GUIDANCE

SAFETY BARRIERS – GUIDANCE

TENDER SPECIFICATION

SEPTEMBER 2011

DISCLAIMER

The translation into English of Road Standards (Vejregler) and Tender Specifications is to be regarded entirely as a service. In the event of any discrepancy or shortcomings in the translation, the Danish version will prevail. At any time the Danish versions of Road Standards (Vejregler) and Tender Specifications are those in force.

VEJREGLER

PREFACE

These tender specifications deal with the requirements for CE marked safety barriers as well as the requirements for supplementary safety barrier equipment and how such equipment is to be mounted. The overall purpose is to ensure that when the use of safety barriers is prescribed, they shall also be able to comply with the requirements of the *DS/EN 1317 series – Road restraint systems* with regard to documentation of test results, etc.

In order for safety barriers with supplementary safety barrier systems to function as intended in case of collision, it is necessary to select the correct type. This means that the individual types shall be chosen carefully. Where the tender specification (road or bridge) is used, it is possible to take the following into account:

- Mode of operation of safety barrier and supplementary systems
- Operation and maintenance
- Aesthetics

as assessment criteria in the collection and assessment of tenders.

The tender specification form part of the series *Tender specifications for road Equipment*. The series consist of:

- *Common to Road Equipment – GWS*
- *Road Signs*
- *Street Lighting Equipment*
- *Road Safety Barriers and Related Systems*
- *Bridge Barriers and Parapets*.

The tender specification for road safety barriers is a new road standard, while the tender specification for bridge barriers and parapets is a revision of the section under concrete bridges, which is omitted. The tender specifications have been prepared under the road standards group that deals with road equipment and structures. The road standards group for structures has contributed to a large extent to the tender specification on bridge barriers and parapets.

The tender specifications became necessary because all safety barriers shall be CE marked in the future.

The tender specifications have been prepared by a consultant with contributions from the two road standards groups up to a preliminary version. Subsequently, the comments of three road standards groups have been coordinated and incorporated into the current result.

Prepared by the road standards group, which during that period had the following composition:

John Kjærsgaard	Danish Road Directorate (chairman until May 2011)
Morten Larsen	Danish Road Directorate (chairman from May 2011)
Tim Larsen	TL Engineering (secretary)
Erik Petersen	NESA (until August 2011)

Kai Sørensen	DELTA Lys og Optik (until June 2011)
Charlotte Sejr	Danish Road Directorate
Johannes Vindum	Møller & Grønborg AS
Peter Johnsen	Johnsen Consult
Henrik Aagaard	Dragør Local Authority, Vej og Park
Ole Hardt	Danish Road Directorate (VRS)
P. Allan Nestén	Seri Q Sign
Erik Vejsgaard Christensen	NCC Roads.

On 25 January 2011, the Danish Road Standards Committee was presented with the preliminary version and informed about the further course until publication.

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1 GENERAL

This instruction on tender of safety barriers is intended for the designer when preparing tender materials for safety barriers.

The safety barriers mean either road safety barriers or bridge barriers and parapets. Related systems mean safety barrier transitions, crash cushions and flexible safety barrier ends.

The material is thus divided into road safety barriers and related systems as well as bridge barriers and parapets, see section 1.1. The reason for this is that road safety barriers are normally mounted with the related systems – independently or together with the connection to vehicle parapet by means of safety barrier transitions. Accordingly, the bridge is normally established with bridge barriers and parapets under a separate contract before road safety barriers and related systems are established.

The European standards for safety barriers and related systems under the Construction Products Directive have been incorporated into this tender specification. The detailed rules for when and how tenders shall be carried out are described in the Public Procurement Directive, including rules for awarding the entity's (the Employer's) reference to technical specifications – or any failure to do this – in connection with tender of civil engineering works, services and goods.

See also *Handbook of Tenders*.

1.1 Structure

Tender specifications are organised as illustrated in Figure 1.

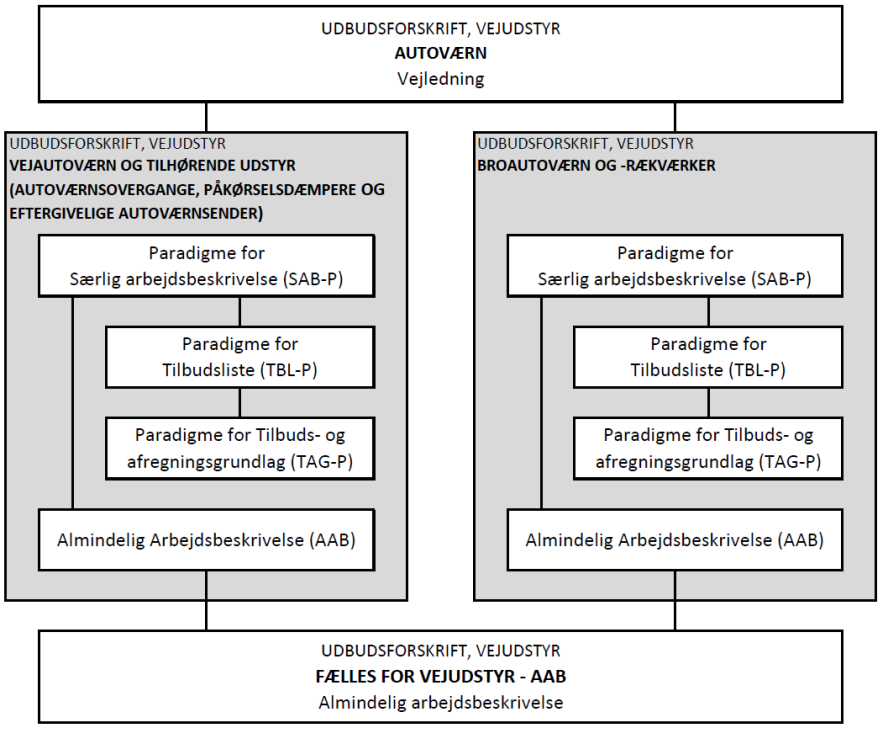

Figure 1 Structure of tender specifications on safety barriers.

2 USE

Tenders and purchase of safety barriers and related products are controlled by the Construction Products Directive, the Public Procurement Directive and Executive Order on procedures for the award of public works contracts, public supply contracts and public service contracts (*The Public Procurement Directive*).

For safety barriers and related systems, various standards have been prepared under the *Construction Products Directive*, which came into force on 1 January 2011. The standards have been prepared by CEN TC 226/WG1 *Safety barriers*. The standards (DS/EN 1317 series) will be binding for road safety barriers and bridge barriers and parapets as well as crash cushions, but optional for other related systems (flexible safety barrier ends, bridge parapets, safety barrier transitions and safety barriers used during roadworks).

Temporary safety barriers are not subject to CE marking, as the *Construction Products Directive* specifies that this only includes permanent installations, even if temporary safety barriers have been included in the European safety barrier standards (DS/EN 1317 series).

A safety barrier that is mounted in connection with civil engineering works and shall remain there for 25-30 years is permanent. A safety barrier that is mounted in connection with e.g. roadworks and shall remain there for three weeks is temporary. The rules of the *Construction Products*

Directive ranks prior to the rules set out in the standards so even if temporary safety barriers are included in the standard, they need not be CE marked.

3 REQUIREMENTS FOR SAFETY BARRIERS, ETC.

3.1 Safety barriers (binding European standard)

The type of safety barrier is selected for each section based on the specific mounting conditions. Choice of safety barrier is described in more detail in the *Handbook for mounting safety barriers and related systems*. The following overview of the choice of safety barriers is a specification of the essential elements for determining safety barrier types.

Choice of safety barrier type is made according to a prioritised order. The order is as follows:
1. First, the working width available for the safety barrier on the relevant section is determined based on the rule that that there shall be no obstacles within the working width. Since increased working width results in a smaller risk of injury, the aim should be to choose the safety barrier type with the greatest possible working width in relation to what is physically practicable on the location in question.

The working width is defined in DS/EN 1317-2 and is divided into classes, see Figure 3. Working width W specifies the distance from the front edge of the safety barrier before collision to the rear edge of the safety barrier (or test vehicle) after collision, see Figure 2.

For safety barrier with CE marking in accordance with DS/EN 1317-5 or DS/EN 1317-5+A1 on the basis of DS/EN 1317-2:1998, the working width will only be stated at the measured working width W.

For tests based on the latest edition of DS/EN 1317-2:2010, the working width will be defined by W_N and VI_N, which are described in the following.

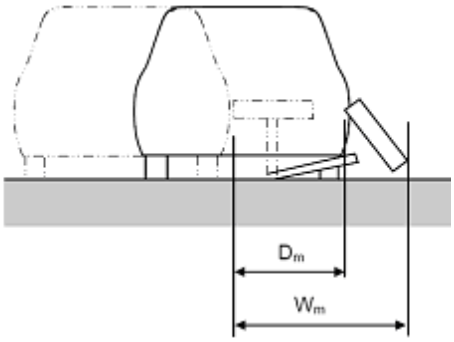

Figure 2 Working width (DS/EN 1317-2:2010).

W_m is the measured working width during the collision test. Since it cannot be avoided that the angle of collision, speed and vehicle weight differs, a normalised working width W_N is calculated on the basis of the measured working width. The normalised working width W_N is used as the system working width.

W class	W1	W2	W3	W4	W5	W6	W7	W8
W_N(m)	≤ 0.6	≤ 0.8	≤ 1.0	≤ 1.3	≤ 1.7	≤ 2.1	≤ 2.5	≤ 3.5

Figure 3 Classification (W) according to working width (DS/EN 1317-2:2010).

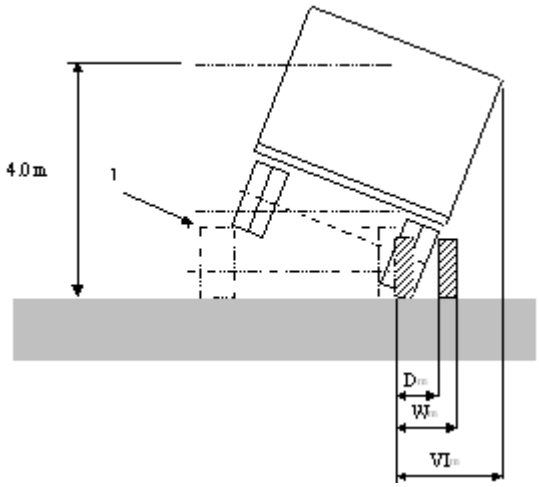

Figure 4 Working width (DS/EN 1317-2:2010).

In connection with the collision test, it is also measured whether the vehicle contributes to an increase of the working width that shall be available VI_m.

VI_m is normalised in the same manner as W_N. The normalised value WI_N is used as the system working width. VI_N is relevant for e.g. installation of safety barrier through a bridge underpass where the piers stand close to the safety barrier or where a safety barrier is mounted in front of a noise barrier.

VI class	VI1	VI2	VI3	VI4	VI5	VI6	VI7	VI8	VI9
VI_N(m)	≤ 0.6	≤ 0.8	≤ 1.0	≤ 1.3	≤ 1.7	≤ 2.1	≤ 2.5	≤ 3.5	> 3.5

Figure 5 Classification (VI) according to working width (DS/EN 1317-2:2010).

In addition to the working width, the system's dynamic deflection D_m will also be specified in the CE marking of the product.

2. Then – in accordance with the guidelines set out in section 4.1 in *Road standards for mounting of safety barrier and crash cushions in rural areas*, and in table 4.1 of the road standard (reproduced as Figure 6) – the strength class the safety barrier shall meet is chosen. The strength class is also defined in DS/EN 1317-2.

Safety barrier	Situation	Strength class
Side safety barrier	Roads with a desired speed > 80 km/h	H1
	Roads with a desired speed ≤ 80 km/h	N2 or H1
	Roads with a desired speed ≤ 80 km/h where protection against heavy vehicles is desired	T3 or H1
	Roads with a desired speed ≥ 80 km/h where protection of housing areas, traffic areas, water protection areas is desired	H3 or H4
Central safety barrier	Roads with a desired speed > 80 km/h	H1
	Roads with a desired speed ≤ 80 km/h	N2 or T2
	Roads with a desired speed ≥ 80 km/h. Truck percentage (vehicles ≥ 10 ton) between 5-10% and annual average daily traffic ≥ 50,000	H2
	Roads with a desired speed ≥ 80 km/h. Truck percentage (vehicles ≥ 10 ton) ≥ 10% and annual average daily traffic ≥ 50,000	H3

Figure 6 Choice of strength class (Table 4.1 in "Road standards for mounting of safety barrier and crash cushions in rural areas, July 2006, rev. November 2007").

European standard DS/EN 1317-2 also specifies other strength classes (L classes). These are currently not used in Denmark. If a safety barrier complies with an L class, it also complies with an "underlying" class. For instance, L3 will mean that H3 is observed, so L classes may therefore also form the basis of an approval.

For bridge barriers and parapets, the strength class is chosen according to section 3.2 in *Road specifications for mounting bridge barriers and parapets, July 2006*.

Both the requirement for working width and strength class shall be observed on the specific mounting sites.

3. Next, the safety barrier type is selected (steel, concrete or other) in consideration of operation and maintenance, traffic volumes, aesthetics, etc.

4. Finally, the safety barrier with the lowest injury risk is selected. The injury risk is an expression for the impact the driver and passengers are exposed to. Generally, class A should always be chosen, unless rendered impossible by the specific mounting conditions.

Acceptance criterion	Limit values		
A	ASI ≤ 1.0	and	THIV ≤ 33 km/h
B	ASI ≤ 1.4		
C	ASI ≤ 1.9		

Note: ASI (**A**cceleration **S**everity **I**ndex) is an expression of the deceleration a person in the vehicle is exposed to during collision. It is expressed as a dimensionless ratio specifying the relationship between the current maximum deceleration and the deceleration which will normally cause no harm. The acceptance criterion is ASI ≤ 1.0. However, in special cases it is acceptable that the value is 1.4 or higher. THIV (**T**heoretical **H**ead **I**mpact **V**elocity) describes the horizontal component of the speed of the head when it hits the car's interior for a person not wearing a seat belt. The acceptance criterion is THIV ≤ 33 km/h. PHD (**P**ost-impact **H**ead **D**eceleration) is an expression of the horizontal deceleration the head is exposed to after contact with the car's interior. The acceptance criterion is PHD ≤ 20 g.

Figure 7 Injury risk (DS/EN 1317-2:2010).

According to the newest standards (2010), CE marking of safety barriers and crash cushions will only include requirements for ASI and THIV, whereas older CE markings are based on all of the values in the above note (ASI, THIV and PHD).

3.2 Crash cushions (binding European Standard)

Crash cushions are described using the following criteria:

- The speed at which they can be hit
- The sides from which the crash cushion is hit
- Absorbing/non-absorbing
- Location of vehicle after collision
- Location of crash cushion after collision
- Acceptance criteria.

Crash cushions are only intended for collision with passenger cars, since it is not possible to absorb the energy from large vehicles if the crash cushion shall work properly in relation to passenger cars.

Test requirements for crash cushions are described in DS/EN 1317-3, and the use of crash cushions is described in *Road standards for mounting of safety barrier and crash cushions in rural areas*.

The speed at which they can be hit (Speed class)
Crash cushions can be tested in four different speed classes (50, 80, 100 and 110 km/h). Depending on the speed at which the crash cushion is hit during the test, it can be used in the situations described below.

On all motorways, crash cushions in speed class 110 km/h shall be used. On principal highways, crash cushions in speed class 100 km/h shall be used. On roads with a desired speed greater than 50 km/h and less than or equal to 80 km/h, crash cushions in speed class 80 km/h shall be used. On roads with a desired speed greater than 80 km/h, crash cushions in speed class 100 km/h shall be used. On other roads, crash cushions in speed class 50 km/h shall be used.

The sides from which the crash cushion is hit (Angle of collision)

The crash cushion can be tested at five different angles of collision, depending on its application. See the scenarios (tests) 1-5 in Figure 8.

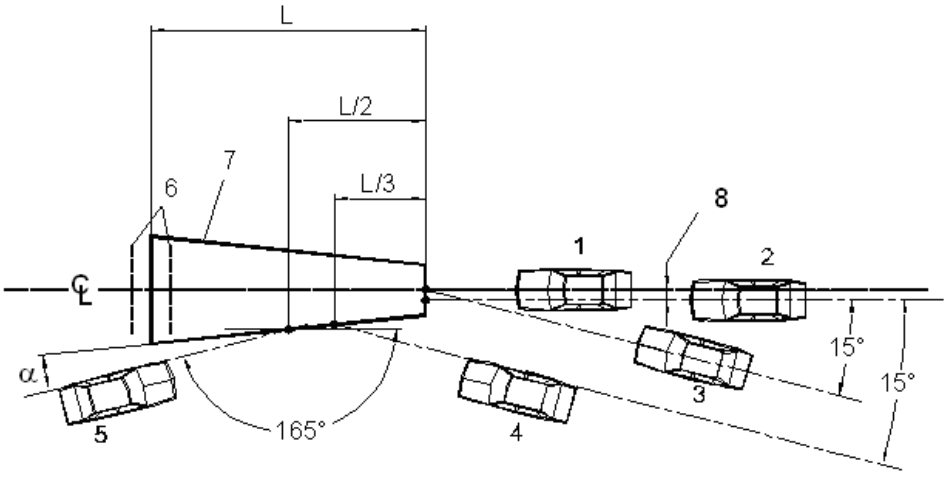

Figure 8 Collision scenarios (DS/EN 1317-3:2010).

Depending on the collision speed, one or more of the five collision scenarios shall be carried out. For instance, test 1, and possibly test 4, are required at 50 km/h, whereas at 110 km/h, tests 1, 2, 3 and possibly tests 4 and 5 shall be carried out.

Absorbing/non-absorbing

Crash cushions are divided into absorbing and non-absorbing. An absorbing crash cushion will withhold the vehicle in the structure within certain limits (see subsequent section on vehicle location after collision).

A non-absorbing crash cushion shall function as a safety barrier in the event of collision from the side (tests 4 and 5), meaning that tests 4 and 5 are relevant for non-absorbing crash cushions. Absorbing crash cushions shall be used where there is a risk that the vehicle may pose a nuisance or danger after collision. In all other cases, non-absorbing crash cushions can be used. Moreover, test 5 is relevant if the crash cushion can be hit from the opposite direction of travel.

Location of vehicle after collision

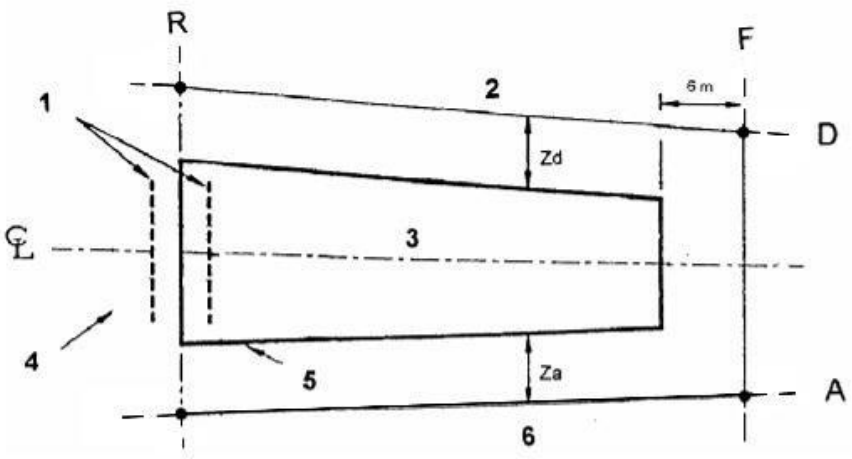

Figure 9 Location of the vehicle after collision (DS/EN 1317-3:2010).

The location of the vehicle shall not pose a danger to the traffic after collision with the safety barrier. The standard therefore requires that the location of the vehicle after collision will be described in relation to figure 9.

The location of the vehicle is described by the distances Z_a and Z_d, and the crash cushion is classified in classes depending on the size of Z_a and Z_d, see Figure 10.

Z class	Approach side	Departure side
	Z_a (m)	Z_d (m)
Z1	4	4
Z2	6	6
Z3	4	4*
Z4	6	6*
*Test 3		

Figure 10 Classification (Z) (DS/EN 1317-3:2010).

Location of crash cushion after collision
The crash cushion has a permanent deflection after collision.

The maximum permanent deflection of the crash cushion is relevant where it is to be assessed whether its deflection after collision may pose a danger or nuisance to the other traffic. The deflection of the crash cushion is characterised by the distances D_d and D_a, where D_a faces the approach side and D_d is measured on the departure side.

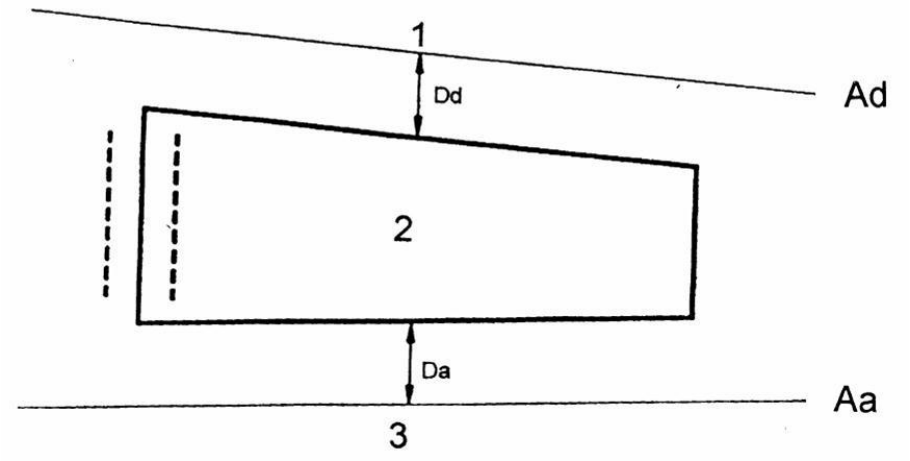

Figure 11 Permanent deflection (DS/EN 1317-3:2010).

The permanent deflection of the crash cushion is divided into classes, see Figure 12.

D class	Permanent horizontal deflection	
	D_a (m)	D_d (m)
D1	0.5	0.5
D2	1.0	1.0
D3	2.0	2.0
D4	3.0	3.0
D5	0.5	≥ 0.5 (test 3)
D6	1.0	≥ 1.0 (test 3)
D7	2.0	≥ 2.0 (test 3)
D8	3.0	≥ 3.0 (test 3)

Figure 12 Classification (D) (DS/EN 1317-3:2010).

Acceptance criteria

Acceptance criterion	Limit values		
A	ASI ≤ 1.0	and	THIV ≤ 44 km/h in tests 1, 2 and 3 THIV ≤ 33 km/h in tests 4 and 5
B	1.0 < ASI ≤ 1.4		THIV ≤ 44 km/h in tests 1, 2 and 3 THIV ≤ 33 km/h in tests 4 and 5

Figure 13 Injury risk (DS/EN 1317-2:2010). See note in section 3.1.

As in the case of safety barriers, it should be ensured that the crash cushion meet criterion A. However, most test results will probably only be able to observe criterion B, which should be considered acceptable.

3.3 Flexible safety barrier ends (optional European standard)

Flexible safety barrier ends are described in DS/EN 1317-4, and in *Road standards for mounting of safety barrier and crash cushions in rural areas*.

Flexible safety barrier ends are only intended for collision with passenger cars, since it is not possible to absorb the energy from large vehicles if the flexible safety barrier shall work properly in relation to passenger cars.

Flexible safety barrier ends are described using the following criteria:

- The speed at which they can be hit
- The sides from which the flexible safety barrier end is hit
- Location of vehicle after collision
- The location of the flexible safety barrier after collision
- Acceptance criteria.

The speed at which they can be hit

Flexible safety barrier ends are tested at the speed 80, 100 or 110 km/h. Depending on the speed at which the flexible safety barrier end is hit during the test, it can be used in the situations described below.

On motorway, strength class P4 shall be used. On principal highways, strength class P3 shall be used. On other roads with a desired speed greater than or equal to 80 km/h, strength class P3 shall be used. On other roads with a desired speed less than or equal to 80 km/h, strength class P2 shall be used.

The sides from which the flexible safety barrier end is hit (Angle of collision)

The flexible safety barrier end can be tested at five different angles of collision, depending on its application. See scenarios (tests) 1-5 in Figure 14.

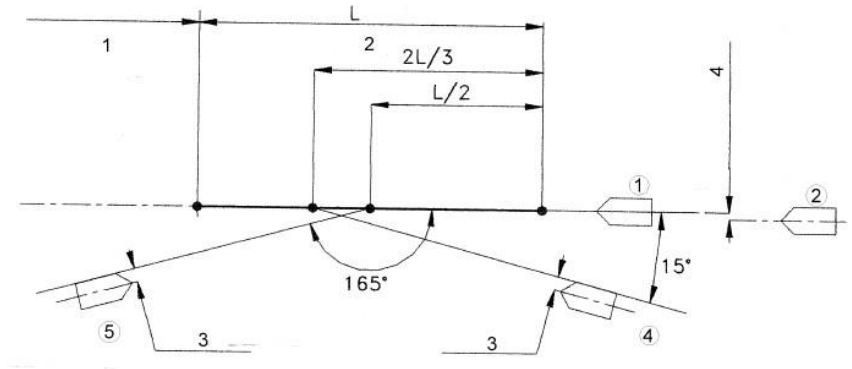

Figure 14 Collision scenarios (DS/EN 1317-4:2001).

Depending on the collision speed, one or more of the five collision scenarios shall be carried out. For instance, test 2, and possibly test 4 and 5, are required at 80 km/h, whereas at 110 km/h, tests 1, 2 and 4 and possibly tests 4 shall be carried out.

Test 5 should be required if the flexible safety barrier end can be hit from the opposite side.

Location of vehicle after collision

The location of the vehicle shall not pose a danger to the traffic after collision. The standard therefore requires that the location of the vehicle after collision be described as illustrated in Figure 15.

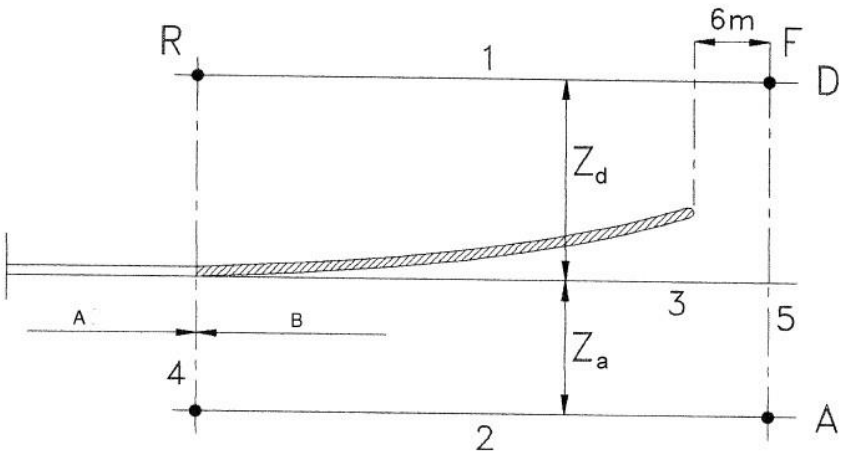

Figure 15 Location of the vehicle after collision (DS/EN 1317-4:2001).

The location of the vehicle is described by the distances Z_a and Z_d, and the flexible safety barrier end is classified in the following classes depending on the size of Z_a and Z_d, see Figure 16.

Z class	Approach side	Departure side
	Z_a (m)	Z_d (m)
Z1	4	4
Z2	6	6
Z3	4	No limitation
Z4	6	No limitation

Figure 16 Classification (Z) (DS/EN 1317-4:2001).

The location of the flexible safety barrier after collision

The flexible safety barrier end has a permanent deflection after collision.

The maximum permanent deflection is relevant where it is to be assessed whether the deflection of the flexible safety barrier end after collision may pose a danger or nuisance to the other traffic. The deflection of the flexible safety barrier end is characterised by the distances D_d and D_a , where D_a faces the approach side, and D_d is measured on the departure side.

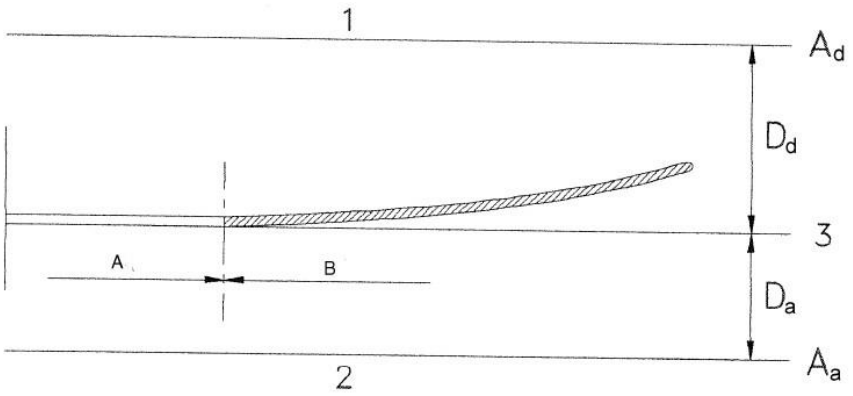

Figure 17 Permanent deflection (DS/EN 1317-4:2001).

Flexible safety barrier ends are divided into the following classes depending on the maximum permanent deflection, see Figure 18.

(x,y) Class		Permanent horizontal deflection (m)	
x	1	D_a	0.5
	2		1.5
	3		3.0
y	1	D_d	1.0
	2		2.0
	3		3.5
	4		> 3.5

Figure 18 Classification (x,y) (DS/EN 1317-4:2001).

Acceptance criteria

Acceptance	Limit values			
A	ASI ≤ 1.0	and	THIV ≤ 44 km/h in the tests 1 and 2. THIV ≤ 33 km/h in tests 4 and 5	PHD ≤ 20 g
B	ASI ≤ 1.4		THIV ≤ 44 km/h in the tests 1 and 2. THIV ≤ 33 km/h in tests 4 and 5	PHD ≤ 20 g

Figure 19 Injury risk (DS/EN 1317-4:2001).

As in the case of safety barriers, it should be ensured that the flexible safety barrier ending meets criterion A. However, most test results will probably only be able to meet criterion B, which should be considered acceptable.

3.4 Safety barrier transitions (optional European standard)

Test requirements for safety barrier transitions are described in DS/EN 1317-4, and the use of crash cushions is described in *Road standards for mounting of safety barrier and crash cushions in rural areas, July 2006, rev. November 2007*.

Safety barrier transitions can either be selected as a tested product in accordance with DS/ENV 1317-4 or the instructions in *Road standards for mounting of safety barrier and crash cushions in rural areas. July 2006, rev. November 2007* can be followed.

The test requirements for safety barrier transitions in DS/ENV 1317-4 are identical to the tests requirements for safety barriers (DS/EN 1317-1 and DS/EN 1317-2). If a tested safety barrier transition is selected, its strength class shall not exceed the strength class for the connected safety barrier with the highest strength class and not be below the strength class of the connected safety barrier with the lowest strength class. Moreover, the working width of the transition shall not be greater than the largest working width for the connected safety barrier.

3.5 Other conditions

Aesthetics
For main roads, safety barrier types such as steel beam safety barriers or cable safety barriers have an aesthetic, open appearance ideally suited for rural areas. Concrete safety barriers have a more closed appearance which harmonises more with main roads in urban areas.

For small roads, it may be necessary to adapt the safety barrier to the surroundings, and e.g. choose a wooden safety barrier in forest areas.

For more details, see *Safety barrier manual* (under preparation).

Emergency telephones
Emergency telephones are mainly located on motorways. Generally, emergency telephones should, in the interest of road user safety, be shielded by safety barriers. This can be done by establishing actual emergency telephone bays or by placing emergency telephones at the end of the safety barrier. Emergency telephones may be staggered up to 200 m in relation to the usual location per 2 km to achieve optimal location.

Passage openings
Passage openings can be established in the central reserve if requested by the police or emergency services.

If passage openings are established, it shall not be possible to pass the central reserve in the normal operating state.

Single-sided/double-sided central safety barriers
In some central reserves, there may be situations where two single-sided road safety barriers are preferable to one double-sided road safety barrier. This may be the case where consideration is given to traffic flow since repair of one double-sided road safety barrier will normally require that both directions of travel shall be closed and where it is assessed that one barrier in both directions of travel constitutes an operational expense in relation to two single-sided road safety barriers.

Motor cycle protection
There are systems which can improve the collision situation for motorcyclists. These systems normally consist of an extra longitudinal beam mounted on existing steal safety barrier types, so that the motorcyclist will not come into direct conflict with the safety barrier posts. These systems are normally tested in accordance with national standards in the individual countries.

Mounting of other road equipment on road safety barriers
Where additional elements are mounted onto the safety barrier such as amphibian fencing, screens, etc., it shall in each case be assessed whether this has an impact on the function of the safety barrier.

3.6 Bridge barriers and parapets

General
In connection with the construction of new bridges, it is often appropriate to integrate the tender of the vehicle parapet with the tender of the bridge itself; accordingly, an independent tender specification has been prepared for bridge barriers and parapets.

For existing bridges, it is necessary to describe the geometrical conditions of the bridge and mounting requirements for the new vehicle parapet in connection with tender of a new vehicle parapet.

Requirements for the height of a combined vehicle/pedestrian parapet should be incorporated in the tender material depending on the conditions. This may be the presence of pedestrian and cyclist traffic or protection against e.g. electrified trains under the bridge.

3.7 Bridge parapets

The tender material shall specify that the Contractor shall declare the strength of the pedestrian parapet in relation to the absorption of vertical and horizontal loads and maximum deformations, the height of the parapet, geometric requirements for infilling and the maximum size of infilling holes and lifespan.

3.8 Soil conditions

In connection with testing of safety barriers, safety barrier transitions, etc. a specification of anchoring and soil conditions will be provided.

It shall be checked whether the soil conditions in connection with the establishment of the safety barrier are equivalent to the test conditions, or assessed whether additional requirements for the safety barrier should be made or whether the soil conditions should be improved.

At tunnel underpasses, it shall be assessed whether the safety barrier can be established conventionally or whether special solutions shall be established in the form of e.g. a concrete foundation for fixing the posts. Furthermore, in connection with special solutions, it should be ensured that the supplier can render probable that the solution will not significantly change the function of the safety barrier.

Crash cushions and flexible safety barrier ends shall be established to correspond to the setup used for the test of the product. If necessary, soil conditions shall be improved.

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