INTERNATIONAL STANDARD

ISO 15623

First edition
2002-10-01

Transport information and control systems — Forward vehicle collision warning systems — Performance requirements and test procedures

Systèmes de commande et d'information des transports — Systèmes d'avertissement de collision frontale — Exigences de performance et modes opératoires

Reference number
ISO 15623:2002(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15623 was prepared by Technical Committee ISO/TC 204, *Transport information and control systems*.

Annexes A, B, C, and D form a normative part of this International Standard.

Introduction

The main system function of a Forward Vehicle Collision Warning System (FVCWS) is to warn the driver when the subject vehicle encounters the situation when a forward vehicle in the subject vehicle's trajectory becomes a potential hazard. This is done by using information about: (1) the range to forward vehicles, (2) the time to a potential collision and (3) the grade of warnings provided to the driver (see Figure 1). Based upon the information acquired, the controller identified as "FVCWS warning strategy" in Figure 1 produces the warning to the driver.

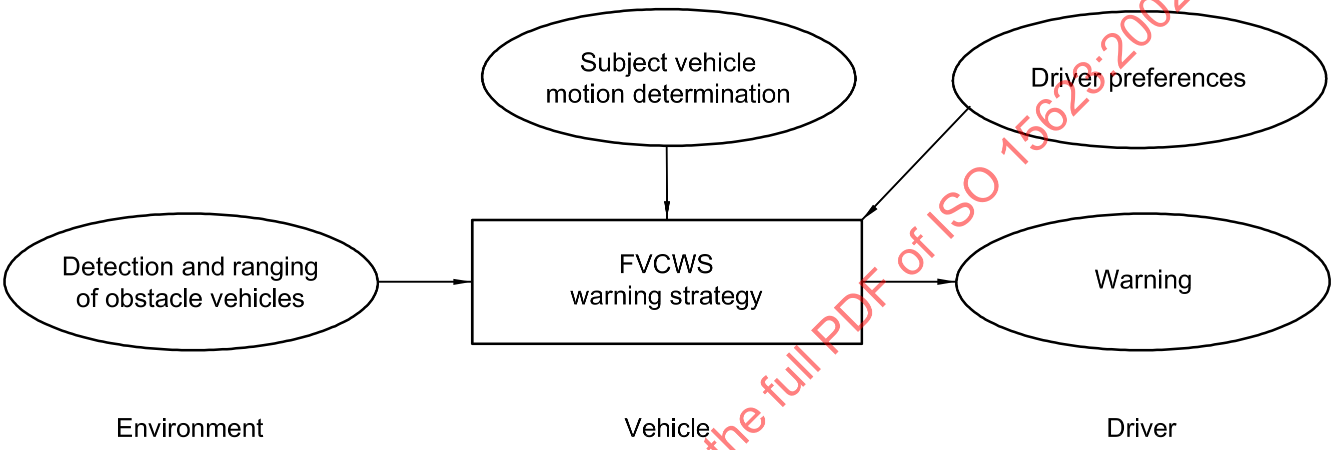


Figure 1 — Functional forward vehicle collision warning system's elements

Automobile manufacturers and component suppliers throughout the world have been vigorously pursuing the development and commercialization of these FVCWS systems. Systems of this type have already been introduced onto the market in some countries. Thus the standardization efforts began in 1994 amongst interested countries. This International Standard is composed to address only the basic performance requirements and test procedures for the FVCWS type systems. This International Standard may be used as a basis by other advanced standards for systems which have more advanced features and may extend beyond this International Standard.

Transport information and control systems — Forward vehicle collision warning systems — Performance requirements and test procedures

1 Scope

This International Standard specifies performance requirements and test procedures for systems capable of warning the driver of short inter-vehicle distance and closing speed which may cause a rear-end collision with other vehicles, including motor cycles, ahead of the subject vehicle while it is operating at ordinary speed.

This International Standard is applicable to operations on roads with curve radii over 125 m as well as higher radius curves.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

IEC 60825-1:2001, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide* (consolidated edition)

3 Terms and definitions

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

3.1
collision warning
information that the system gives to the driver indicating the need for urgent action to avoid a collision

NOTE This warning is issued in the advanced stages of a dangerous situation to warn the driver of the need to perform emergency braking, lane changing or other emergency manoeuvres in order to avoid a collision.

3.2
coefficient of test target
CTT
coefficient representing the optical radar reflectivity of the target which is defined as the coefficient of radiated intensity, measured in front of the receiver surface, divided by the intensity of irradiation out of the transmitter

NOTE See clause C.4.

3.3
forward vehicle
vehicle in front of and moving in the same direction and travelling on the same roadway as the subject vehicle

3.4
forward vehicle collision warning system
system capable of warning the driver of a potential collision with another vehicle in the forward path of the subject vehicle, but excluding intersections

3.5
obstacle vehicles
vehicles, both moving and stationary, considered potential hazards that can be detected by this system

NOTE Vehicles include motor vehicles only, that is cars, trucks, buses, and motorcycles.

3.6
preliminary collision warning
information that the system gives to the driver indicating the presence of a forward obstacle vehicle

NOTE This warning is issued in the early stages of a potentially dangerous situation, caused by such circumstances as driver's inattention/daydreaming, or the sudden change in movement of a preceding vehicle, which may result in a collision.

3.7
radar cross section
RCS
measure of the reflective strength of a radar target expressed in square meters, and defined as 4π times the ratio of the power per unit solid angle scattered in a specified direction to the power per unit area in a radio wave incident on the scatterer from a specified direction

3.8
visibility
distance which the illuminance of a non-diffusive beam of white light with the colour temperature of 2 700 K is decreased to 5 % of its original light source illuminance

4 Symbols

$a_{\text{lateral\_max}}$	Maximum allowed lateral acceleration in curves
a_{min}	Minimum deceleration of the subject vehicle's emergency braking
CTT	Coefficient for Test Target for infrared reflector
d_0	Minimum detectable distance without distance measuring capability
d_1	Minimum detectable distance with distance measuring capability
d_2	Minimum detection distance for a cut-in vehicle
d_{max}	Maximum detectable distance
h	Upper detection height from ground
h_1	Lower detection height from ground
T_{max}	Maximum driver's brake reaction time after the warning
T_{min}	Minimum driver's brake reaction time after the warning
RCS	Radar Cross Section

V_{circle_start}	Speed of the test vehicles at the start of the test
V_{max}	Maximum vehicle speed at which the system is capable of operating
V_{min}	Minimum vehicle speed at which the system is capable of operating
W_L	Lane width
W_V	Subject vehicle width

5 Specifications and requirements

5.1 Warnings

5.1.1 General

Forward vehicle collision warning systems shall provide warnings in accordance with the following functions.

5.1.2 Monitoring distance and relative speed between obstacle vehicle and subject vehicle

A forward obstacle vehicle is sensed by obstacle detecting devices such as optical radar, radio wave radar, and image processing systems.

5.1.3 Judging the timing of collision

The timing of a potential collision is judged by the results of evaluating the subject vehicle speed, the distance to the obstacle vehicle, and the relative speed between the subject vehicle and the obstacle vehicle. When the system detects multiple obstacle vehicles at the same time, the one in the subject vehicle's expected trajectory that the subject vehicle will reach the soonest[1)] shall be selected.

5.1.4 Preliminary collision warning and collision warning (see annex A)

Forward vehicle collision warning systems shall provide at least two separate warnings: a preliminary collision warning and a collision warning. The purpose of the preliminary collision warning is to inform the driver of the presence of a forward obstacle vehicle. In this case the driver should prepare to take the necessary action to avoid a collision. The purpose of the collision warning is to inform the driver of the need to take action in order to avoid a collision.

Warnings consist of independent or combined use of visual, audible and/or tactile senses. However in the case of a collision warning, audible and/or tactile means of warning shall be used and visual means may be used in addition to the aforementioned means.

Warnings are issued depending on the relative speed between the subject vehicle and the obstacle vehicle, the subject vehicle speed, the inter-vehicle distance, the free running (driver's brake reaction) time and the deceleration.

When the subject vehicle is approaching an obstacle vehicle, the warning distance should be decided according to criteria with respect to time to collision threshold values.

5.1.5 Fault indicator

If a fault is detected during system start up or during system operation, the driver shall be informed.

---

1) "Soonest" means the smallest time to collision.

5.2 System classification

Systems are classified according to curve radius capability as shown in Table 1.

Table 1 — System classifications

Class	Horizontal curve radius capability
I	curve radius ⩾ 500 m
II	curve radius ⩾ 250 m
III	curve radius ⩾ 125 m

— Class I systems shall have the capability to detect forward obstacle vehicles in the subject vehicle's trajectory along curves of radii down to 500 m.

— Class II systems shall have the capability to detect forward obstacle vehicles in the subject vehicle's trajectory along curves of radii down to 250 m.

— Class III systems shall have the capability to detect forward obstacle vehicles in the subject vehicle's trajectory along curves of radii down to 125 m.

5.3 Obstacle vehicle detection area and performance

5.3.1 Obstacle vehicle detection area

5.3.1.1 Minimum detection area (Class I, II and III)

The minimum detection area is illustrated in Figure 2.

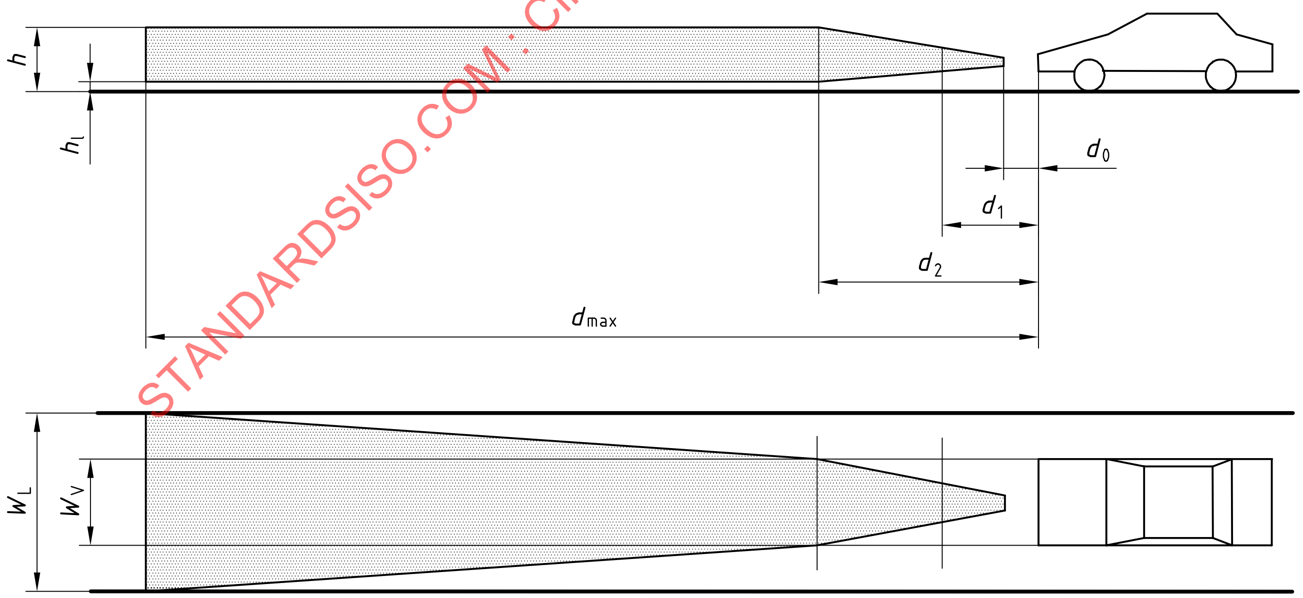


Figure 2 — Detection area

5.3.1.1.1 Detection range

Detection range requirements are specified in Table 2.

Table 2 — Detection range requirements

Distance	Formula or value	Meaning
d_{max}	$V_{max} \times T_{max} + V_{max}^2 / 2a_{min}$	The maximum detectable distance.
d_2	Less than or equal to 10 m for Class I Less than or equal to 7,5 m for Class II Less than or equal to 5 m for Class III	The minimum detection distance for a cut-in vehicle (which crosses the line of the subject vehicle's trajectory by the width of the subject vehicle and is thus possible to disturb the subject vehicle's ordinary driving).
d_1	$T_{min} \times V_{min}$	The system's minimum distance with distance measuring capability.
d_0	Less than or equal to 2 m	The minimum detectable distance without distance measuring capability.

where

V_{max} is the maximum vehicle speed at which the system is capable of operating, in metres per second (m/s);

V_{min} is the minimum vehicle speed at which the system is capable of operating, in metres per second (m/s);

T_{max} is the maximum driver's brake reaction time after the warning, in seconds (s);

T_{min} is the minimum driver's brake reaction time after the warning, in seconds (s);

a_{min} is the minimum deceleration of the subject vehicle's emergency braking, in metres per square second (m/s^2).

V_{max} and V_{min} are the design parameters for actual systems, which will be decided by the vehicle manufacturer, while T_{max} , T_{min} and a_{min} are the design parameters (see Annex A) and following values should be used to calculate the d_{max} and d_1.

T_{max} = 1,5 s

T_{min} = 0,4 s

a_{min} = 3,6 m/s^2

5.3.1.1.2 Detection width and detection height

Table 3 — Detection width and detection height requirements

Distance	Minimum detection width	Minimum detection height
d_{max}	W_L, metres	$h_1 = 0{,}2$ m and $h = 1{,}1$ m
d_2	W_V , metres	$h_1 = 0{,}2$ m and $h = 1{,}1$ m
d_1	not specified	not specified
d_0	not specified	not specified

5.3.1.2 Detection range for horizontal curve radius

The width of the detection range for horizontal curve radius shall be extended in relation to the curve's radius (see Annex B).

5.3.2 Warning distance accuracy

Warning distance accuracy, which is defined as the difference between the warning distance where the system produces the warning at the test and the system design warning distance, shall be the maximum system design warning distance, with a relative tolerance of ± 1 m or ± 5 %. Both distances are calculated by evaluating the inter-vehicle distance, the relative speed, the time to collision, the subject vehicle speed and so on.

5.3.3 Target discrimination ability

5.3.3.1 Longitudinal discrimination

If there are two or more obstacle vehicles in the detection range from a distance d_1 to d_{max} from the subject vehicle's front end, the system shall be capable of clearly selecting the soonest one in the subject vehicle's trajectory and shall give appropriate warnings.

5.3.3.2 Lateral discrimination

If there are two or more obstacle vehicles in the subject vehicle's trajectory or in an adjacent position, the system shall be capable of clearly selecting the vehicle in the subject vehicle's trajectory and shall give appropriate warnings.

5.3.3.3 Overhead discrimination

If there are obstacles at overhead of the road such as overhead sign, etc., the system shall be capable of avoiding nuisance warnings.

5.4 User safety requirements

5.4.1 Optical radar

The optical radar shall satisfy the requirements for Class 1 lasers as defined in IEC 60825-1.

5.4.2 Radio wave radar

No International Standard giving the relevant requirements currently exists.

5.5 Human interface requirements

5.5.1 Warning output specification

Visual, audible warnings shall correspond to the characteristics given in Table 4.

Table 4 — Warning characteristics

Warning	Visual warning	Auditory warning
Collision warning	Colour: red Position: main glance direction Luminance: high luminance Interval: intermittent at short interval is recommended	Pressure: sound pressure should be the highest of those of all auditory warnings present in the vehicle conveying more urgency than other auditory warnings Tone: pure tone should be avoided Interval: intermittent at short interval is recommended
Preliminary collision warning	Colour: yellow or amber Luminance: luminous enough in daylight, not glaring in the night Interval: continuous or intermittent at long interval	Pressure: sound pressure overriding background noise Tone: not annoying tone Interval: continuous sound or intermittent at long interval or single sound

5.5.2 Interference with other warnings

Even when a vehicle is equipped with a forward vehicle collision warning system along with other warning systems such as those for rear or side obstacles, the warning shall be clearly distinguishable to the driver.

5.5.3 Operational status display

5.5.3.1 General

The indications given in 5.5.3.2 and 5.5.3.3, which clearly identify the system's operational status, shall be provided.

5.5.3.2 System in-operation indication

An indication which informs the driver that the system is operational shall be provided (e.g. an illuminated power switch).

5.5.3.3 Fault indication

An indication which informs the driver of a system failure shall be provided (e.g. a fault indication on the display panel).

5.6 Awareness of system limitations

System users should be made aware of the system limitations as follows using appropriate means such as owner's manual and/or caution label.

For example warnings for head-on collision, crossing-path collision, operations beyond the sensor limit (including short radius curve etc.), and the maximum velocity (V_{max}) has been reached are not available with this system.

6 Evaluation test method for measuring detection performance

6.1 Test target specification

6.1.1 Optical radar

The test target is defined according to the CTT (Coefficient for Test Target) which represents the reflectivity of motorcycles.

The specific value for CTT shall be 2 m^2/sr (see annex C).

The CTT only describes the quality of a reflector (damping). For the test procedure it is sufficient to have a corner reflector (reduction of the surface to “a point”). But it is also possible to have a larger surface of reflection, if the whole reflectivity of the reflector surface does not exceed the mentioned value.

6.1.2 Radio wave radar

The test target is defined by a Radar Cross Section (RCS) that is representative of motorcycles.

The specific value for RCS shall be 3 m^2.

NOTE In actual use, the measurement range of automotive obstacle vehicle detection sensors is comparatively short, it is difficult to achieve a plane wave on the scatterer. Therefore RCS values for the automotive use are defined by measured values in the actual using range for the sake of convenience.

Examples of possible test target geometry are discussed in annex D.

6.2 Environmental conditions

— Test location shall be on a flat, dry asphalt or concrete surface.

— Temperature range shall be 20 °C ± 20 °C.

— Horizontal visibility shall be greater than 1 km.

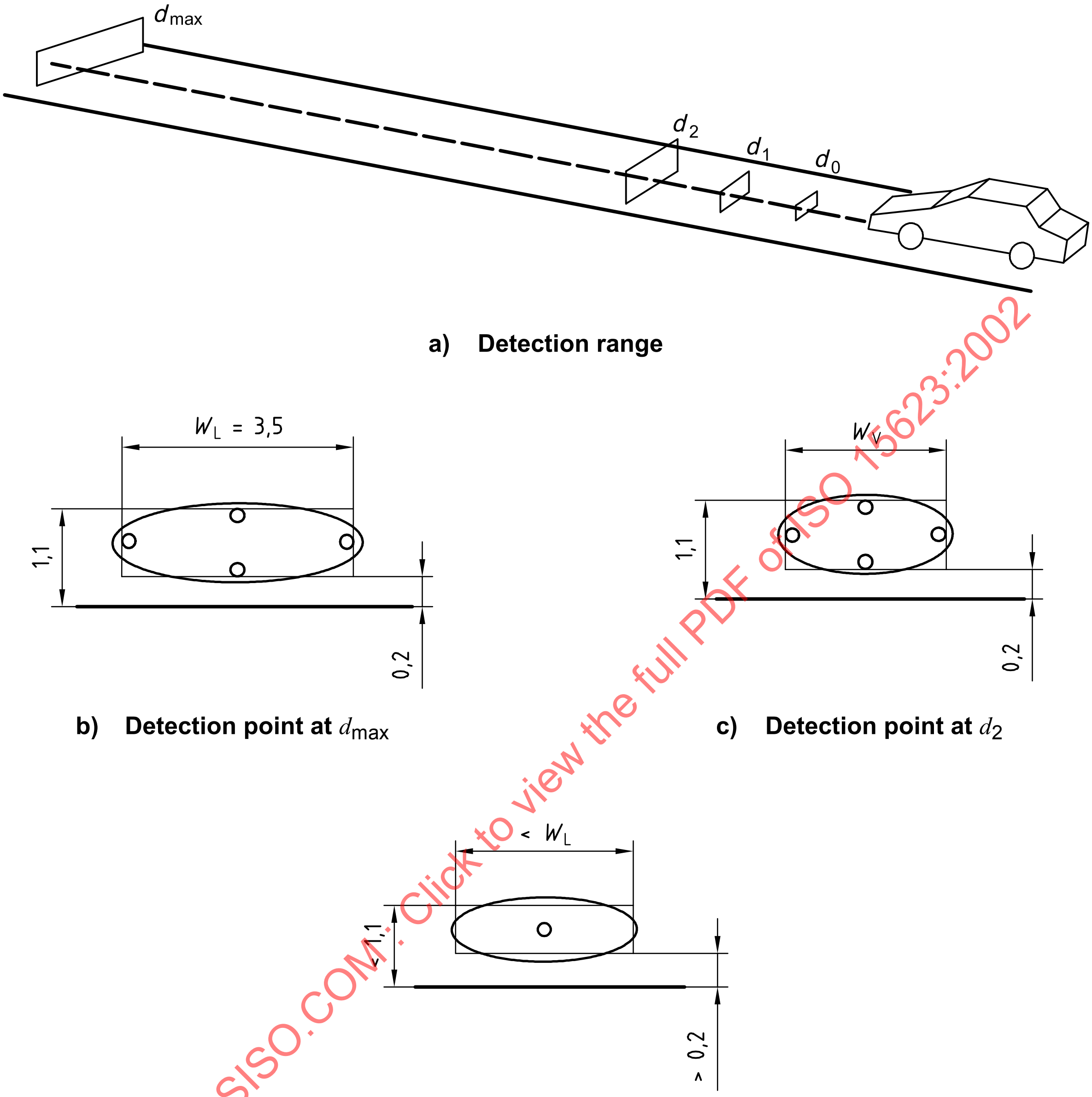
6.3 Test method for detection zone

The most realistic test for detection area is a dynamic test, however, a static test is available as an option also. The test shall be done as follows. The system shall detect a test target positioned at an arbitrary distance between d_0 and d_1 as shown in Figure 3. A range measurement is not needed for measurements between these two distances.

The system shall detect a test target positioned at an arbitrary distance between d_1 and d_2 as shown in Figure 3. A range measurement is required for measurements between d_1 and d_2.

The system shall detect with range measurement, each of four test targets positioned in turn at both distance d_2 and d_{max} as shown in Figure 3. The four points shall be within the area of height $(h - h_1)$ and width (W_V) at distance d_2 and within the area of height $(h - h_1)$ and width (W_L) at distance d_{max}.

Dimensions in metres



a) **Detection range**

b) **Detection point at d_{max}**

c) **Detection point at d_2**

d) **Arbitrary distance detection point between d_0 and d_2**

NOTE The centre of the test targets shall be located at points marked by **O** in the figure above, however when this is not possible (i.e. at the centre lower position), the test target shall be set up on the ground surface.

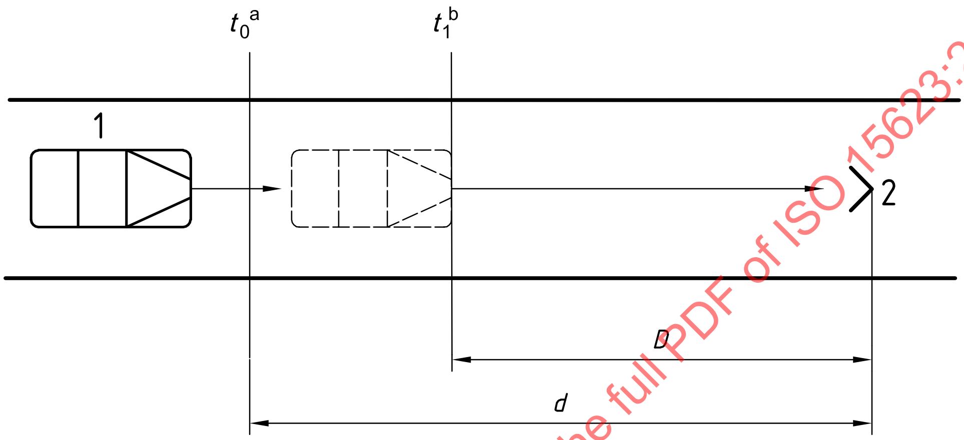
Figure 3 — Detection range and detection points

6.4 Test method for warning distance accuracy

This test shall be done with vehicles in motion.

The standard target shall be in the detection area. While the subject vehicle is driving toward the standard target at the speed V_{max}, the warning distance shall be measured by following procedure.

Two timings shall be measured. The first timing, t_0, is at the point where the subject vehicle to the standard target is equal to d. The second timing t_1 is at the point where the warning is issued. The warning distance from the standard target is calculated as $D = d - V_{max} \times (t_1 - t_0)$. The D is compared to the warning distance specified by manufacturer. The warning distance accuracy shall be smaller than that defined in 5.3.2.



Key

1 Subject vehicle

2 Standard target

[a] Standard timing

[b] Warning timing

Figure 4 — Warning distance accuracy test

6.5 Test method for target discrimination ability

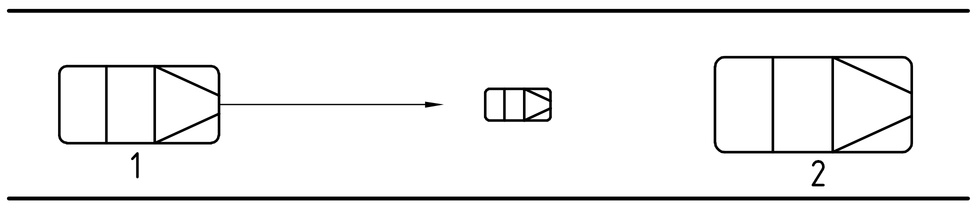
6.5.1 General

This test shall be done with vehicles in motion. The tests in this section are finished when the vehicle has "produced a warning". Tests should also show the ability to avoid "nuisance warnings". For example test conditions which are finished when the manoeuvre is complete and no warning has been produced.

6.5.2 Longitudinal discrimination

Two target vehicles in the detection area are driving with the same speed, which is V_{max}. The subject vehicle is following the two target vehicles. The time gap between the two target vehicles shall be T_{min} (= 0,4 s) and the two target vehicles are positioned along a line in such a way that the near target vehicle does not mask the far target vehicle. The time gap between the subject vehicle and the near target vehicle may be over T_{max} (= 1,5 s). The subject vehicle accelerates until the system produces a preliminary collision warning. After that, the subject vehicle decelerates until the warning stops, then keeps that speed. Next, after a few seconds only the near target vehicle decelerates to a speed which is low enough to have the subject vehicle produce the preliminary collision warning. The test is finished when the subject vehicle has produced a warning.

See Figure 5.



Key

1 Subject vehicle

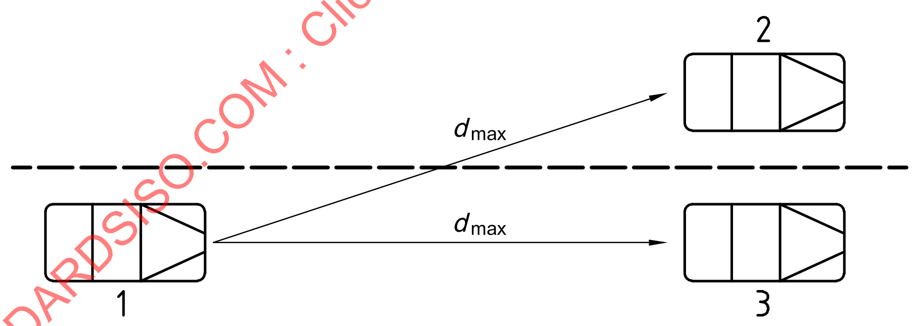
2 Target vehicles

Figure 5 — Longitudinal target discrimination ability test

6.5.3 Lateral discrimination

6.5.3.1 Straight road lateral discrimination test

The test shall be performed dynamically. Subject vehicle and target vehicle are driving with the same speed, which is V_{max}, and in a time gap which does not cause a warning. The forward vehicle drives beside the target vehicle at a same speed of V_{max}. The spacing between the longitudinal centrelines of the preceding vehicles is 3,5 m ± 0,25 m. The width of the preceding vehicles shall be between 1,4 m and 2 m. The lateral displacement of the longitudinal centreline of the subject vehicle relative to the longitudinal centreline of the target vehicle shall be less than 0,5 m. After a few seconds, the forward vehicle decelerates to a speed which is significantly lower than the speed of the subject and target vehicle. During passing of the forward vehicle, the subject vehicle shall not produce a warning. Next, after a few seconds, the target vehicle decelerates to a speed which is low enough to have the subject vehicle produce the preliminary collision warning. The test is finished when the subject vehicle has produced a warning.



Key

1 Subject vehicle

2 Forward vehicle

3 Target vehicle

Figure 6 — Straight road lateral target discrimination ability test

6.5.3.2 Curved road lateral target discrimination test

In addition to the straight road test, the following test shall be done on a circle or a sufficient part of a circle with a radius of 500 m or less in case of Class I, with a radius of 250 m or less in case of Class II, and with a radius of 125 m or less in case of Class III. The test shall be performed dynamically. Subject vehicle and target vehicle are driving in the same lane with the same speed and in a headway which does not cause a warning. The speed of the test vehicles at the start of the test is as follows.

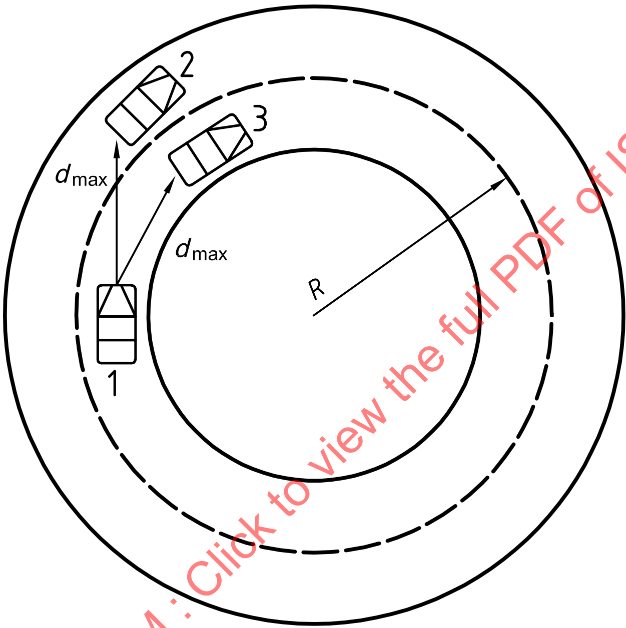
$$V_{\text{circle\_start}} = \min[(a_{\text{lateral\_max}} \times R)^{1/2}, V_{\max}] \pm 1 \text{ m/s} \quad (1)$$

where

$a_{\text{lateral\_max}}$ = 2 m/s^2 for Class I;

$a_{\text{lateral\_max}}$ = 2,3 m/s^2 for Class II and III.

The forward vehicle drives beside the target vehicle in the outer lane. After a few seconds, the forward vehicle decelerates to a speed which is significantly lower than the speed of the subject and target vehicle. During passing of the forward vehicle, the subject vehicle shall not produce a warning. Next, after a few seconds, the target vehicle decelerates to a speed which is low enough to have the subject vehicle produce the preliminary collision warning. The test is finished when the subject vehicle has produced a warning.



Key

1 Subject vehicle

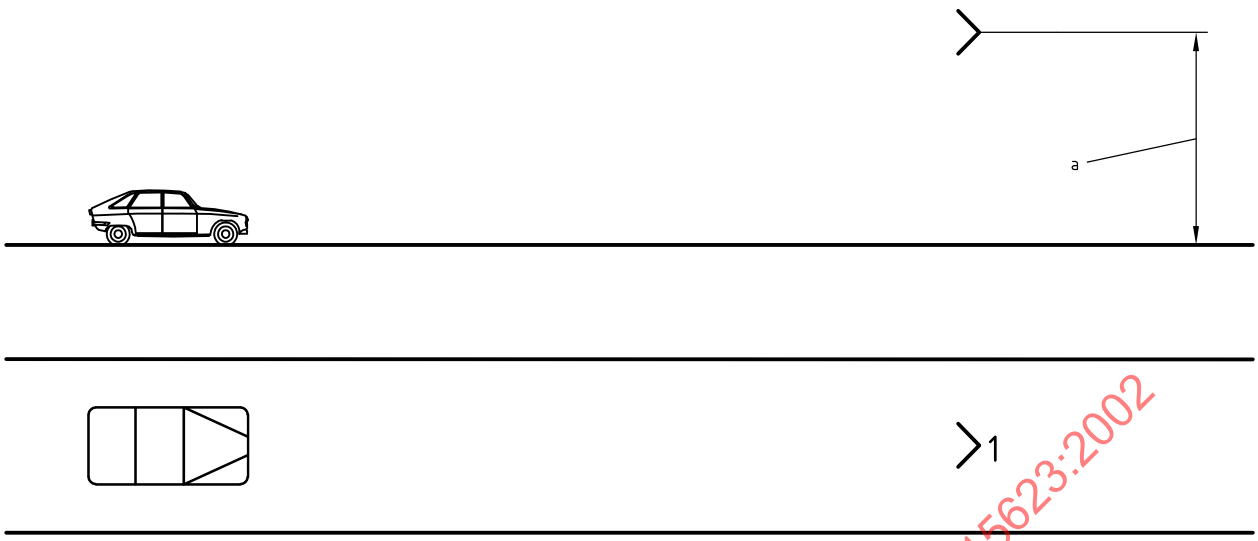
2 Forward vehicle

3 Target vehicle

Figure 7 — Curved test track and target discrimination ability test

6.5.4 Overhead discrimination

The test shall be performed dynamically. As shown in Figure 8, the test target which may cause false warnings is installed. The subject vehicle approaches the test target. The test is finished when the subject vehicle has not produced a warning. The height of the test target is defined according to the road construction standard of each country.



Key

1 Test target

[a] The height of the test target is defined according to the road standard of each country.

Figure 8 — Overhead target discrimination ability test

Annex A
(normative)

Basic consideration of collision warning

A.1 Basic equation

As indicated in Figure A.1, the basic mathematical model is based on a warning distance algorithm that takes preceding and subject vehicle absolute speed and calculates a warning distance. This warning distance is compared with the measured distance and if exceeded, the driver is warned. The warning distance for preliminary collision warning and collision warning may be adjusted by selecting appropriate free running (driver's brake reaction) time, T and vehicle deceleration a.

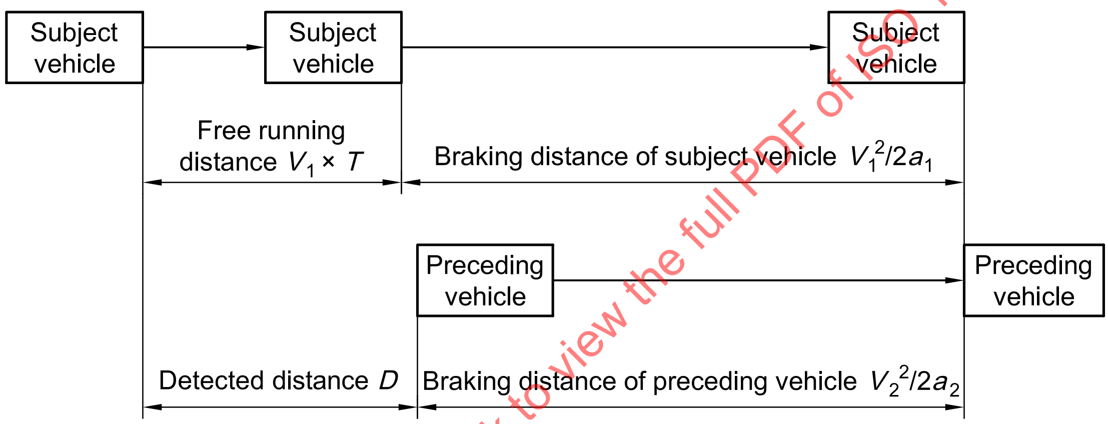


Figure A.1 — Operation principles

$$D = V_1 \times T + (V_1^2/2a_1 - V_2^2/2a_2) \qquad \text{(A.1)}$$

where

- D is the distance to preceding vehicle (obstacle);
- V_1 is the subject vehicle speed;
- V_2 is the preceding vehicle (obstacle) speed;
- T is the free running (driver's brake reaction) time;
- a_1 is the subject vehicle deceleration;
- a_2 is the preceding vehicle (obstacle) deceleration.

A.2 Scenarios where warning is issued

A.2.1 General

Although there are many scenarios where the warning is issued, typical scenarios are examined.

A.2.2 Preceding vehicle is travelling at the same speed as a subject vehicle

$$D_1 = V_1 \times T \qquad \text{(A.2)}$$

A.2.3 Preceding vehicle is a stationary obstacle

$$D_2 = V_1 \times T + V_1^2 / 2a_1 \qquad \text{(A.3)}$$

When the subject vehicle is approaching to the preceding vehicle travelling at a constant speed, V_1 means the relative speed between the subject vehicle and the preceding vehicle.

A.2.4 Preceding vehicle is decelerating with relative speed $V_{rel} = (V_1 - V_2)$

$$D = (T + V_{rel} / a) \times V_1 - V_{rel}^2 / 2a \qquad \text{(A.4)}$$

A.3 Evaluation results of T and a

A.3.1 Free running (driver's brake reaction) time, T

Values for T were based on Johansson and Rumar [5].

Tests for free running (driver's brake reaction) time T fell within 0,3 ~ 2 s. The average value of T was 0,66 s. The test was put into effect by 321 persons and measured the delay time of brake operation after indication by the horn. The distribution of values was scattered very widely. However 98 % of all subject persons were under 1,5 s.

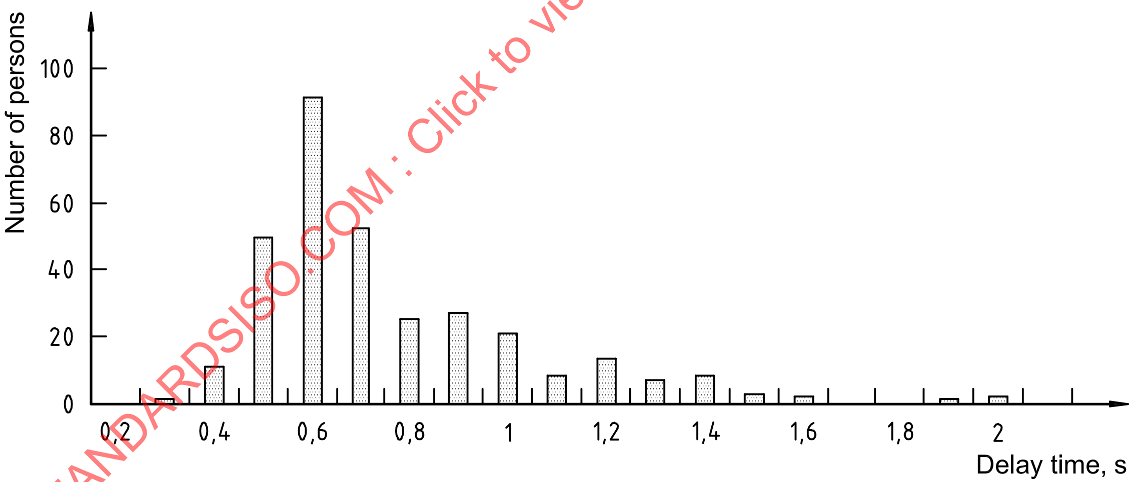


Figure A.2 — Distribution of driver's brake reaction time T

A.3.2 Deceleration, a

Values for a were measured through evaluating emergency brake performance on a dry, flat road surface [6].

Tests for deceleration a indicate that values fell within 3,6 m/s^2 ~ 7,9 m/s^2. The average value of a for passenger cars was 7 m/s^2 and 5,3 m/s^2 for commercial vehicles. The distribution of values was scattered very widely and depended on vehicle type, laden condition, driver reaction characteristics.

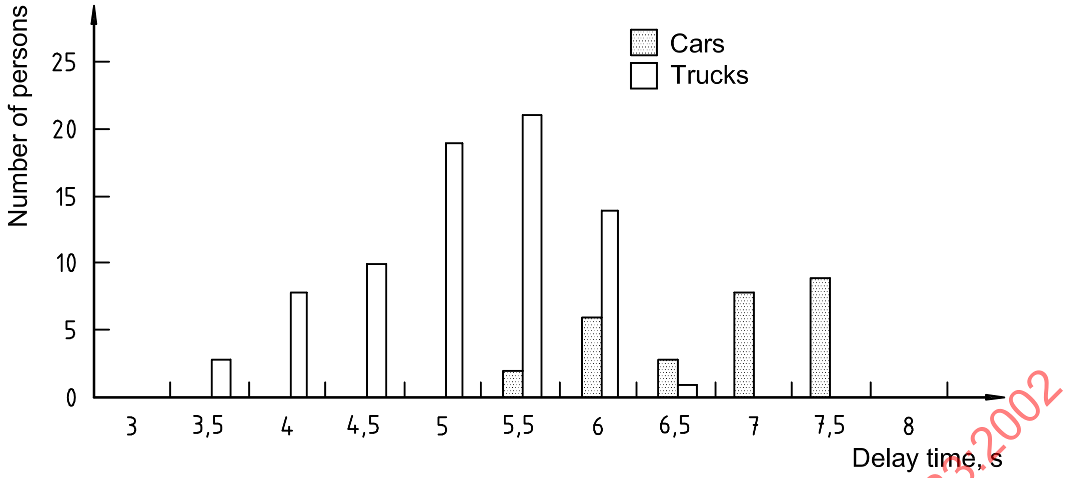


Figure A.3 — Distribution of deceleration *a*

A.4 Calculation examples of the warning distance

A.4.1 Preceding vehicle is travelling at ordinary speed

For the case of the subject vehicle travelling at ordinary speed slightly higher than that of a preceding vehicle assuming a free running (driver's brake reaction) time of 1,5 s, 0,66 s, 0,4 s, the warning distance [equation (A.2)] is as Figure A.4.

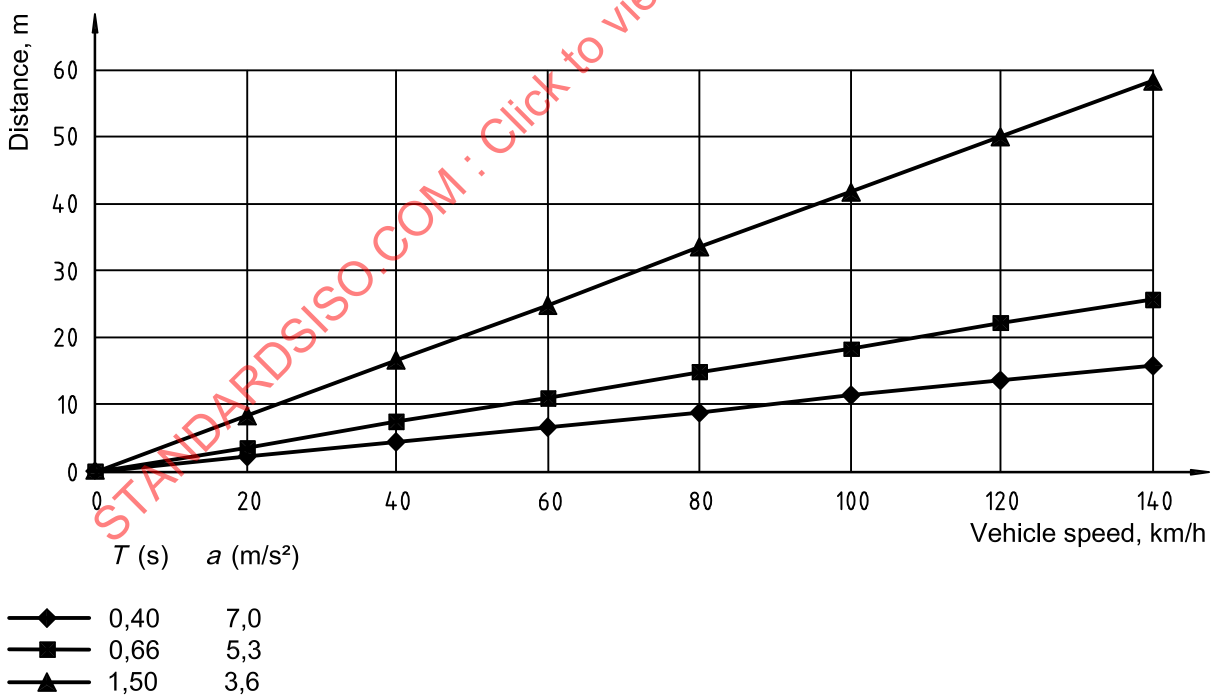


Figure A.4 — Relationship between vehicle speed and warning distance for preceding vehicle at ordinary speed

A.4.2 Preceding vehicle is a stationary obstacle vehicle

For the case of subject vehicle encountering a stationary obstacle vehicle and assuming a free running (driver's brake reaction) time of 1,5 s, 0,66 s, 0,4 s and deceleration of 3,6 m/s^2, 5,3 m/s^2, 7 m/s^2, the relationship between subject vehicle speed and stop distance is as indicated in Figure A.5.

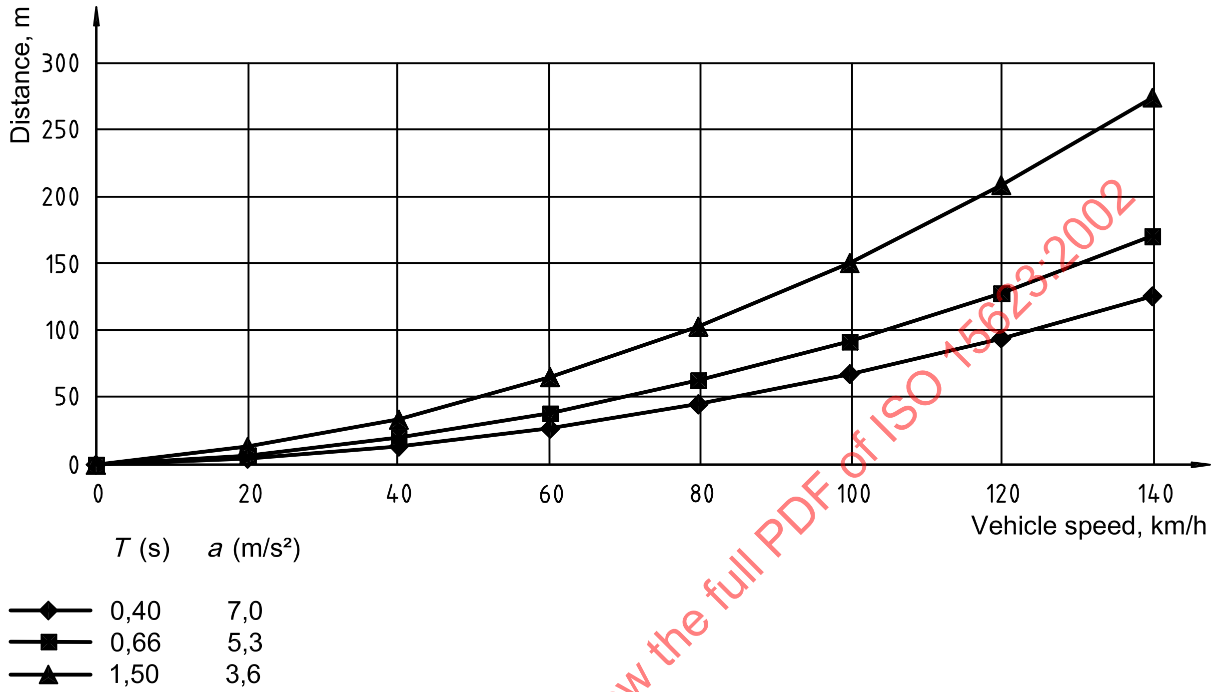


Figure A.5 — Relationship between vehicle speed and stopping distance for stationary obstacle

A.4.3 Preceding vehicle is decelerating with relative speed $V_{rel} = (V_1 - V_2)$

Also from equation (4), the relationship between relative speed and inter-vehicle distance can be determined and is as shown in Figure A.6 for the case of subject vehicle speed of 100 km/h, a free running (driver's brake reaction) time of 1,5 s, 0,66 s, 0,4 s and deceleration of 3,6 m/s^2, 5,3 m/s^2, 7 m/s^2.

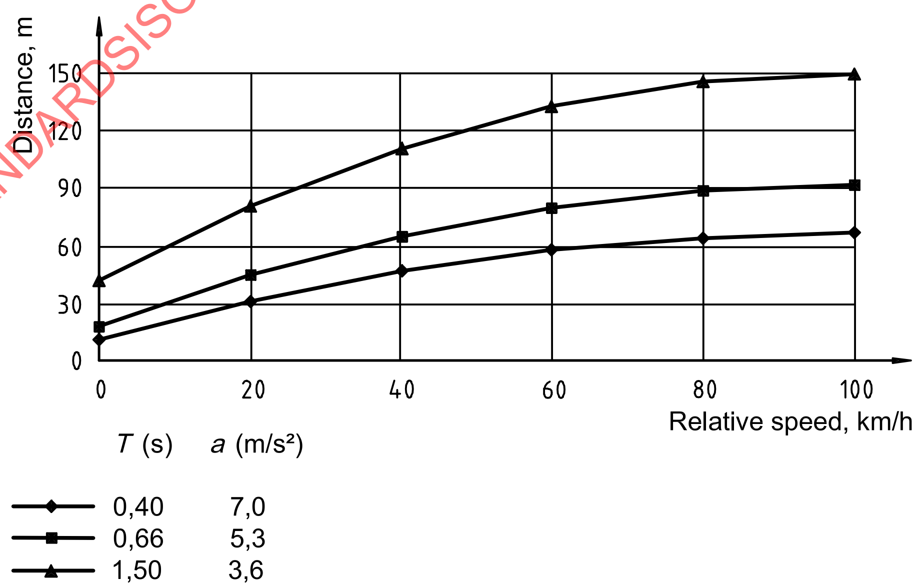


Figure A.6 — Relationship between relative speed and inter-vehicle distance

A.5 Design parameter

Following values should be used to calculate the D_{max} and d_1.

T_{max} = 1,5 s

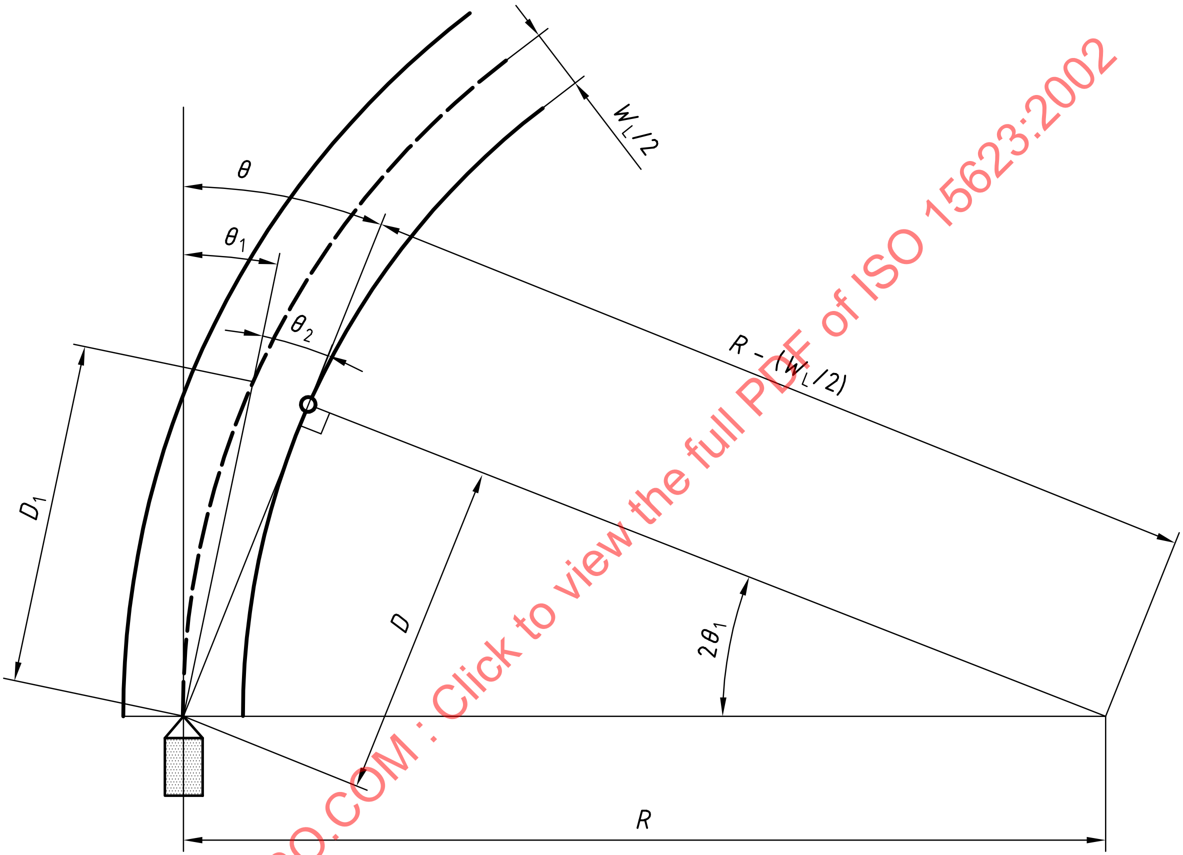
T_{min} = 0,4

a_{min} = 3,6 m/s^2

Annex B
(normative)

Obstacle detection along curves

Systems with curve recognition shall require a coverage of obstacle detection as shown in Figure B.1.



R = curve radius (m)

D = distance to obstacle (m)

θ = detection angle

W_L = lane width (m)

Figure B.1 — Coverage of Class I, II and III systems

From Figure B.1, D is given by the following equation.

$$D = (R \times W - W_L{}^2 / 4)^{0,5} \qquad \text{(B.1)}$$

$$D_1 = (D^2 + W_L{}^2 / 4)^{0,5} \qquad \text{(B.2)}$$

Then $\theta_1 = 90 \times D_1 / (\pi \times R)$ (B.3)