

TECHNICAL GUIDELINE ON THE BRAKE SYSTEM FOR EASING FRONTAL OBSTACLE IMPACT

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1. Scope

This Technical Guideline shall apply to the functions of the brake systems for easing frontal obstacle impact that have been installed by the motor vehicle manufacturer on ordinary-sized motor vehicles, small-sized motor vehicles, and mini-sized motor vehicles (excluding two-wheeled motor vehicles classified as small-sized motor vehicles and mini-sized motor vehicles, as well as buses having standing space). However, the provisions of this Technical Guideline shall not apply to the control of braking for the purpose of alarm.

2. Function of this system

This system means one that is intended to ease damage caused by collision with a frontal obstacle, and which has a function for issuing a warning or alarm when there is a possibility of collision with a frontal obstacle and for controlling the brake system when it has judged that there is a high probability of a collision or there will be a collision.

3. Definitions

(1) Terms

- ① Ordinary-sized motor vehicles, small-sized motor vehicles and mini-sized motor vehicles

“Ordinary-sized motor vehicles”, “small-sized motor vehicles” and “mini-sized motor vehicles” according to the Road Vehicles Act.

- ② Frontal obstacle

An object that exists in front of the path of the vehicle and that may collide with the motor vehicle.

- ③ Relative speed

Relative speed between the frontal obstacle and the motor vehicle.

- ④ Estimated time to collision

The time taken until the vehicle collides with the frontal obstacle, assuming that the relative speed does not change. Obtained by dividing the distance between the motor vehicle and the frontal obstacle at a given instant by the relative speed.

- ⑤ Boundary for collision avoidance by braking

The estimated time to collision that is the physical limit required for avoiding collision with the frontal obstacle by braking.

- ⑥ Boundary for collision avoidance by steering

The estimated time to collision that is the physical limit required for avoiding collision with the frontal obstacle by steering.

- ⑦ Collision judgment line

The physical limit for collision avoidance that enables the driver to avoid collision by braking and steering.

⑧ Width for collision avoidance

The transverse displacement of the motor vehicle which is required to avoid collision with the frontal obstacle.

⑨ Overlap ratio

The ratio of the transverse overlapping of the motor vehicle and the frontal obstacle to the width of the motor vehicle. The product of the width of the motor vehicle and the overlap ratio is the width for collision avoidance.

⑩ Normal lower limit for collision avoidance by braking

The distributed lower limit where the timing to start avoiding the collision against a frontal obstacle by braking in the normal driving is expressed as the estimated time to collision.

⑪ Normal lower limit for collision avoidance by steering

The distributed lower limit where the timing to start avoiding the collision against a frontal obstacle by steering in the normal driving is expressed as the estimated time to collision.

⑫ Collision probability judgment line

The lower limit for collision avoidance by normal braking and steering.

(2) Concepts of collision judgment

① Setting the collision judgment line

- 1) The collision judgment line is that which links the points representing the boundary for collision avoidance by braking, or the boundary for collision avoidance by steering respectively, whichever estimated time to collision is smaller, assuming the relative speed remains the same.
- 2) The standard test conditions when obtaining the collision judgment line shall be as follows.

i) State of the vehicle

The state of the vehicle shall be in accordance with the brake test method (technical standard of brake systems in the Announcement to Specify the Details of the Safety Regulations for Road Vehicles (Ministry of Land, Infrastructure and Transport Announcement No. 619 of 2002)). However, the loading condition shall be the unloaded state given in the brake test method.

ii) State of the road

Regarding the state of the ground surface and the road gradient, the road shall be flat, with an appropriate coefficient of friction.

iii) Relative state of the vehicle and the frontal obstacle

The overlap ratio shall be 40%.

iv) State of movement of the frontal obstacle

The speed of the frontal obstacle measured shall not change until the next measurement.

② Collision judgment

It shall be judged that collision occurs in the area where the estimated time to collision is less than the collision judgment line.

③ Setting the boundary for collision avoidance by braking

- 1) The boundary for collision avoidance by braking shall be the estimated time to collision, which is obtained for each relative speed by calculating the deceleration from the shortest braking distance of the motor vehicle, thus making the said deceleration the maximum possible deceleration of the motor vehicle. However, in cases where

the shortest braking distance under the loaded state is shorter than that under the unloaded state, the shortest braking distance under the loaded state shall be regarded as the shortest braking distance of the motor vehicle.

2) It can be obtained by other methods provided its meaning is the same as that given in the preceding item.

④ Setting the boundary for collision avoidance by steering

1) The estimated time to collision shall be obtained, after obtaining the width for collision avoidance from the overlap ratio that is specified in the standard test conditions, by determining the minimum time required to traverse the said width for collision avoidance. The thus-obtained estimated time to collision shall be the boundary for collision avoidance by steering. Furthermore, the boundary for collision avoidance by steering can be set as follows.

i) 0.6 second for ordinary-sized motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or less.

ii) 0.6 second for small-sized motor vehicles and mini-sized motor vehicles (except those motor vehicles enumerated in the next Item iii)).

iii) 0.8 second for motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or more and motor vehicle for transport of goods with a gross vehicle weight of 8 tons or more or with a maximum loading capacity of 5 tons or more.

2) It can be obtained by other methods provided its meaning is the same as that given in the preceding items.

⑤ Correction of the collision judgment line

1) If the system can detect the conditions under actual circumstances that are different from the standard test conditions, the collision judgment line may be corrected to fit the recognized conditions.

2) Even when the collision judgment line is corrected, the physical limit for collision avoidance shall be used as the criteria for collision judgment.

3) Case examples in which the collision judgment line can be corrected are given below.

i) State of the ground surface

If it is possible to detect the state of the ground surface such as wet ground surface or frozen ground surface, the collision judgment line may be corrected according to the state of the ground surface detected.

ii) Width for collision avoidance

If it is possible to detect the width for collision avoidance, the collision judgment line may be corrected according to the width for collision avoidance detected.

iii) Loaded weight

If it is possible to detect the number of occupants and the weight of the cargo loaded, the collision judgment line may be corrected according to the number of occupants and the weight of the cargo loaded that have been detected.

iv) State of movement of the frontal obstacle

If it is possible to detect the state of movement of the frontal obstacle, the collision judgment line may be corrected by making an estimate based on the state of movement detected.

v) Longitudinal gradient of the road

If it is possible to detect the longitudinal gradient of the road on which the vehicle is running, the collision judgment line may be corrected according to the longitudinal gradient detected.

(3) Concepts of collision probability judgment

① Setting the collision probability judgment line

The collision probability judgment line is that which links the points representing the normal lower limit for collision avoidance by braking, and the normal lower limit for collision avoidance by steering respectively, whichever estimated time to collision is smaller, assuming the relative speed remains the same.

② Collision probability judgment

It shall be judged that the probability of a collision is high in the area where the estimated time to collision is less than the collision probability judgment line.

③ Setting the normal lower limit for collision avoidance by braking

The estimated time to collision obtained by using the following formula shall be set as the normal lower limit for collision avoidance by braking.

- 1) In the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of less than 10 persons:

$$T = 0.0167 \cdot V_r + 1.00$$

Here, T is the estimated time to collision (second), and V_r is the relative speed (km/h).

- 2) In the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or more and motor vehicle used for transport of goods with a gross vehicle weight of 8 tons or more or with a maximum loading capacity of 5 tons or more:

$$T = 0.0317 \cdot V_r + 1.54$$

Here, T is the estimated time to collision (second), and V_r is the relative speed (km/h).

④ Setting the normal lower limit for collision avoidance by steering

The normal lower limit for collision avoidance by steering shall be set, as follows, according to the overlap ratio that the motor vehicle manufacturer determines between 0 and 100% at its discretion.

- 1) In the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of less than 10 persons:

$$T = 0.0067 \cdot R + 1.13$$

Here, T is the estimated time to collision (second), and R is the overlap ratio (%). (R: 0 to 100%)

- 2) In the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or more, and motor vehicle used for transport of goods with a gross vehicle weight of 8 tons or more or with a maximum loading capacity of 5 tons or more:

$$T = 0.0142 \cdot R + 1.62$$

Here, T is the estimated time to collision (second), and R is the overlap ratio (%). (R: 0 to 100%)

4. Limiting conditions in the case of applying the system

A vehicle stabilization system such as ABS shall be equipped.

5. Requirements on functions and performance

(1) Start of operation

① Start of operation of the alarm function

- 1) An alarm shall be started, at the latest, when it has become less than the timing that is obtained by adding the “reaction time to the alarm (0.8 second)” to the timing for performing braking control based on the concepts of

collision judgment.

- 2) If a situation has occurred abruptly in which the estimated time to collision is less than the collision judgment line, the start of operation of the alarm function may be simultaneous with the start of operation of the braking control function. Moreover, when the warning function is already operative, the warning function may replace the alarm function.

② Start of operation of the warning function

- 1) A warning shall be started, at the latest, when it has become less than the timing that is obtained by adding the “reaction time to the warning (0.8 second)” to the timing for performing braking control based on the concepts of collision probability judgment.
- 2) If a situation has occurred abruptly in which the estimated time to collision is less than the collision probability judgment line, the start of operation of the warning function may be simultaneous with the start of operation of the braking control function.

③ Start of operation of the braking control function based on the collision judgment

If the frontal obstacle has been detected and the estimated time to collision has become less than the collision judgment line, the operation of the braking control function for the purpose of deceleration shall be started.

④ Start of operation of the braking control function based on the collision probability judgment

If the frontal obstacle has been detected and the estimated time to collision has become less than the collision probability judgment line, the operation of the braking control function for the purpose of deceleration may be started.

⑤ Conditions of the range of speeds in which the operation is started and of the range of relative speeds

In principle, the system is deemed to have the performance that enables it to start operation if the conditions of the start of operation have been satisfied when the speed of the vehicle is not less than 15 km/h and not more than the maximum speed that is specified as the maximum speed on highways in the Road Transport Law (Law No. 105 of 1960) and when the relative speed between the vehicle and the frontal obstacle is not less than 15 km/h.

(2) Method of operation

- ① The warning and alarm to the driver shall be issued by a method that enables the driver to recognize the response that should be made.
- ② When the system performs control of the braking for the purpose of deceleration, immediately after the operation of the braking control function was started, control corresponding to the deceleration that is not less than the following deceleration shall be carried out in the states given in 3. (2) · 2) i) and ii) above:
 - 1) 6.0 m/s² in the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of less than 10 persons
 - 2) 4.0 m/s² in the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or more and motor vehicles used for transport of goods
- ③ When the system performs control of the braking for the purpose of deceleration, control shall be carried out to increase the deceleration immediately.
- ④ The system should preferably have a function to increase the amount of control further after the operation of the braking control function has been started.
- ⑤ When control is carried out for the purpose of alarm, control that is primarily intended to give an alarm to the driver shall be carried out, and also control shall be performed in such a way that the deceleration becomes less than that enumerated below:
 - 1) 6.0 m/s² in the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of less than 10 persons

2) 4.0 m/s² in the case of motor vehicles used exclusively for carriage of passengers with a passenger capacity of 10 persons or more and motor vehicles used for transport of goods

(3) Transmission of information to the outside

When controlling the service brake system, the stop lamp shall be lit.

(4) Functions of selection and adjustment by the driver

- ① It shall be possible to add a main switch that enables the driver to turn on/off the entire functions of this system.
- ② It shall be possible to add a function that enables the driver to adjust the timing of the warning and alarm function.

(5) Considerations for driver recognition of the situation of this system

- ① The system shall enable the driver to recognize the following situations:
 - 1) On/Off of the main switch of this system
 - 2) Failure of this system
 - 3) Range beyond which this system functions (excluding the speed and relative speed). However, this shall only apply when the system can recognize that the range is beyond the one in which it functions.

6. Failure protection (fail-safe) function

- (1) The system shall have a function to monitor the operating state of the said system, and shall detect failures by means of this function.
- (2) If any failure has occurred in the system, the operation of the said system shall stop safely and the system shall return to its original function as the brake system.
- (3) The mechanism that provides the major functions should preferably be a dual-redundant system.

7. Special notes

(1) Information for users

Information on the following shall be made available to users appropriately by means of instruction manuals, caution labels, etc. Consideration shall be given to ensure that users are fully familiar with ④ in particular.

- ① Conditions of the start of operation of the system and cases in which it will not operate
- ② Sounds given off by the system, indications and their meanings
- ③ Effects of the system
- ④ Functional limit of the system
- ⑤ Other cautions on use