Design Manual for Roads and Bridges

Highway Structures & Bridges
Design

CD 378
Impact test and assessment criteria for truck mounted attenuators

(formerly TD 49/07)

Revision 0

Summary
This document contains the requirements for the testing and assessment of truck mounted attenuators (formerly known as lorry-mounted crash cushions (LMCCs)).

Application by Overseeing Organisations
Any specific requirements for Overseeing Organisations alternative or supplementary to those given in this document are given in National Application Annexes to this document.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Feb 2020	CD 378 replaces TD 49/07. This full document has been re-written to make it compliant with the new Highways England drafting rules and to add reference to the newer American guidelines (MASH). The update also introduces additional minimum reporting requirements for the UK tests as a guide to test houses and to ensure a level of consistency in reporting. This document only considers the testing of TMAs, not how they are implemented - this is still covered by Chapter 8 of the Traffic Signs Manual.

Foreword

Publishing information

This document is published by Highways England.

This document supersedes TD 49/07, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This document is a performance-based specification and provides the requirements for the testing and assessment of truck mounted attenuators (TMAs) (formerly known as lorry-mounted crash cushions (LMCCs)) for use in the UK, as referred to in Part 2: Section O5.4.1 of the TSM Chapter 8 2009 [Ref 8.N].

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 2.N] apply to this document.

Mutual Recognition

Where there is a requirement in this document for compliance with any part of a "British Standard" or other technical specification, that requirement may be met by compliance with the Mutual Recognition clause in GG 101 [Ref 2.N].

Abbreviations

Abbreviations

Abbreviation	Definition
ASI	Acceleration Severity Index
ATD	Anthropomorphic Test Device
LMCC	Lorry-mounted crash cushions
MASH	Manual for Assessing Safety Hardware
NCHRP	National Cooperative Highway Research Programme
OIV	Occupant Impact Velocity
ORA	Occupant Ridedown Acceleration
THIV	Theoretical Head Impact Velocity
TL	Test level
TMA	Truck mounted attenuator
w	width of vehicle (excluding wing mirrors)

Terms and definitions

Terms and definitions

Term	Definition
Durability	The ability of a product to maintain its required performance over time, under the influence of foreseeable actions.
Test inertial mass	The mass of the test vehicle and all items (including ballast and test equipment) rigidly attached to the vehicle structure. The mass of an Anthropomorphic Test Device (ATD), irrespective of the degree of restraint, is not included in the test inertial mass.
Test site	Location of the supporting vehicle and truck mounted attenuator (TMA) prior to the test, the approach and exit paths of the impacting vehicle, and the distance in front of the supporting vehicle into which it might roll during the test.
Total test mass	The mass of the test vehicle and all items (including ballast, ATD and test equipment).
Working life	The period of time during which the performance of a product is maintained at a level that enables the product to fulfil the requirements of this document

1. Scope

Aspects covered

1.1 This document is a performance-based specification and provides the requirements which shall be followed for the testing and assessment of truck mounted attenuators (TMAs) (formerly known as lorry-mounted crash cushions (LMCCs)) for use in the UK, as referred to in Part 2, Section O5.4.1 of the TSM Chapter 8 2009 [Ref 8.N].

Implementation

1.2 This document shall be implemented forthwith on all schemes involving truck mounted attenuators on the Overseeing Organisations' motorway and all-purpose trunk roads according to the implementation requirements of GG 101 [Ref 2.N].

1.3 This document shall be read in conjunction with the TSM Chapter 8 2009 [Ref 8.N].

1.4 These requirements shall only apply to new TMA designs being placed on the Overseeing Organisations' motorway and all-purpose trunk roads.

NOTE *TMA products and designs currently being used on the Overseeing Organisations' motorway and all-purpose trunk roads require no additional testing to these requirements.*

Use of GG101

1.5 The requirements contained in GG 101 [Ref 2.N] shall be followed in respect of activities covered by this document.

2. Test requirements

Test laboratory

2.1 All testing shall be carried out by an independent laboratory, accredited to ISO/IEC 17025 [Ref 1.N] which measures, examines, tests or otherwise determines the performance of products within the scope of this document.

Test procedures

2.2 All testing procedures shall be as defined in MASH 16 [Ref 3.N] unless alternative requirements are detailed within this document.

Impact test parameters

Velocity Class 80

2.3 TMAs shall be deemed to meet the requirements of Velocity Class 80 by successfully meeting the requirements of the tests specified in either:

1) test matrix TL2.UK (refer to Table 2.6.1), and/or;
2) clauses 2.4 and 2.5 in this document and/or;
3) clause 2.6 in this document.

2.4 All mandatory tests at test designation TL2 in NCHRP 350 [Ref 5.N] shall be successfully completed, plus an additional 2-51.UK test (refer to Table 2.6.1).

2.5 Any tests designated as being 'optional' within NCHRP 350 [Ref 5.N], for which the test vehicle is defined as a 'pick up', shall also be successfully completed.

2.6 All mandatory tests at test designation TL2 in MASH 09 [Ref 4.N] or MASH 16 [Ref 3.N] shall be successfully completed, plus an additional 2-51.UK test (refer to Table 2.6.1).

2.6.1 Where the optional MASH test number 3-54 has been successfully completed on the TMA, this may be submitted instead of completing the 2-51.UK test.

Table 2.6.1 Test matrix – TL2.UK

UK Velocity Class	Test designation		Impacting car parameters		
			Total test mass (kg)	Impact speed (km/h)	Approach angle and location of impact point
80	TL2.UK	2-50.UK	900	80	head-on centre
		2-51.UK	1500	80	
		2-52.UK	1500	80	head-on centre, 1/3 vehicle width offset
		2-53.UK	1500	80	nose 1/4 vehicle width offset, at 10 degrees

Velocity Class 110

2.7 TMAs shall be deemed to meet the requirements of Velocity Class 110 by successfully meeting the requirements of the tests specified in either:

1) test matrix TL3.UK (refer to Table 2.10), and/or;
2) clauses 2.8 and 2.9 in this document and/or;
3) clause 2.10 in this document.

2.8 All mandatory tests at test designation TL3 in NCHRP 350 [Ref 5.N] shall be successfully completed, plus an additional 3-51.UK test (refer to Table 2.10).

2.9 Any tests designated as being 'optional' within NCHRP 350 [Ref 5.N], for which the test vehicle is defined as a 'pick up', shall also be successfully completed.

2.10 All mandatory tests at test designation TL3 in MASH 09 [Ref 4.N] or MASH 16 [Ref 3.N] shall be successfully completed, plus an additional 3-51.UK test (refer to Table 2.10).

Table 2.10 Test Matrix – TL3.UK

UK Velocity Class	Test designation		Impacting car parameters		
			Total test mass (kg)	Impact speed (km/h)	Approach angle and location of impact point
110	TL3.UK	3-50.UK	900	100	head-on centre
		3-51.UK	1500	110	
		3-52.UK	1500	110	head-on centre, 1/3 vehicle width offset
		3-53.UK	1500	110	nose 1/4 vehicle width offset, at 10 degrees

Approach angle and location of impact point

2.11 The approach angle and location of impact point for the impacting vehicle shall be in accordance with Figures 2.11a, 2.11b and 2.11c below.

Figure 2.11a Head-on centre impact

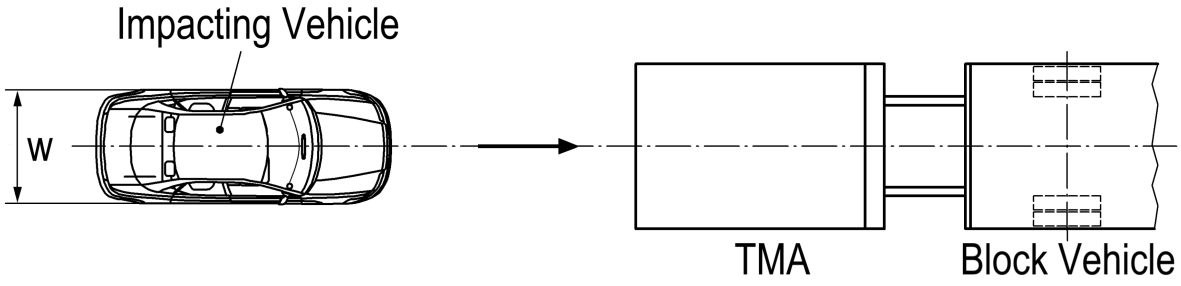


Figure 2.11b Head-on centre, 1/3 vehicle width offset

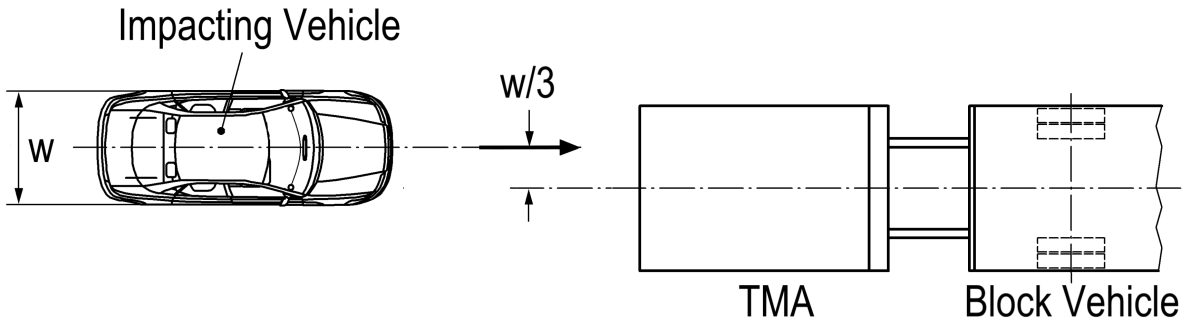
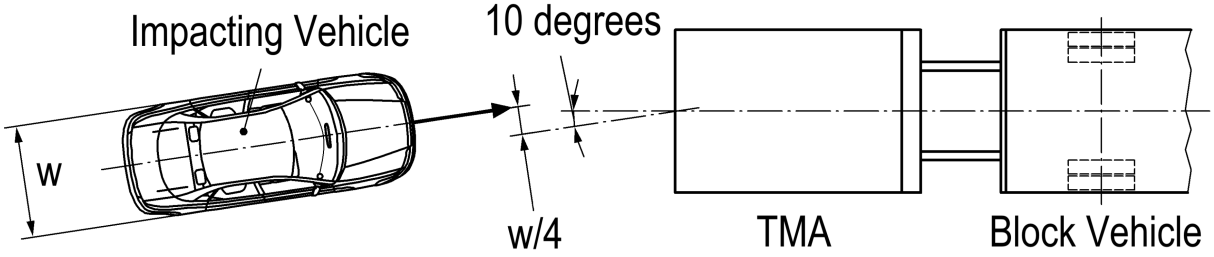


Figure 2.11c Nose 1/4 vehicle width offset, at 10 degrees



Test site

2.12 The test site shall be flat with a gradient not exceeding 2.5% with a level hardened paved surface which is clear of dust, debris, standing water, ice and/or snow at the time of the test.

2.13 Conditions such as a polished surface or a bleeding asphalt surface that could lower the tyre to pavement friction shall not be used at the test site.

NOTE 1 Asphaltic or concrete surfaces are recommended at the test site.

NOTE 2 The area surrounding the test site does not need to meet the requirements for the test site.

2.14 The impacting vehicle shall remain on the test site until it comes to a complete stop.

2.15 The impacting vehicle approach path shall be wholly located on the test site.

2.16 For tests 2-50.UK, 2-51.UK, 3-50.UK and 3-51.UK, an impacting vehicle exit box shall be marked on the test site prior to test.

2.17 The exit box shall consist of a line which is parallel to each of the two longer sides of the TMA, at a distance of 3.0m from the side of the TMA.

Test vehicles

2.18 When testing in accordance with the TL2.UK and TL3.UK test matrices, and/or for the 2-51.UK and 3-51.UK tests, the following shall apply:

1) all impacting vehicles meet the requirements of BS EN 1317-1 [Ref 7.N] and BS EN 1317-2 [Ref 6.N];
2) when testing with a 900 kg vehicle, the ATD is located in the front driver-side seat of the impacting vehicle, and secured by means of the vehicle seat belt;
3) the supporting vehicle has a minimum test inertial mass of 10,000kg;
4) the supporting vehicle is roadworthy;
5) the supporting vehicle is fitted with an automatic brake activation system in accordance with the Appendix 4.2 of the TSM Chapter 8 2009 [Ref 8.N];
6) the supporting vehicle's automatic brake activation system is switched on during the test;
7) the supporting vehicle's gear box is in neutral;
8) the supporting vehicle's parking brake on;
9) the supporting vehicle's engine is off;
10) the supporting vehicle's front wheels have no steering angle, that is, they are not turned to the left or to the right.

3. Reporting requirements

3.1 When testing in accordance with the TL2.UK and TL3.UK test matrices, and/or for the 2-51.UK and 3-51.UK tests, the information detailed below shall be recorded prior to the test, and included in the test report:

1) total mass, dimensions and technical drawings of the TMA;
2) dimensions, make and model of the supporting vehicle;
3) dimensions, make and model of the impacting vehicle;
4) total and test inertial mass of the impacting vehicle;
5) total and test inertial mass of the supporting vehicle (excluding TMA and associated mounting system);
6) total and test inertial mass of the whole system (including TMA and associated mounting system);
7) details of the mounting and/or connection to the lifting frame/connection to the supporting vehicle;
8) drawings of the as-tested item and connection to the supporting vehicle;
9) identification of any details not compliant with the manufacturer's description of the TMA;
10) materials and protective coatings used on the TMA;
11) height from the ground to the structural elements of the TMA;
12) total length of the TMA and supporting vehicle;
13) date of manufacture and serial number of the TMA;
14) test conditions (weather, etc.);
15) condition of the test site (dry, wet, snow);
16) any other details deemed important to the set-up and execution of the test.

3.2 When testing in accordance with the TL2.UK and TL3.UK test matrices, and/or for the 2-51.UK and 3-51.UK tests only, the following shall be included in the test report:

1) impact conditions (impacting vehicle mass, speed and angle);
2) the weight and final location of all totally detached parts of the whole system with a mass greater than 2 kg;
3) a detailed description of the damage/deformation to the TMA;
4) a statement identifying those elements which were energy absorbing during the test;
5) a detailed description of damage/deformation to the supporting vehicle;
6) a detailed description of damage/deformation of the impacting vehicle after impact, including any penetration into the passenger compartment, and/or penetration of the windscreen;
7) the final location of the impacting vehicle with respect to the original centre of the front (impact) face of the TMA;
8) the trajectory and orientation of the impacting vehicle during the test, including whether, or not, the vehicle rolled onto its side;
9) a statement as to whether the impacting vehicle crossed the exit box lines detailed in clause 2.17 (Test site sub section, Section 2);
10) the distance which the supporting vehicle has rolled forwards during the test.

3.3 Where the impacting or supporting vehicle has a secondary impact with another item at the test site, this shall be noted in the test report.

3.4 Any damage to the impacting or supporting vehicle as a result of a secondary impact with another item at the test site shall not be used in the evaluation of the TMA.

4. Assessment criteria

Test pass/fail criteria

4.1 Elements of the TMA shall not penetrate the passenger compartment of the impacting vehicle.

4.2 There shall be no deformations of, or intrusions into, the passenger compartment of the impacting vehicle that can cause serious injuries to the occupants.

4.3 Element(s) of the TMA with a solid mass greater than 2kg shall not become totally detached.

4.4 The impacting vehicle shall remain upright during and after collision.

4.5 The maximum roll and pitch angles of the impacting vehicle shall not exceed 75 degrees.

4.6 After a head-on centre test (approach 50 or 51), the impacting vehicle's post impact trajectory shall not cross either of the exit box lines detailed in clause 2.17 (Test site sub section, Section 2).

Severity indices

4.7 For all tests, the severity indexes ASI and THIV shall be computed using the vehicle instrumentation and calculation procedure contained in BS EN 1317-1 [Ref 7.N].

4.8 The maximum value of ASI shall be reported in the test report to one decimal place.

4.9 The maximum value of THIV shall be reported in the test report with no decimals.

4.10 For tests conducted to NCHRP 350 [Ref 5.N], MASH 09 [Ref 4.N] or MASH 16 [Ref 3.N], the Occupant Ridedown Acceleration (ORA) and Occupant Impact Velocity (OIV) shall also be calculated in accordance with the requirements of the standard to which the TMA was tested.

4.11 The values of ASI, THIV, ORA and OIV shall not exceed the maximum values specified in Table 4.11.

Table 4.11 Impact Severity Values – Car Occupant

Impact Severity Index	Maximum value	Requirement
ASI	1.9	TL2.UK, TL3.UK test matrices and 2-51.UK and 3-51.UK tests only
THIV	44km/h	TL2.UK, TL3.UK test matrices and 2-51.UK and 3-51.UK tests only
ORA	20g	NCHRP 350, MASH 09 and MASH 16 tests only
OIV Lateral and Longitudinal	12m/s (44km/h)	NCHRP 350, MASH 09 and MASH 16 tests only

NOTE *For 'head-on' impacts, THIV is equivalent to OIV.*

5. Durability

5.1 A declaration of the working life for the system shall be obtained from the manufacturer.

NOTE 1 An appropriate measurement of durability could be the in-service inspection of a TMA.

NOTE 2 The working life of an TMA depends upon its inherent durability and the prevailing environmental conditions.

5.2 A clear distinction shall be made between the (declared) working life for a product, based on the assessment of durability in technical specifications, and the actual working life of a product.

NOTE The actual working life of a product depends on many factors beyond the control of the manufacturer, such as installation design, environmental location, handling, use, and maintenance.

5.3 A list of the materials and protective coatings used on the TMA shall be obtained from the manufacturer.

NOTE The list of materials and protective coatings enables the validity of the declared working life to be assessed.

5.4 An assessment of durability (including the identification of technical characteristics of materials affecting durability, and the methods of evaluation) shall be obtained from the manufacturer.

6. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	International Organization for Standardization. ISO/IEC 17025, 'General requirements for the competence of testing and calibration laboratories'
Ref 2.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'
Ref 3.N	American Association of State Highway and Transportation Officials (AASHTO) . MASH 16, 'Manual for Assessing Safety Hardware'
Ref 4.N	American Association of State Highway and Transportation Officials (AASHTO). MASH 09, 'Manual for Assessing Safety Hardware'
Ref 5.N	Transportation Research Board. NCHRP 350, 'Recommended Procedures for the Safety Performance Evaluation of Highway Features'
Ref 6.N	BSI. BS EN 1317-2, 'Road restraint systems. Performance classes, impact test acceptance criteria and test methods for safety barriers including vehicle parapets '
Ref 7.N	BSI. BS EN 1317-1, 'Road restraint systems. Terminology and general criteria for test methods.'
Ref 8.N	The Stationery Office. TSM Chapter 8, 'Traffic Signs Manual Chapter 8 - Road works and temporary situations' , 2009

Highway Structures & Bridges
Design

CD 378
England National Application Annex to CD 378 Impact test and assessment criteria for truck mounted attenuators

(formerly TD 49/07)

Revision 0

Summary
There are no specific requirements for Highways England supplementary or alternative to those given in CD 378.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Highways England team. The email address for all enquiries and feedback is: Standards_Enquiries@highwaysengland.co.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Feb 2020	Highways England National Application Annex to CD 378.

Department for Infrastructure
An Roinn Bonneagair

Highway Structures & Bridges
Design

CD 378
Northern Ireland National Application Annex to CD 378 Impact test and assessment criteria for truck mounted attenuators

(formerly TD 49/07)

Revision 0

Summary
This National Application Annex sets out the Department for Infrastructure, Northern Ireland specific requirements on impact test and assessment criteria for truck mounted attenuators.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated team in the Department for Infrastructure, Northern Ireland. The email address for all enquiries and feedback is: dcu@infrastructure-ni.gov.uk

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Feb 2020	Department for Infrastructure, Northern Ireland National Application Annex for CD 378.

Foreword

Publishing information

This document is published by Highways England on behalf of Department for Infrastructure, Northern Ireland.

This document supersedes TD 49/07, which is withdrawn.

Contractual and legal considerations

This document forms part of the works specification. It does not purport to include all the necessary provisions of a contract. Users are responsible for applying all appropriate documents applicable to their contract.

Introduction

Background

This National Application Annex gives the Department for Infrastructure, Northern Ireland-specific requirements for impact test and assessment criteria for truck mounted attenuators.

Assumptions made in the preparation of this document

The assumptions made in GG 101 [Ref 1.N] apply to this document.

NI/1. Applicability of document

NI/1.1 The requirements of CD 378 shall not apply in Northern Ireland.

NI/2. Normative references

The following documents, in whole or in part, are normative references for this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Ref 1.N	Highways England. GG 101, 'Introduction to the Design Manual for Roads and Bridges'

Highway Structures & Bridges
Design

CD 378
Scotland National Application Annex to CD 378 Impact test and assessment criteria for truck mounted attenuators

(formerly TD 49/07)

Revision 0

Summary
There are no specific requirements for Transport Scotland supplementary or alternative to those given in CD 378.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Transport Scotland team. The email address for all enquiries and feedback is: TSStandardsBranch@transport.gov.scot

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Feb 2020	Transport Scotland National Application Annex to CD 378.

Llywodraeth Cymru
Welsh Government

Highway Structures & Bridges
Design

CD 378
Wales National Application Annex to CD 378 Impact test and assessment criteria for truck mounted attenuators

(formerly TD 49/07)

Revision 0

Summary
There are no specific requirements for Welsh Government supplementary or alternative to those given in CD 378.

Feedback and Enquiries
Users of this document are encouraged to raise any enquiries and/or provide feedback on the content and usage of this document to the dedicated Welsh Government team. The email address for all enquiries and feedback is: Standards_Feedback_and_Enquiries@gov.wales

This is a controlled document.

Contents

Release notes

Version	Date	Details of amendments
0	Feb 2020	Welsh Government National Application Annex to CD 378.