout the test procedure or to disable and then re-enable the system for each successive grid square. If the system is enabled for the duration of the test, the tester shall ensure that no latch-ups, or results from previously tested grid squares, are being reported by the system. The results from each grid square test shall be fully independent of the test result of any other grid square.

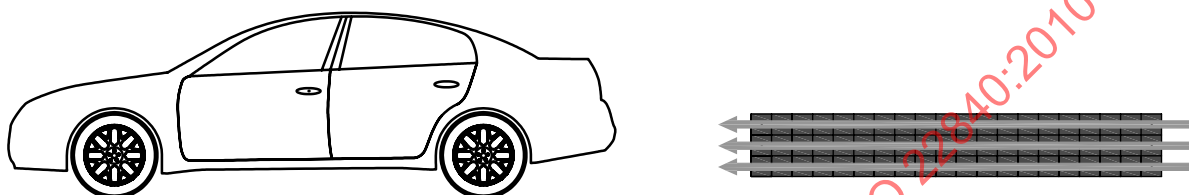


Figure 4 — Elevation zone of regard — Dynamic warning test

Table 5 — Elevation zone of regard — Dynamic warning test

Zone of regard	Location	Speed m/s
Elevation	Row 1	$3,0 \pm 0,3$
Elevation	Row 2	$3,0 \pm 0,3$
Elevation	Row 3	$3,0 \pm 0,3$

7.6 Detection acceptance criteria — Presence warning

7.6.1 Azimuth zone of regard — Presence warning

Sum the number of grid squares having positive detections within each zone and divide this number by the total number of grid squares contained within that zone. It is understood that the total number of grid squares within any specific zone varies depending on the subject vehicle bumper's width.

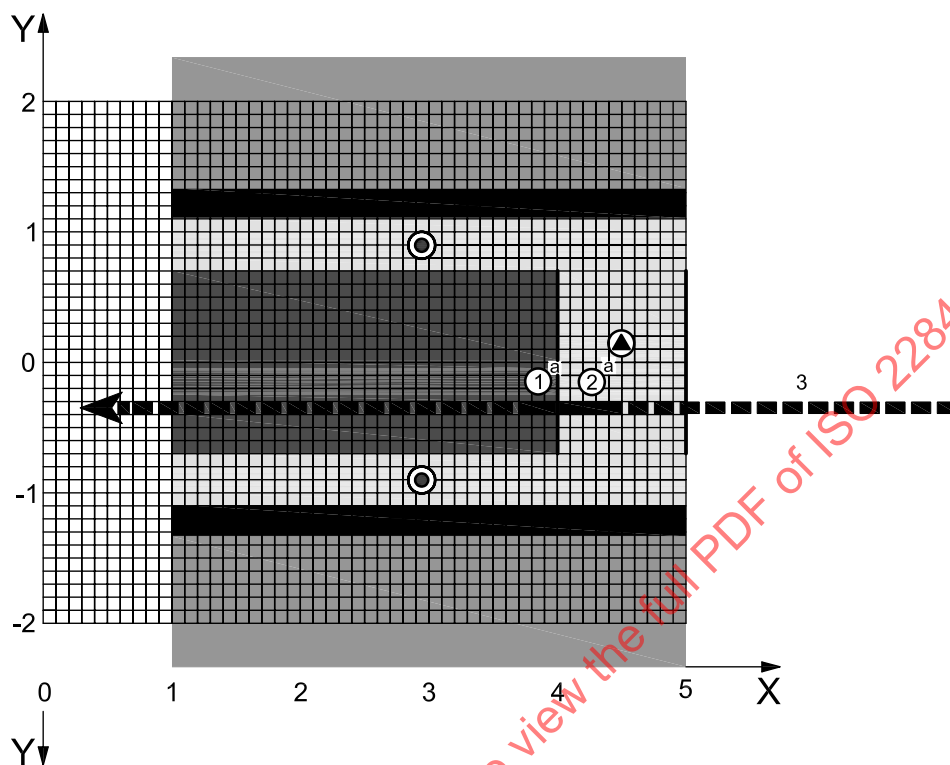
The successful acceptance criteria (i.e. for a “pass”) shall be as follows:

- The required detection percentage shall be achieved for each zone, as specified in 5.9.2.
- There shall be no more than three contiguous grid squares of non-detection for the B_{near} zone and no more than five contiguous grid squares of non-detection for the B_{far} and B_{edge} zones. The B_{side} zone has no requirement for contiguous holes.
- Special case: In the event that B_{near} contiguous grid squares are adjacent with B_{far} contiguous grid squares along an approaching line, then there shall be no more than five total contiguous holes (see Figures 5 and 6).

The definition of “contiguous grid squares” shall mean grid cells located in a straight line, horizontally, vertically or diagonally.

7.6.2 Elevation zone of regard — Presence warning

The successful acceptance criterion (i.e. for a “pass”) shall be the achievement of the required number of detected cells per column in accordance with 5.9.4.



Key

X horizontal distance, expressed in metres
Y vertical distance, expressed in metres

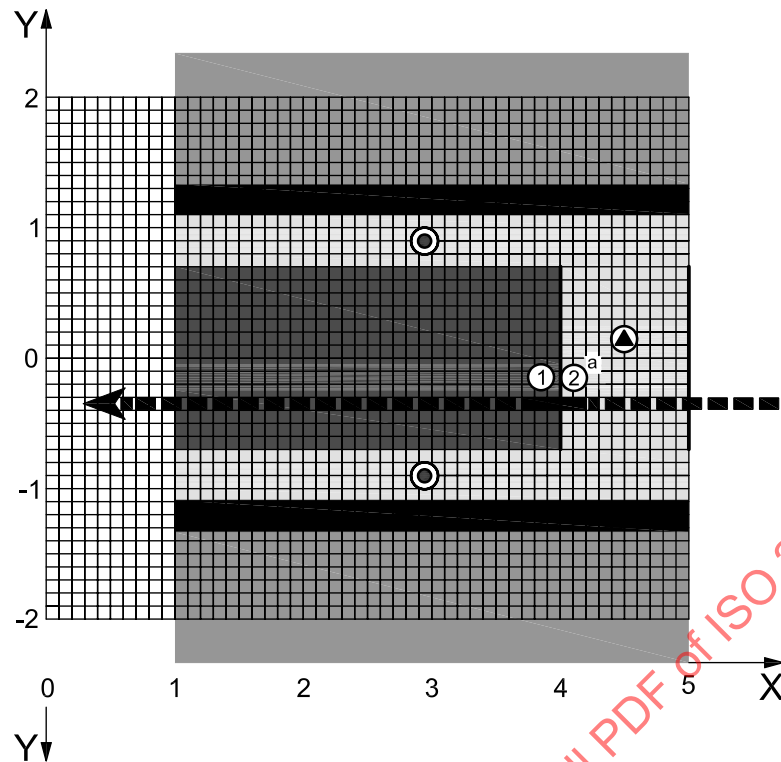
- 1 3 B_{near} contiguous holes
- 2 5 B_{far} contiguous holes
- 3 approaching line

^a Violation: $3 + 5 = 8$ contiguous holes.

Detection areas

- min. 90 % B_{near}
- min. 60 % B_{edge}
- B_{far}
- max. 60 % B_{side}
- max. 10 % B_{out}

Figure 5 — Violation of contiguous holes limit along an approaching line



Key

X horizontal distance, expressed in metres

Y vertical distance, expressed in metres

1 3 B_{near} contiguous holes

2 2 B_{far} contiguous holes

3 approaching line

a Violation corrected: $3 + 2 = 5$ contiguous holes.

Detection areas

 min. 90 % B_{near}

 min. 60 % B_{edge} 

 B_{far}

Bside

 max. 60 % B_{side}

 max. 10 % B_{out}

Figure 6 — Violation corrected

7.7 Detection acceptance criteria — Dynamic warning

7.7.1 Azimuth zone of regard — Dynamic warning

The successful acceptance criterion (i.e. for a “pass”) shall be that the system provides warnings in accordance with 5.10.2.

7.7.2 Elevation zone of regard — Dynamic warning

The successful acceptance criterion (i.e. for a “pass”) shall be that the system provides warnings in accordance with 5.10.4.