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Part 8A
NRA TD 19/01

NATIONAL ROADS AUTHORITY
An tÚdarás um Bóithre Náisiúnta

Safety Barriers

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Summary:

This Standard gives the requirements for roadside Safety Barriers and their Terminals and Transitions on new roads.

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VOLUME 2 HIGHWAY STRUCTURES: DESIGN (SUBSTRUCTURES AND SPECIAL STRUCTURES) MATERIALS

SECTION 2 SPECIAL STRUCTURES

PART 8A

NRA TD 19/01

SAFETY BARRIERS

Contents

Chapter

1. INTRODUCTION

General

1.1 This Standard gives the requirements for roadside Safety Barriers on roads with a Design Speed of 85 km/h or above. However, much of the information within the Standard may be applicable to roads with Design Speeds below 85 km/h where the Designer considers that a particular hazard warrants the provision of a barrier.

1.2 The Standard supersedes:-

(a) TD 19/85 (DMRB 2.2) Safety Fences and Barriers;
(b) Amendment No.1 to TD 19/85 dated November 1986;
(c) IAN 14/98, The Use of Crash Cushions;
(d) IAN 24/98, Use of Temporary Safety Barriers at Road Works;
(e) IAN 26/99, Revised Clearances for Safety Fences;
(f) NRA Addendum to TD 19/85 - Safety Fences and Barriers;
(g) TD 32/93 (DMRB 2.2.3) Wire Rope Safety Fence;
(h) NRA Addendum to TD 32/93 - Wire Rope Safety Fence.

1.3 The Standard adopts the performance requirements of:-

(a) IS EN 1317-1, Road Restraint Systems - Part 1: Terminology and General Criteria for Test Methods;
(b) IS EN 1317-2, Road Restraint Systems - Part 2: Performance Classes, Impact Test Acceptance Criteria and Test Methods for Safety Barriers.

1.4 The Standard also follows the main principles of the following draft Parts of EN 1317:-

(a) Draft prEN 1317-4: 1999, Road Restraint Systems - Part 4: Performance Classes, Impact Test Acceptance Criteria and Test Methods for Terminals and Transitions of Safety Barriers;
(b) Draft prEN 1317-5: 2000, Road Restraint Systems - Part 5: Product Requirements, Durability and Evaluation of Conformity.

Scope

1.5 This Standard details the performance requirements of Safety Barriers in common situations in the verge and central reserve of roads. The requirements for exceptional circumstances which are not encompassed by this Standard shall be agreed with the National Roads Authority in each case.

1.6 The Standard also provides guidance on the positioning and detailing of Safety Barriers.

1.7 This Standard is concerned only with the requirements for roadside safety barrier systems and their terminals and transitions, but excluding vehicle parapets and crash cushions. Parapets on bridges and retaining walls shall be designed in accordance with BD 52 (DMRB 2.3.3). Crash cushions are not currently covered by NRA Standards.

Implementation

1.8 This Standard should be used forthwith for all schemes for the construction and/or improvement of national roads. The Standard should be applied to the design of schemes already being prepared unless, in the opinion of the National Roads Authority, application would result in significant additional expense or delay progress. In such cases, Designers should confirm the application of this Standard to particular schemes with the National Roads Authority.

1.9 If this Standard is to be used for the design of local road schemes (non-national roads), the Designer should agree with the relevant Road Authority the extent to which the document is appropriate in any particular situation.

1.10 For the application of this Standard to side roads which are improved or diverted as part of a national road scheme, refer to the National Roads Authority.

1.11 In situations of exceptional difficulty, it may be necessary to apply for a Departure from Standards in respect of the provisions of this Standard. Proposals to adopt Departures from Standards must be submitted to the National Roads Authority for approval before incorporation into a design layout to ensure that safety is not significantly reduced.

Transition to EN 1317 Standard

1.12 It is intended that harmonised standards for safety barrier products be introduced throughout the European Union in accordance with the Construction Products Directive (89/106/EEC). When published, EN 1317-5 will be the 'harmonised product standard' setting out the requirements for ensuring that safety barrier products conform to the Standard.

1.13 Once a due period has elapsed after the publication of EN 1317-5, all safety barrier products falling within the scope of the Standard must conform.

1.14 During the period between publication and conformity to EN 1317 becoming mandatory, 'transitional arrangements' are permitted, whereby products can be supplied to the existing national standards and specifications as an alternative. This Standard and the associated Series 400 of the Specification for Road Works have been prepared to allow for the transitional arrangements. Accordingly, safety barriers to the designs previously used in Ireland may be used in certain circumstances (see Paragraphs 5/50 and 5/51 and Table 5/7).

2. DEFINITIONS

General

2.1 For clarification, and for the purposes of this Standard, the following terms defined in IS EN 1317-1 apply:-

(a) road restraint system
(b) vehicle restraint system
(c) safety barrier
(d) permanent safety barrier
(e) temporary safety barrier
(f) deformable safety barrier
(g) rigid safety barrier
(h) single-sided safety barrier
(i) double sided safety barrier
(j) terminal
(k) leading terminal
(l) trailing terminal
(m) transition
(n) vehicle parapet.

2.2 In other parts of the NRA Design Manual for Roads and Bridges and in the NRA Manual of Contract Documents for Road Works, the term 'safety fence' is used to describe a deformable safety barrier other than a vehicle parapet. Similarly, the term 'safety barrier' is used to describe a rigid safety barrier other than a vehicle parapet. It should, however, be noted that this Standard follows the terminology of EN 1317, whereby the term 'safety barrier' is used to describe both deformable and rigid barriers as well as vehicle parapets. Nevertheless, as noted above, vehicle parapets are not covered within this Standard.

Safety Barrier System

2.3 A safety barrier system is defined as the complete installation of a length of safety barrier at any location and includes terminals, transitions, support posts, foundations, beams, brackets, bolts and the like.

Hazard

2.4 A hazard is any physical obstruction which may, in the event of an errant vehicle leaving the carriageway, result in significant injury to the occupants of the vehicle. See Chapter 3 for information on hazards and their mitigation.

Summary of EN 1317 Performance Classes

2.5 EN 1317 defines various performance parameters for Safety Barriers, Terminals and Transitions as outlined below. These parameters are described in more detail in the following chapters:

Safety Barriers and Transitions

- Containment Level (N1, N2, etc)
- Impact Severity Level (A or B)
- Working width, (W1, W2, etc.)

Terminals

- Performance Class (P1, P2, etc)
- Impact Severity Level (A or B)
- Displacement Class, (Dx.y)

2.6 The performance parameters for a particular design of safety barrier, transition, etc. are established empirically by full-scale testing of representative samples. Details of the tests are specified in IS EN 1317-2 and Draft prEN 1317-4.

Set-back

2.7 The Set-back is the dimension between the traffic face of the safety barrier and the edge of the road pavement (see Paragraphs 5.14 to 5.17).

Clear Zone

2.8 The Clear Zone is the total width of land on the nearside or offside, within the road boundary, which is to be kept clear of unprotected hazards. This width is available for use by errant vehicles. The zone is measured from the nearest edge of the trafficked lane: i.e. the hard shoulder or hard strip forms part of the Clear Zone (see Chapter 4).

Length of Need

2.9 The Length of Need is the length of a barrier which provides the full level of protection required for a particular hazard. An additional length will normally be required between the start of the Length of Need and the terminal in order for the barrier to reach full performance (see Paragraphs 5.27 to 5.39).

3. HAZARD MITIGATION

General

3.1 Generally, the provision of safety barriers is warranted if the consequences of the vehicle striking the barrier are considered to be less serious than those which would result if the vehicle were to remain unchecked by the barrier.

3.2 Safety barriers may be located in the verge or central reserve depending on the purpose for which they are provided.

3.3 However, safety barriers themselves may be a hazard to traffic and their use should be avoided wherever practicable. In many circumstances, a hazard can be relocated sufficiently far from the road that the protection of a safety barrier is not warranted.

3.4 The three main reasons for installing a safety barrier are:-

a) To minimise injuries to the occupants of vehicles which leave the carriageway;
b) To provide protection to third parties who may otherwise be adversely affected by errant vehicles;
c) To protect property or equipment, damage to which would result in high repair costs and/or instability of a structure.

3.5 This Standard details the requirements and guidance for the provision of safety barriers which will normally satisfy items a) and b) above. In circumstances where item c) is considered to be relevant, a risk assessment shall be undertaken by the Designer and the provision of a safety barrier shall be agreed with the National Roads Authority.

Categories of Hazard

3.6 The general categories of hazards include: side slopes, fixed objects, water and railways etc. In addition, several other conditions require special consideration:

- Locations with high accident histories;
- Locations with pedestrian and bicycle usage;
- Playgrounds, monuments, and other locations with high social or economic value.

3.7 The following paragraphs provide guidance for determining when the main categories of hazard present a significant risk to an errant vehicle. Use of a safety barrier for obstacles other than those described below will require the approval of the National Roads Authority.

Mitigation of Hazards

3.8 Mitigation of hazards is only required if obstructions are within the area which is likely to be traversed by an errant vehicle. This area is termed the Clear Zone and its width is defined in Chapter 4. The Clear Zone does not extend beyond the road boundary but should not be considered as the full extent of travel of an errant vehicle. In some high risk situations, it may, therefore, be necessary to provide a safety barrier to protect a hazard outside the Clear Zone. In such cases, details shall be agreed with the National Roads Authority.

3.9 The possible mitigative measures for hazards within the Clear Zone are listed below in order of preference.

- Remove;
- Relocate;
- Reduce impact severity (e.g. by using a breakaway feature or by setting a culvert flush with the existing ground);
- Shield the object by using redirectional landform, safety barrier, or crash cushion.

Side Slopes

Embankment Slopes

3.10 Embankment slopes can present a hazard to an errant vehicle with the degree of severity dependent upon the slope and height of the embankment. Providing embankment slopes that are 1:5 or flatter can mitigate this hazard. If flattening the slope is not feasible or cost effective the installation of a barrier may be appropriate.

3.11 Table 5/4 in Chapter 5 identifies where safety barriers are required. However, even where Table 5/4 does not require a safety barrier, obstacles on the slope may compound the hazard and thus warrant the provision of a barrier or some other safety feature.

Cut Slopes

3.12 A cut slope is usually less of a hazard than a safety barrier. The exceptions are a slope steeper than 1:2 or a rock cut with a rough face that could cause vehicle snagging rather than providing relatively smooth redirection. The Designer should consider the potential risks and benefits to the motorist of treatment of rough rock cuts located within the Clear Zone. A cost-effectiveness analysis that considers the consequences of doing nothing, removal or smoothing of the cut slope, and all other viable options to reduce the severity of the hazard can be used to determine the appropriate treatment. Some potential options are:

- Redirectional land form;
- Flexible barrier;
- More rigid barrier;

3.13 Individual investigations should be conducted for each rock cut or group of rock cuts and the most cost-effective treatment selected.

Fixed Objects

3.14 Obstructions which comply with IS EN 12767, Passive Safety of Support Structures for Road Equipment – Requirements and Test Methods, and have a maximum Accident Severity Index (ASI) value of 1.0 at the appropriate Speed Class are not considered a hazard.

3.15 The following obstructions within the Clear Zone should be considered as hazards requiring mitigation unless they comply with the above requirements:

- Wooden poles or posts with cross sectional area greater than 22,500mm^2 that do not have breakaway features;
- Non-breakaway (non-frangible) steel posts or supports greater than 150mm diameter tube by 3.6mm thick, or equivalent strength;
- Non-breakaway lighting columns;
- Trees having a girth of 500mm or more measured at 1m above the ground;
- Substantial fixed obstacles extending above the ground by more than 150mm;
- Concrete posts with cross sectional area greater than 15,000mm^2 that do not have breakaway features;
- Drainage items, such as culvert headwalls and transverse ditches.

Trees.

3.16 When evaluating new plantings or existing trees, the maximum allowable girth should be 500mm measured at 1m above the ground when the tree has matured. When removing trees within the Clear Zone, complete removal of stumps is preferred. However, to avoid significant disturbance of the roadside vegetation, larger stumps may be mitigated by grinding or cutting them flush to the ground and grading around them.

Culvert Ends.

3.17 A traversable end treatment should be provided when the culvert end section or opening is on the roadway side slope and within the Clear Zone. This can be accomplished for small culverts by bevelling the end to match the side slope, with a maximum of 150mm extending out of the side slope. A grill may be necessary to provide a traversable opening for larger culverts and should be placed in the plane of the culvert opening when:

a) A single cross culvert opening exceeds 1000mm measured parallel to the direction of travel;
b) Multiple cross culvert openings exceed 750mm each, measured parallel to the direction of travel; or
c) A culvert approximately parallel to the roadway has an opening that exceeds 600mm measured perpendicular to the direction of travel.

3.18 Grills are permitted where they will not significantly affect the stream hydraulics and where debris drift is minor. If debris drift is a concern, options to reduce the amount of debris that can enter the pipe should be considered. Other treatments are extending the culvert to move the end outside the Clear Zone or installing a safety barrier.

Sign Posts.

3.19 Whenever possible, sign supports should be located behind safety barrier installations that have been provided for other purposes. This will eliminate the need for breakaway supports. Sign posts with cross sectional areas greater than the sizes outlined in Paragraph 3.15 that are within the Clear Zone and not located behind a barrier must have breakaway features.

Water

3.20 Water with a likely depth of 0.6 m or more and located with a likelihood of encroachment by an errant vehicle must always be considered a hazard. If the water feature forms part of the design (e.g. a balancing pond), consideration should be given to relocation. In most cases however, it is likely that the feature is existing or cannot be moved and a safety barrier will need to be provided.

3.21 Cut-off ditches close to the road boundary, parallel to the road and not more than 1.2m deep need not be regarded as a hazard in normal circumstances.

Linear Hazards (e.g. Roads and Railways)

3.22 Particular difficulties can be experienced at locations where the road crosses or runs alongside a linear hazard such as a road or railway. In these cases, users of the other road or railway as well as the occupants of an errant vehicle need to be protected. The rules and guidance concerning Clear Zones and Length of Need may not provide sufficient protection to the hazard beneath. Therefore the Designer should undertake a risk assessment to identify the extent and type of safety barrier to be used. The outcome of the risk assessment must be agreed with the National Roads Authority.

3.23 The recommended procedure for linear hazards is:

a) Prepare an initial layout using Clear Zone, Length of Need, etc.;
b) Select the appropriate barrier as a minimum from Table 5/4;
c) Consider if the physical layout of the safety barrier will adequately prevent vehicles from reaching the hazard. (Note: This stage is purely to determine the layout and it should therefore be assumed that vehicles will be arrested by the selected barrier if this is hit.);
d) Undertake a risk assessment to decide whether layout determined in c) above should be adopted and whether the Containment Level should be increased. Consideration should be given, inter alia, to the types and numbers of vehicles using the road, the road geometry, Design Speed and the frequency of use of the linear feature;
e) Agree the proposals with the National Roads Authority.

4. CLEAR ZONE

General

4.1 A primary consideration when designing a road is to minimise the hazards to which the motorist is exposed. As described in Chapter 3 this can largely be achieved by removing the hazards from the immediate roadside through careful design. The width of land which should be kept clear of hazards so as to be available for use by errant vehicles is termed the Clear Zone. Where hazard mitigation is not reasonably practicable, safety barriers will be required.

4.2 The Clear Zone is the total width of land on the nearside or offside, within the road boundary, which is to be kept clear of unprotected hazards. The zone is measured from the nearest edge of the trafficked lane: i.e. the hard shoulder or hard strip forms part of the Clear Zone. The zone does not normally include the boundary fence nor areas of land beyond the road boundary. However, in some circumstances, it may be necessary to consider hazards on or beyond the road boundary.

Zone Width

4.3 Several factors influence the path of a vehicle which leaves the carriageway. The most notable of these are the vehicle speed, the horizontal curvature of the road and the terrain over which the vehicle passes. Table 4/1 indicates the required Clear Zone width for various design speeds and curvatures. However, where the road boundary is closer to the trafficked lane than the relevant width from Table 4/1, the Clear Zone is curtailed at the road Boundary.

4.4 Figures 4/1 and 4/2 indicate the Clear Zone width available with different classes of terrain. Where the ground is reasonably flat (Terrain Class 1), the width of the embankment or cutting slope can be included in the available Clear Zone. Where there is a medium embankment slope (Terrain Class 2), it is considered that a vehicle can cross the slope without overturning but cannot slow down. In such terrain, therefore, the available Clear Zone does not include the width of the slope. Where the slope is steep enough to form a hazard in itself (Terrain Class 3), the available Clear Zone does not extend onto or across the slope.

4.5 Where the required Clear Zone (from Table 4/1 or the width to the road boundary, whichever is the lesser) is not available and clear of hazards, a safety barrier will normally be required.

Terrain Classes

4.6 The Terrain Classes are defined as:

Class 1: Slope is equal to or less steep than 1:5 (falling) or 1:2 (rising).
The area is considered as level terrain.
If the total change in level is less than 0.5m the area can be judged as level terrain regardless of the angle of the slope.

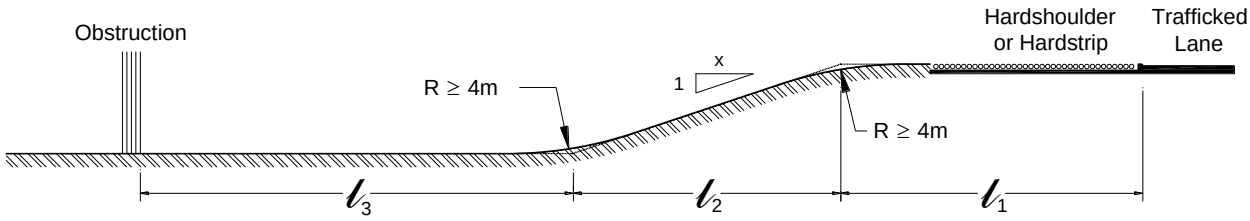
Class 2: Slope is between 1:3 and 1:5 (falling).
It is possible to drive on such a slope without overturning, provided the transition to the slope is rounded off, but vehicles cannot decelerate on the slope. The slope width can be part of the Clear Zone, but can not be included in the determination of the necessary width of the Clear Zone.

Class 3: Slope rises sharply (steeper than 1:2) or falls sharply (steeper than 1:3).
These inclinations present a danger of overturning or sudden halting of the vehicle. These areas are considered hazards if it is not possible to remove the risk in some way.
On falling ground, the width of level ground beyond a slope between 1:3 and 1:2 and which is less than 2m high may be included in the computation of Clear Zone Width. See Category 3a in Figure 4/1.

4.7 A fundamental feature of the concept is to round the top and bottom of the slope such that vehicles do not become unstable as they traverse the embankment or cutting. The slope rounding should generally have a radius of at least 4m.

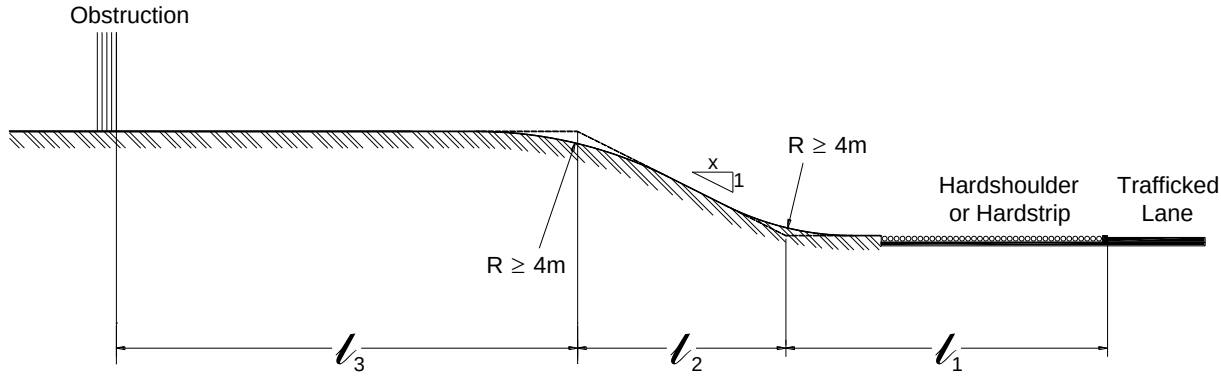
	Design Speed (km/h)		
	85	100	120
Horizontal radius (m)	**Required Width of Clear Zone (m)**		
Inside of bend or Straight	**6.5**	**8.0**	**10.0**
Outside of bend ≥1,000m	6.5	8.0	10.0
" 900m	7.1	8.8	12.4
" 800m	7.7	9.6	14.9
" 700m	8.3	10.4	17.5
" 600m	8.8	11.2	20.0
" 500m	9.4	12.0	
" 400m	10.0	12.8	
" 300m	10.6		

Table 4/1 : Required Clear Zone Width



Embankment or Falling Terrain	Terrain Class	Clear Zone Width
Slope flatter or equal to 1:5	1	$l_1 + l_2 + l_3$
Slope between 1:5 and 1:3	2	$l_1 + l_3$
Slope between 1:3 and 1:2 and <2m high	3a	$l_1 + l_3$
All other slopes between 1:3 and 1:2	3b	l_1

Figure 4/1: Land Included in Clear Zone: Embankments



Cutting or Rising Terrain	Terrain Class	Clear Zone Width
Slope shallower or equal to 1:2	1	$l_1 + l_2 + l_3$
Slope steeper than 1:2	3	l_1

Figure 4/2: Land Included in Clear Zone: Cuttings

5. PERMANENT SAFETY BARRIERS

General

5.1 Safety Barriers should be considered an integral part of the highway alignment design since their position may affect the stopping sight distance and clearance to structures etc. In particular, it will be necessary to ensure that the visibility requirements of NRA TD 9 (NRA DMRB 6.1.1) are not compromised by the presence of safety barriers.

5.2 The introduction of a safety barrier adjacent to the carriageway should only be considered where the elimination of all hazards within the Clear Zone is not reasonably practicable. In such cases, the provision of a safety barrier is mandatory.

5.3 The ideal position of a safety barrier in relation to the edge of the road will depend, inter alia, on the type of device being considered and on the number of hazards being protected. In general, the designer should provide the maximum width of level verge or central reserve in front of the system as possible. This will optimise the opportunity of an errant vehicle regaining control without striking the safety barrier.

EN 1317 Performance Classes

5.4 IS EN 1317-2 defines various performance parameters for Safety Barriers as outlined in Tables 5/1 to 5/3 and Figure 5/1.

Containment Level

5.5 Containment level is an indication of the severity of impact – type, weight and speed of vehicle – which the safety barrier is designed to contain. The standard levels stipulated in IS EN 1317-2 are as shown in Table 5/1.

Containment Level	**Vehicle Impact Test**				
	Test	Impact Speed (km/h)	Impact Angle (degrees)	Vehicle Mass (t)	Vehicle Type
Normal Containment N1 N2	 TB 31 TB 32	 80 110	 20 20	 1.5 1.5	 Car Car
Higher Containment H1 H2 H3	 TB 42 TB 51 TB 61	 70 70 80	 15 20 20	 10.0 13.0 16.0	 Rigid HCV Bus Rigid HCV
Very High Containment H4a H4b	 TB 71 TB 81	 65 65	 20 20	 30.0 38.0	 Rigid HCV Articulated HCV

Note: Barriers with a Containment Level of N2 or higher shall also be subjected to Test TB 11, using a light vehicle (900kg), in order to verify that satisfactory attainment of the maximum level is also compatible for a light vehicle.

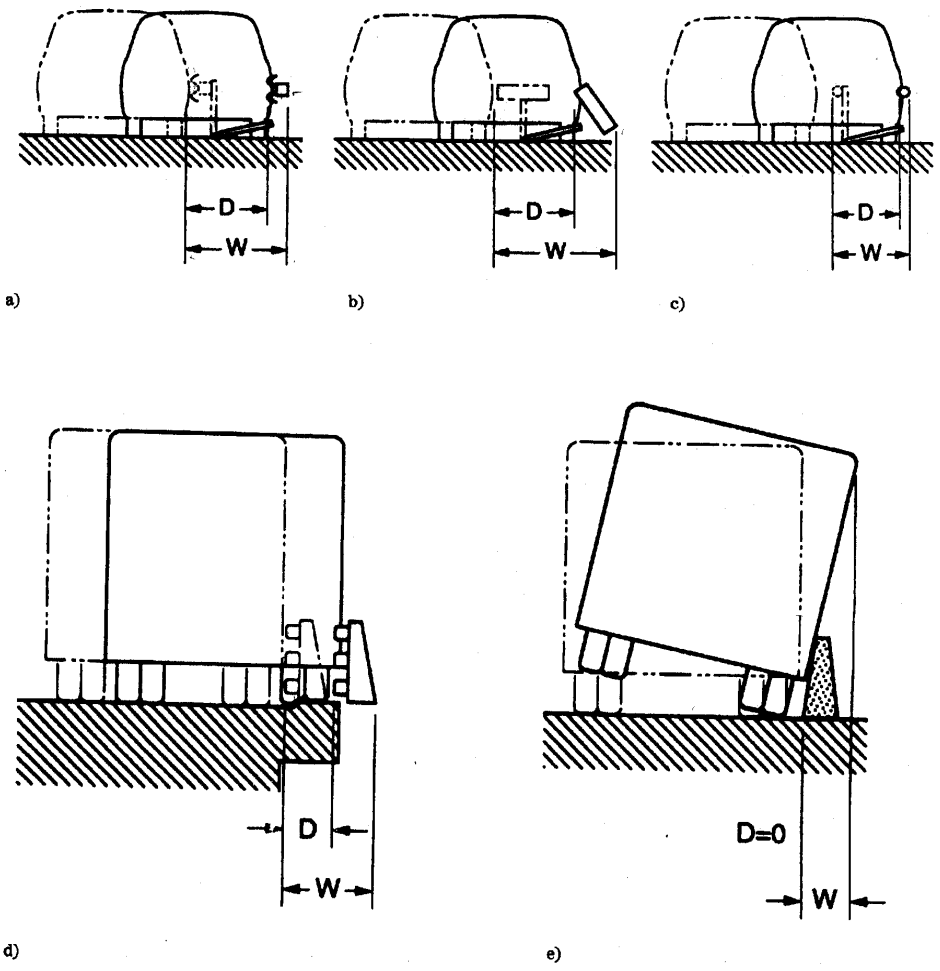
(Source: IS EN 1317-2)

Table 5/1 : EN 1317 Containment Level Tests

Impact Severity Level	Index Values		
	ASI	THIV	PHD
A	≤ 1.0	≤ 33 km/h	≤ 20g
B	≤ 1.4	≤ 33 km/h	≤ 20g

(Source IS EN 1317-2)

Table 5/2 : EN 1317 Impact Severity Levels



(Source: IS EN 1317-2)

Figure 5/1: Dynamic Deflection (D) and Working Width (W)

Impact Severity Level

5.6 Impact Severity Level is measured as a function of the Acceleration Severity Index (ASI), the Theoretical Head Impact Velocity (THIV) and the Post-impact Head Deceleration (PHD). IS EN 1317-2 defines these terms and describes how they should be measured. The two levels given in the Standard are shown in Table 5/2.

5.7 Impact Severity Level A affords a greater level of safety for vehicle occupants than Level B (see Paragraph 5.11).

Working Width

5.8 Working Width (W) is the distance between the side facing the traffic before impact of the safety barrier and the maximum dynamic lateral position under test of any major part of the system. If the vehicle body deforms around the road restraint system, the maximum lateral position of any part of the vehicle shall be taken as an alternative. Examples or Working Width are illustrated in Figure 5/1.

5.9 Working Width is specified as one of the classes listed in Table 5/3.

Class of Working Width	Level of Working Width
W1	≤ 0.6 m
W2	≤ 0.8 m
W3	≤ 1.0 m
W4	≤ 1.3 m
W5	≤ 1.7 m
W6	≤ 2.1 m
W7	≤ 2.5 m
W8	≤ 3.5 m

(Source: IS EN 1317-2)

Table 5/3 : Working Width Classes

Provision Criteria

5.10 On a new roads with a Design Speed of 85km/h or more, a safety barrier shall be provided where there is a hazard within the Clear Zone. At the locations described in Table 5/4, the barrier shall have at least the Containment Level indicated.

5.11 Barriers on verges should have Impact Severity Level A and barriers on central reserves should have an Impact Severity Level no worse than B. However, on central reserves wider than 7.5m, provision of Impact Severity Level A is preferred. The use of Impact Severity Level B on verges shall constitute a Relaxation, for which justification will be required.

5.12 The Designer shall agree the provision of safety barriers with the National Roads Authority where:-

a) the Design Speed is less than 85 km/h, or

b) there are exceptional local hazards or conditions which are not identified in Table 5/4 or which are considered to warrant an increase in the containment level. Account shall be taken, for example, of an unusually high percentage of Heavy Commercial Vehicles in deciding whether to increase the containment level of the safety barrier at any particular location.

5.13 Where a combination of hazards are in close proximity, the highest required Containment Level shall be provided throughout the safety barrier length.

Set-back

5.14 The Set-back is the dimension between the traffic face of the safety barrier and the edge of the road pavement. It should be noted that the road pavement includes any hard shoulder or hard strip.

5.15 The minimum Set-back on a verge shall be 1.2m. This may be reduced to 0.6m if a hard strip or hard shoulder is present or where the road Design Speed is 85km/h or less.

Location		Containment Level
1. Within the Clear Zone:		
Embankments:		
Slope Angle	Slope Height	
Steeper than 1:2 (see Note 1)	≥0.5	**N2**
Between 1:2 and 1:3 (inclusive)	>2m	**N2**
From 1:3 and up to1:5	≥6m	**N2**
Cuttings:		
At steep sided cuttings or earth bunds (steeper than 1:2) within the Clear Zone		**N2**
Verges:		
a) At individual hazards such as bridge piers or abutments, sign posts, gantry legs, non-frangible lighting columns and trees, etc. (see Chapter 3) (see Note 3)		**N2**
b) At substantial obstructions such as retaining walls which present a smooth traffic face for at least 1.5m above the carriageway level		**N2**
c) At underbridges or at retaining walls >0.5m high supporting the road, where a vehicle parapet or vehicle/pedestrian parapet of the required performance class is not provided		**N2**
Central Reserves:		
a) At central reserves up to 7.5m wide		**H2**
b) At central reserves greater than 7.5m wide but not exceeding 15m wide		**N2**
c) At individual hazards such as bridge piers, sign gantry legs, non-frangible lighting columns and trees, etc. (see Chapter 3) (see Note 3)		**H2**
d) Where there are non-frangible lighting columns		**H2**
e) Where the difference in adjacent carriageway channel levels exceeds 1.0m and the slope across the reserve exceeds 1:4		**H2**
Parapets:		
For a minimum of 30m in advance of the approach end of a vehicle parapet or vehicle/pedestrian parapet (see BD 52, DMRB 2.3.3) (see Note 4).		**N2**
2. Beyond the Clear Zone		
Verges:		
a) At locations where an errant vehicle may encroach onto an adjacent road or impact another significant hazard		**H2**
b) At locations where an errant vehicle may encroach onto an adjacent railway		**H4(a or b)**

Notes:

1. The use of 4m radius slope rounding will prevent the development of slopes steeper than 1:2 until the embankment height is greater than 0.85m.
2. This Table provides minimum Containment Levels for particular situations. Higher Containment Levels may be justified in some situations.
3. Where the hazard is not designed to withstand collision loads and where impact may result in injuries to people other than those in the errant vehicle, a higher Containment Level may be required.
4. The Containment Level on the approach shall be equal to that of the parapet or the adjacent safety barrier, whichever is the greater

Table 5/4: Minimum Containment Level

5.16 At central reserves the minimum Set-back shall be 0m (zero) where a hardstrip of width 0.6m or greater is present. If there is no hardstrip present, the minimum Set-back shall be 0.6m.

5.17 The performance of the safety barrier system must not be compromised by the presence of a filter drain, cables or the like close to the barrier foundations. The clear distance required between the barrier and any feature which may affect the safety barrier performance shall be ascertained. Alterations to the Set-back may be required in some circumstances although the minimum Set-back shall never be compromised.

Lateral Positioning

5.18 For normal containment barriers, the Working Width should be **W6** where space is available. However, the Set-back should also be as large as practicable in order to provide the maximum width in which errant vehicles can regain control. Within the limited verge or central reserve widths available with many road cross-sections, it will be necessary to provide a reasonable compromise between a large Working Width and a generous Set-back. It must also be ensured that the detailing of the drainage and services within the verge does not restrict the selection of safety barrier unduly.

5.19 Design decisions regarding the lateral position of the barrier and its Working Width are further complicated by factors such as the barrier Set-back required to achieve the required stopping sight distance. In some cases, additional verge width may need to be provided in order to accommodate a higher Working Width barrier or a larger Set-back.

5.20 For isolated hazards, the safety barrier should be placed as close to the obstruction as possible and hence a small Working Width (normally **W2** to **W4**) should be selected. This provides the maximum available Set-back and maximises the space available for the errant vehicle to be brought under control.

5.21 For high containment barriers with small Working Widths, it is considered preferable to keep the Set-back distance as small as possible as this will minimise the angle of impact and consequently reduce the severity of impact on the occupants of the errant vehicle.

5.22 Where combinations of hazards are to be protected by a single length of safety barrier, the Set-back of the barrier should be established by assessing the obstruction nearest to the road as if this was an isolated hazard. This Set-back should be retained for the remaining obstructions although the Working Width can be varied to suit each obstruction. Changes in Working Width, however, along the length of a barrier are subject to suitable transitions being available.

5.23 Where objects are being protected, the Working Width of the safety barrier must be such that under design conditions the hazard is not impacted. There must also be full headroom in the Working Width zone.

5.24 On embankments, the Working Width specified for the safety barrier shall not allow the traffic face of the barrier, when deflected to the full Working Width, to extend beyond the intersection of the embankment slope and the verge.

5.25 On central reserves, the safety barrier position and Working Width shall be such that under design impact conditions no part will deflect into the opposing traffic lane.

Examples of Safety Barrier Requirements

5.26 Examples of the requirements for safety barriers in typical situations – in terms of Containment Level, Impact Severity Level, Working Width and Set-back – are indicated in Tables 5/5 and 5/6.

Road Type	Grassed Verge Width (m)	Hard Shoulder or Hard Strip	Set-back (m)	Safety Barrier Criteria			Comments
				Contain-ment Level	Impact Severity Level	Working Width	
1. Top of Embankment (1:2, 2m to 6m high							
Standard Motorway or Dual Carriageway	2.0	Yes	0.6 – 0.8	N2	A	W4	Assumes barrier is 100mm wide when deflected (see Note 1)
Wide Motorway or Dual Carriageway; Wide, Standard or Reduced Single Carriageway	3.0	Yes	0.6 – 1.0	N2	A	W6	Assumes barrier is 100mm wide when deflected (see Note 1)
Existing Road	3.0	No	1.2 – 1.4	N2	A	W5	Assumes barrier is 100mm wide when deflected (see Note 1)
Slip Road	4.0	Yes	0.6 – 2.0	N2	A	W6	Assumes barrier is 100mm wide when deflected (see Note 1)
2. At Isolated Obstruction							
Pier	2.0 2.0*	Yes	0.6	N2	A	W4	
Abutment	2.0 4.5*	Yes	0.6 or: 1.1	N2 N2	A A	W5 W4	Working Width limited by encroachment onto face of cutting slope
Existing Pier	2.0 2.0*	No	1.2	N2	B	W2	Impact Severity Level A would be difficult to achieve in such a restricted space

Notes: 1. Traffic face of barrier must not extend beyond the top of the embankment slope (see Paragraph 5.24).
2. * = distance from edge of road pavement to obstruction.

Table 5/5 : Examples of Safety Barrier Requirements on Verges

Barrier Type and Position	Central Reserve Width (m) (see Note 1)	Set-back (m)	Safety Barrier Criteria		
			Containment Level	Impact Severity Level	Working Width
1. Double Sided Barrier					
Barrier 0.6m wide on centreline	2.6	0	H2	B	W4
Barrier 0.8m wide on centreline	2.8	0	H2	B	W5
Barrier 1.0m wide on centreline	3.2	0.1	H2	B	W6
Barrier 1.0m wide on centreline	4.5	0.75	H2	B	W7
Barrier 1.0m wide offset or on centreline	9.0	0.6 - 3.0	N2	A	W7
2. Single Sided Barrier					
At 2.0m wide bridge pier on centreline	9.0	0.6	H2	A or B	W5

Note: 1. Central reserve width includes 2 x 1.0m hard strips.

Table 5/6 : Examples of Safety Barrier Requirements on Central Reserves

Length of Need (LoN)

5.27 The length of safety barrier shall be derived from a detailed consideration of each location. The total length of barrier will normally comprise the Length of Need plus, at each end, the length of the terminal and an intermediate length over which the barrier attains full performance.

5.28 The Length of Need consists of the Approach Length, the length of the hazard and the Departure Length. It is dependent on the location and geometry of the hazard, direction(s) of traffic, design speed, traffic volume, and type and location of safety barrier.

Approach Length

5.29 The calculation of the Approach Length should be made with the consideration that the errant vehicle must not be able to leave the carriageway and get behind the barrier and thereby hit the obstacle. For most situations, the Approach Length can be determined from the use of Figures 5/2 and 5/3 although care must be taken in certain situations such as cuttings. The calculation is based on a typical impact angle of 8^0 but the Approach Length should never be less than 30m.

5.30 For safety barriers which are not flared away from the road, the calculation of Approach Length (AL) is derived from the equation:

$$AL = 7.12(C-H-SB)$$

where:

C = Lesser of distance to rear of hazard or width of Clear Zone
H = Hard shoulder or hard strip
SB = Set-back distance.

5.31 For safety barriers with flares the Approach Length is determined from the following equation:-

$$AL = \frac{C + (L/F) - H - SB}{(1/F) + 0.141}$$

where:
C = Lesser of distance to rear of hazard or width of Clear Zone
H = Hard shoulder or hard strip
SB = Set-back distance
F = Flare Rate (e.g. use 20 if flare is 1:20)
L = Distance from hazard to start of flare.

5.32 Gaps of 100m or less between barrier lengths should be avoided. However, short gaps are acceptable when the barriers are terminated in a cut slope. If the end of the Length of Need is near the end of another barrier, it is recommended that the barriers be connected to form a continuous barrier. Maintenance access should be considered when determining whether to connect barriers.

Horizontal Curvature

5.33 The equations given in paragraphs 5.30 and 5.31 and Figures 5/2 and 5/3 are applicable to all normal road curvatures. For particularly onerous circumstances, the Designer should discuss the provision of a safety barrier with the National Roads Authority.

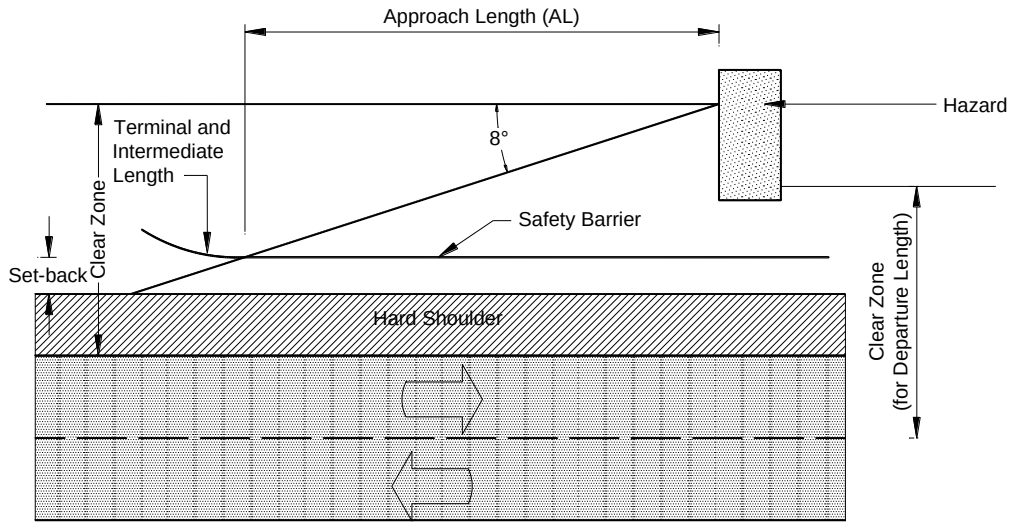
Cuttings and Environmental Bunds

5.34 Cuttings and environmental bunds will not normally require safety barriers unless the slope is severe (>1:2). However, safety barriers may be provided at normal cuttings where there are other hazards, e.g. a bridge abutment. In these cases it is important to ensure that an errant vehicle cannot travel past the terminal section and alter direction such that it can hit the obstacle. Protection of the obstacle could be provided by the use of dense vegetation or gravel beds behind the barrier to provide a deceleration force on the vehicle.

5.35 Terminals should be returned to the cutting face wherever practicable, as this will minimise the risk of end impact by an errant vehicle.

Embankments

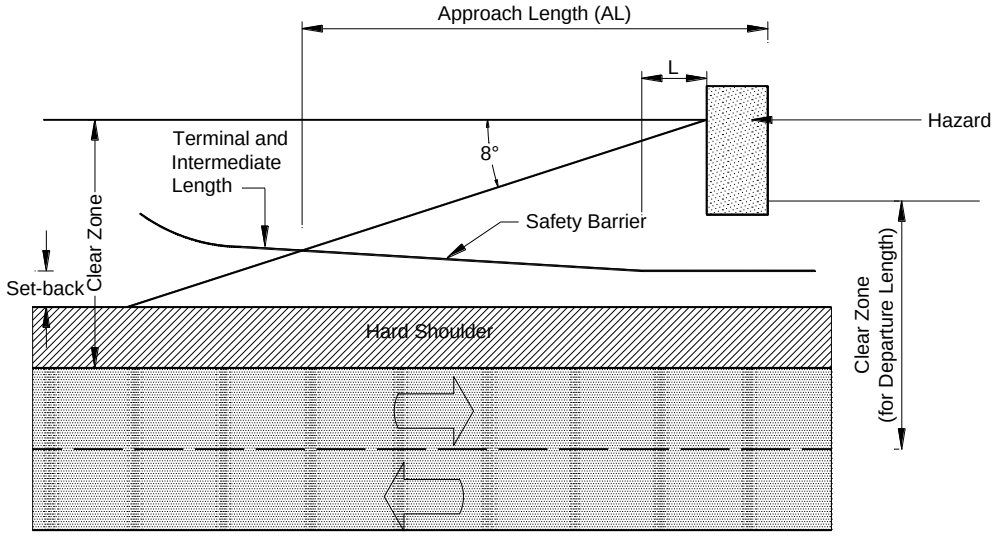
5.36 When designing a barrier for an embankment, the Length of Need begins at the point where the barrier is recommended.



AL = 7.12(C-H-SB)
where:-

C = Lesser of distance to rear of hazard or width of Clear Zone
H = Hard shoulder or hard strip
SB = Set-back distance

Figure 5/2: Determination of Approach Length for Safety Barrier Parallel to Road



$$AL = \frac{C + (L/F) - H - SB}{(1/F) + 0.141}$$

where:
C = Lesser of distance to rear of hazard or width of Clear Zone
H = Hard shoulder or hard strip
SB = Set-back distance
F = Flare Rate (e.g. use 20 if flare is 1:20)
L = Distance from hazard to start of flare

Figure 5/3: Determination of Approach Length for Safety Barrier with Flare

Departure Length

5.37 The length of barrier beyond the hazard is termed the Departure Length and shall generally be determined using the same equations as for the Approach Length. This will normally result in a Departure Length considerable shorter than the Approach Length, as the Clear Zone is determined from a different point.

5.38 For two-way carriageways, the Clear Zone for the Departure Length commences at the divide between the opposing traffic flows (see Figures 5/2 and 5/3). For dual carriageways and motorways, the Clear Zone for the Departure Length commences at the right hand edge of any lane that may be used in a contraflow configuration.

5.39 The Departure Length shall never be less than 15m.

Minimum Length

5.40 An appropriate system must be provided whose minimum length is equal to or less than the length of barrier to be installed, thus ensuring effective operation in service.

Height of Safety Barrier

5.41 Safety barriers shall be set at the height specified for the system, within the specified tolerances. Particular care shall be taken to ensure that the barrier is at the correct height following resurfacing or overlay works.

5.42 Where the Set-back is less than 1.5m, the height of the barriers shall be related to the edge of the road pavement. Elsewhere, the height shall be measured from the general ground level in close proximity to the front of the barrier.

Kerbs

5.43 Kerbs in front of a safety barrier can contribute to the vehicle overturning or ascending the safety barrier. If kerbs in front of the safety barrier cannot be avoided on roads with a Design Speed of 85 km/h or more, the kerbs should be chamfered and not higher than 80 mm.

Flare Rate

5.44 The ends of safety barriers should be flared wherever practicable. There are three functions of the flare:

- To locate the barrier and its terminal as far from the carriageway as is feasible.
- To reduce the Length of Need.
- To minimise a driver's reaction to the introduction of an object near the carriageway.

5.45 It has been shown that an object (or barrier) close to the carriageway may cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so that the driver does not perceive the barrier as a hazard. However, a flare increases the angle at which a vehicle will impact the barrier. A compromise between flare and impact angle is needed. Flares rates steeper than 1:20 should, therefore, not be used.

5.46 The following general principles apply:-

- Vehicles should not be able to pass easily behind the approach flare;
- Anchorages and concrete ramps on central reserves should not be located so they protrude into the deflection space of the opposite fence.

Ground Conditions

5.47 Most safety barrier systems rely on certain ground conditions in order to function satisfactorily. Where this is the case, a test regime, as described in the Series 400 clauses of the NRA Specification for Road Works, shall be established to ensure that the system performs as intended.

In-Situ Concrete Barrier

5.48 The diagrams detailing the In-Situ Concrete Barrier are contained in the NRA Road Construction Details. This barrier design is 900mm in height with a small step 250mm above road surface level. It requires a hardened foundation into which the barrier is rebated.

5.49 This barrier has been approved by the National Roads Authority for use in situations

which require an H2 Containment Level, an Impact Severity Level B and a Working Width of W2.

Safety Barriers Previously in Use

5.50 Until the harmonised product standard of EN 1317-5 comes fully into force (see Paragraphs 1.12 to 1.14), certain safety barriers of types previously specified for use in Ireland may continue to be installed in appropriate circumstances.

5.51 The barriers listed in Table 5/7 have, accordingly, been approved by the National Roads Authority for use in situations which require the criteria noted in the table. Any such barrier must comply with the relevant Clauses of Series 400 of the UK Highways Agency's Specification for Highway Works and the relevant drawings of the UK Highways Agency's Highway Construction Details.

Emergency Crossovers

5.52 Emergency services sometimes need to cross over the central reserve when dealing with an emergency: this normally requires the removal of a section of central reserve safety barrier.

5.53 Most steel beam and post barrier types can be cut and removed relatively quickly using hand power tools. However, with more substantial types, such as most concrete designs, this is not practicable. Therefore, where a barrier type which cannot readily be cut is used in the central reserve, emergency crossovers shall be provided within 1.5km either side of each junction and at intervals not exceeding 4km.

5.54 Emergency crossovers shall be a minimum of 20m long and shall consist either of lengths of safety barrier of a steel beam and post design or of an alternative design which has received the approval of the National Roads Authority for such use. The barriers at the emergency crossovers and their transitions shall have the same required performance criteria as the adjacent lengths of barrier.

Type of Safety Barrier	Ref. Code	Single/Double Sided	Post Spacing (m)	Safety Barrier Criteria		
				Containment Level	Impact Severity Level	Working Width
Tensioned Corrugated Beam (TCB)	TS1	Single	3.2	N2	A	W5
Tensioned Corrugated Beam (TCB)	TS2	Single	1.6	N2	A	W4
Tensioned Corrugated Beam (TCB)	TD1	Double	3.2	N2	A	W6
Tensioned Corrugated Beam (TCB)	TD2	Double	1.6	N2	A	W5
Untensioned Corrugated Beam (UCB)	US1	Single	3.2	N1	A	W6
Untensioned Corrugated Beam (UCB)	US2	Single	1.6	N1	A	W5
Open Box Beam (OBB)	BS1	Single	2.4	N2	A	W4
Open Box Beam (OBB)	BS2	Single	1.2	N2	B	W2
Open Box Beam (OBB)	BSB	Single on brackets fixed to structure	1.2	N2	B	W1
Open Box Beam (OBB)	BD1	Double	2.4	N2	A	W5
Open Box Beam (OBB)	BD2	Double	1.2	N2	B	W4
Open Box Beam (OBB)	BDS	Double with spacers and stiffeners	2.4	N2	A	W5
Double Rail Open Box Beam (DROBB)	DR1	Single	2.4	H1	A	W6
Wire Rope (WR)	WR	Single/Double	3.2	N2	A	W6
Tensioned Rectangular Hollow Section Beam (RHS) (100x100mm)	RH1	Double	3.2	N2	A	W5
Tensioned Rectangular Hollow Section Beam (RHS) (200x100mm)	RH2	Single or Double	3.2	N2	A	W5

Table 5/7: Approved Criteria for Certain Safety Barriers

6. TERMINALS

Definitions

6.1 A Terminal is the treatment of the beginning and/or end of a safety barrier. In addition, it can provide an anchorage for the barrier system.

6.2 A Transition is an interface between two safety barriers of different cross-section or different stiffness. The requirements for transitions are described in Chapter 7.

Types of Terminal

6.3 All safety barriers shall be terminated such that the risk of injury to the occupants of errant vehicles is minimised. For most barriers, appropriate measures will normally take the form of flaring the barrier and terminal away from the road edge and ramping down to ground level.

6.4 Types of terminal include:

a) returning the barrier such that the end is buried in a cutting face or bund;

b) ramping the barrier down to ground level. For steel barriers this often includes a concrete foundation or shaped anchorage block;

c) terminating at a full height terminal or anchorage.

Direct connections to vehicle parapets shall be considered as transitions (see Chapter 7).

6.5 Full height terminals shall not be used where they are exposed to oncoming traffic. Due account shall be taken of the possibility of a vehicle crossing from the opposite lane of a two-way single carriageway road and the possibility that contraflow working will be required at times on a dual carriageway.

Requirements for Terminals

6.6 All terminals shall either:

a) have been approved for use by a national or regional road authority in a member state of the European Economic Area and have been installed successfully in that state. Such approval shall be for use in conjunction with the proposed safety barrier and in an equivalent situation. Evidence of the approval and installation shall be submitted to the National Roads Authority for approval; or

b) comply with the requirements of Draft prEN 1317-4: 1999 for the following performance criteria as described in that document:

Performance Class	P3
Impact Severity Class	A
Lateral Displacement Class	D2.2 unless otherwise specified.

6.7 Evidence of compliance shall be submitted to the National Roads Authority in the form of a full report of a test carried out in accordance with Draft pr EN 1317-4: 1999.

Compatibility

6.8 It must be ensured that the terminal can function adequately in combination with the type of safety barrier it is attached to. In cases where the terminal has not been tested whilst attached to the relevant safety barrier type, evidence will be required of the performance of the combined unit.

7. TRANSITIONS

General

7.1 Transitions are necessary between safety barriers with different Working Width or Containment Level. They may also be required between barriers and bridge parapets.

7.2 A Transition is an interface between two safety barriers of different cross section or different lateral stiffness, where the containment is to be continuous. The purpose of a transition is to provide a gradual change from the first to the second barrier, to prevent the hazard of an abrupt variation. A transition is designed to connect two specified barriers.

7.3 The junction between two barriers having the same cross section and the same material, and differing in the Working Width by no more than one Class, shall not be considered a transition.

7.4 Direct connections between a safety barrier and a vehicle parapet shall be considered as transitions. So too shall expansion joint assemblies.

Transition Between Types of Safety Barrier

7.5 The definitions for Transitions of the Containment Level, Severity Index Level and Working Width are the same as specified in IS EN 1317-2 for safety barriers (see Chapter 5). The Containment Level for the transition shall not be lower than the lower Containment Level, nor higher than the higher, of the two connected barriers. Its Working Width shall not be larger than the larger Working Width of the two connected barriers.

7.6 The design of transitions should be such that changes in Working Width and Containment Level are introduced gradually and evenly along the length of the transition. Additionally the length of the transition should be sufficient to ensure that no significant changes in the dynamic deflection occur over short lengths: a length of at least 10 to 12 times the change in Working Width should normally be provided.

7.7 All transitions shall either:

a) have been approved for use by a national or regional road authority in a member state of the European Economic Area and have been installed successfully in that state. Such approval shall be for use in conjunction with the proposed safety barriers and in an equivalent situation. Evidence of the approval and installation shall be submitted to the National Roads Authority for approval; or

b) comply with the requirements of the impact assessment test criteria specified in IS EN 1317-2 for safety barriers and the critical impact requirements in Paragraphs 7.8 to 7.11. Evidence of compliance shall be submitted to the National Roads Authority in the form of a full test report.

Critical Impact Requirements for Transition to EN 1317

7.8 In order that a transition can be approved for use based on its compliance with Paragraph 7.7b, it must pass two tests, as specified in IS EN 1317-2 for safety barriers, one with a light vehicle for impact severity and another with a heavy vehicle for maximum containment.

7.9 The direction of impact as well as the impact point shall be chosen as the most critical for each test. In general the most critical direction of impact is from the softer to the stiffer barrier. Therefore, the impact direction shall be from the lower containment barrier toward the higher containment barrier, provided the latter has demonstrated the smaller dynamic deflection in the high containment test. If the dynamic deflection of the higher containment barrier is higher than the dynamic deflection of the lower containment barrier, the impact direction for each test shall be chosen by the technical officer responsible for the Test Laboratory, and the justification for such choices shall be recorded in the test report. If the two connected barriers have

the same containment class, the impact direction shall be from the higher dynamic deflection to the lower.

7.10 In general the impact point for the light vehicle shall be at a distance of ¾ of the length of the transition from the beginning of the transition, in the direction of impact. The impact point for the heavy vehicle shall be the midpoint of the transition. In special cases different choices of the critical impact point can be made by the technical officer responsible for the Test Laboratory, and recorded with justification in the test report.

7.11 All the impact test acceptance criteria for transitions are the same as those specified in IS EN 1317-2 for safety barriers.

Removable Barrier Sections

7.12 A Removable Barrier Section not longer than 40m shall be considered a special transition connecting two pieces of the same barrier, installed to allow quick removal and reinstallation. It shall be tested as a single transition.

7.13 A Removable Barrier Section longer than 40m shall be considered a different barrier, connected to the normal barrier by two transitions. The barrier must have passed the two tests specified in IS EN 1317-2 relative to its class. The transition shall be tested as specified in Paragraphs 7.8 to 7.11.

7.14 If the Removable Barrier Section is longer than 40m but shorter than 70m, the barriers shall be tested in the Removable Barrier Section configuration, i.e. with the two transitions installed, and the impact point shall be 1/3 of the Removable Barrier Section length. In this case, the test with a light car (Test TB11 of IS EN 1317-2) on this impact point can be omitted.

7.15 The Containment Level of a Removable Barrier Section can be lower than the Containment Level of the barrier, and the Working Width Class higher.

8 REFERENCES

8.1 Design Manual for Roads and Bridges (DMRB):

Volume 2: Highway Structures: Design (Substructures and Special Structures) Materials:

TD 32/93 (DMRB 2.2.3) – Wire Rope Safety Fence
NRA Addendum to TD 32/93 – Wire Rope Safety Fence.
TD 19/85 (DMRB 2.2) – Safety Fences and Barriers (and Amendment No 1 dated November 1986).
NRA Addendum to TD 19/85 – Safety Fences and Barriers.
BD 52 (DMRB 2.3.3) – The Design of Highway Bridge Parapets.

8.2 Irish and European Standards

IS EN 1317-1, Road Restraint Systems – Part 1: Terminology and General Criteria for Test Methods.

IS EN 1317-2, Road Restraint Systems – Part 2: Performance Classes, Impact Test Acceptance Criteria and Test Methods for Safety Barriers.

Draft prEN 1317-4: 1999, Road Restraint Systems – Part 4: Performance Classes, Impact Test Acceptance Criteria and Test Methods for Terminals and Transitions of Safety Barriers.

Draft prEN 1317-5: 2000, Road Restraint Systems – Part 5: Product Requirements, Durability and Evaluation of Conformity.

8.3 Other Documents

Council Directive 86/106/EEC of 12th December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products. OJ L40, 11.2.1989, European Community.

Highways Agency, Manual of Contract Documents for Highway Works:

Volume 1: Specification for Highway Works.
Volume 3: Highway Construction Details.

IAN 14/98, The Use of Crash Cushions. Highways Agency, London.

IAN 24/98, Use of Temporary Safety Barriers at Road Works. Highways Agency, London.

IAN 26/99, Revised Clearances for Safety Fences. Highways Agency, London.

NRA Manual of Contract Documents for Road Works, Volume 1: Specification for Road Works.

9 ENQUIRIES

9.1 All technical enquiries or comments on this Standard should be sent in writing to:

Head of Project Management and Engineering
National Roads Authority
St Martin's House
Waterloo Road
Dublin 4

……

E O'CONNOR
Head of Project Management and Engineering