



Published by

RSSB
Block 2
Angel Square
1 Torrens Street
London
EC1V 1NY

© Copyright 2010
Rail Safety and Standards Board Limited

GN

GM/GN2695

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Issue One: December 2010
Rail Industry Guidance Note



Documents

Document Sharing Hub

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Issue Record

Issue	Date	Comments
One	04 December 2010	Original document

Superseded documents

This Rail Industry Guidance Note does not supersede any other Railway Group documents.

Supply

The authoritative version of this document is available at www.rgsonline.co.uk. Uncontrolled copies of this document can be obtained from Communications, RSSB, Block 2 Angel Square, 1 Torrens Street, London, EC1V 1NY, telephone 020 3142 5400 or e-mail enquiries@rssb.co.uk. Railway Group Standards and associated documents can also be viewed at www.rgsonline.co.uk.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Contents

Section	Description	Page
Part 1	Introduction	5
1.1	Purpose of this document	5
1.2	Copyright	5
1.3	Approval and authorisation of this document	5
Part 2	Introduction	6
2.1	Scope	6
2.2	Background	6
2.3	Guidance for rail vehicle applications	7
2.4	Supplementary WSP testing	8
Part 3	Requirements for WSP Testing	9
3.1	BS EN 15595:2009 type test	9
3.2	BS EN 15595:2009 rail vehicle implementation tests	9
3.3	GB good practice tests	9
3.4	GB optional tests	9
3.5	WSP testing decision process	11
Part 4	Adhesion Criteria	12
4.1	Dataset measurement and construction	12
4.2	Naturally occurring variable adhesion (NOVA)	12
4.3	Sustained low adhesion condition (SLAC)	14
4.4	Dry rail adhesion condition (DRAC)	14
4.5	High speed adhesion datasets	14
Part 5	GB Good Practice WSP Testing using Simulators	15
5.1	General	15
5.2	Dry rail tests (simulation validity tests)	15
5.3	NOVA tests	15
5.4	SLAC tests	17
5.5	Rail vehicle speeds above 160 km/h	18
5.6	Example of GB good practice WSP test specification	18
5.7	Application specific simulation tests	18
Part 6	Assessment of GB Good Practice WSP Tests (Pass / Fail Criteria)	19
6.1	General	19
6.2	Wheel lock and wheel damage criteria for NOVA and SLAC tests	19
6.3	WSP reference speed (V_{ref}) for NOVA and SLAC tests	19
6.4	Stopping distance for NOVA tests	20
6.5	Air consumption for NOVA tests	21
6.6	Low brake reservoir pressure for NOVA and SLAC tests	21
Part 7	Optional Tests	22
7.1	General requirements	22
7.2	Sanding	22
7.3	Dynamic brake systems	22
7.4	Wheel spin tests (traction interface)	23
Part 8	Guidance on Supplementary Testing for Traction Units, Freight Vehicles and On-Track Machines	24
8.1	General requirements	24
8.2	Traction units	24
8.3	Freight vehicles	25
8.4	On-track machines	25

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Appendices		26
Appendix A	Tables for Variation of Test Limit with Test Entry Speed	26
Appendix B	Example of a Three Dimensional Adhesion Dataset	28
Appendix C	Example of a Passenger Rail Vehicle WSP Test Specification	29
Definitions		34
References		36
Tables		
Table 1	Low adhesion dataset categories	13
Table 2	Summary of NOVA test conditions	15
Table 3	Example of NOVA sequence table	16
Table 4	Summary of SLAC test conditions	17
Table 5	Example of SLAC sequence table	17
Table 6	Summary of high speed test conditions	18
Table 7	Individual extension values for brake entry speed	20
Table 8	Average extension values for a suite of adhesion datasets and a fixed brake entry speed	20
Table 9	Air consumption ratio	21
Figures		
Figure 1	WSP testing decision process flow chart	11
Figure 2	Adhesion profile comparison between samples of leaf film categories and water diluted detergent film	13

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Part 1 Introduction

1.1 Purpose of this document

The Conventional Rail Locomotives and Passenger Rolling Stock Technical Specification for Interoperability (CR LOC & PAS TSI) [currently awaiting publication] requires the design and verification of wheel slide protection (WSP) equipment to be in accordance with key elements of BS EN 15595:2009. The Euronorm includes requirements for type testing and for rail vehicle implementation tests and identifies the possibility of additional WSP testing specific to the member state.

This document is intended to assist railway undertakings, equipment suppliers, train manufacturers and procurement organisations involved in specifying WSP equipment for rail vehicles intended for operation on Great Britain (GB) mainline network. It does not constitute a recommended method of meeting any set of mandatory requirements.

The principles of the document could be applied to the testing of WSP equipment fitted to non-mainline railway vehicles. However the specific details of the WSP testing would need to be agreed with the relevant railway undertaking.

1.2 Copyright

Copyright in the Railway Group documents is owned by Rail Safety and Standards Board Limited. All rights are hereby reserved. No Railway Group document (in whole or in part) may be reproduced, stored in a retrieval system, or transmitted, in any form or means, without the prior written permission of Rail Safety and Standards Board Limited, or as expressly permitted by law.

RSSB members are granted copyright licence in accordance with the Constitution Agreement relating to Rail Safety and Standards Board Limited.

In circumstances where Rail Safety and Standards Board Limited has granted a particular person or organisation permission to copy extracts from Railway Group documents, Rail Safety and Standards Board Limited accepts no responsibility for, and excludes all liability in connection with, the use of such extracts, or any claims arising therefrom. This disclaimer applies to all forms of media in which extracts from Railway Group Standards may be reproduced.

1.3 Approval and authorisation of this document

The content of this document was approved by:

Rolling Stock Standards Committee on 06 August 2010.

This document was authorised by RSSB on 23 September 2010.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Part 2 Introduction

2.1 Scope

- 2.1.1 This document has been produced to supplement the WSP testing requirements set out in BS EN 15595:2009. It provides guidance for a WSP testing programme to evaluate WSP system performance for use primarily on passenger rail vehicles operating on the GB mainline network with representative GB mainline network adhesion conditions.
- 2.1.2 Parts of this document can also be used to assist in developing WSP testing requirements for traction units, freight vehicles and on-track machines. The principles of the document could be applied to WSP equipment fitted to other rail vehicles.
- 2.1.3 The requirements set out in BS EN 15595:2009 represent the minimum requirements for interoperability and do not reflect the specific requirements of rail vehicles dedicated to a single member state or the topographical requirements of the member state.
- 2.1.4 The guidance in this document is relevant to organisations engaged in the manufacture or specification of WSP systems for new build and for refurbishment programmes of rail vehicles and includes:
 - a) Railway undertakings.
 - b) Train manufacturers.
 - c) Equipment suppliers.
 - d) Procurement organisations.

2.2 Background

- 2.2.1 The Railway Group Standard (RGS) suite of braking standards require the use of WSP systems to minimise wheelset damage and control the increase in stopping distances under low adhesion conditions. The RGS suite of braking standards does not set out any specific performance targets that have to be met by WSP systems.
- 2.2.2 The CR LOC & PAS TSI [currently awaiting publication] requires the design and verification of WSP equipment to be in accordance with BS EN 15595:2009. The verification requirements of BS EN 15595:2009 have been derived from European experience of designing a WSP system based on the characteristics of detergent films. BS EN 15595:2009 permits both track based testing and simulation methods.
- 2.2.3 The performance of a WSP system in Europe has historically been tested and optimised for its type test and homologation using a track based testing methodology. This method employs detergent diluted with water to provide a uniform low adhesion film on the railhead that is readily available and relatively repeatable.
- 2.2.4 The characteristic behaviour of detergent film in the contact patch generates adhesion levels of around 0.06 to 0.08. This is different to that of contaminants that occur naturally on the railhead, for example leaf film can produce low levels of adhesion to less than 0.02. BS EN 15595:2009 does require testing on low and very low adhesion conditions but these are artificially generated to ensure that they are repeatable.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

- 2.2.5 Experience in GB has shown that a WSP system optimised for use with detergent films provides inadequate wheelset control when lower levels of adhesion are encountered. This could lead to wheelset damage and increased stopping distances when compared with systems optimised for operation on low adhesion conditions experienced on the GB mainline network.
- 2.2.6 In recognition of this, existing GB WSP systems have been optimised using a testing method based on simulation of adhesion profiles derived from measurements on leaf film. The experience through research by British Railways and the Adhesion Working Group (AWG) led to the development of a GB good practice specification for testing WSP systems fitted to passenger rail vehicles.
- 2.2.7 BS EN 15595:2009 recognises that additional testing may be required to optimise the performance of the WSP system. This document has been developed from experience gained using the GB good practice specification to optimise WSP performance and to reflect the publication of BS EN 15595:2009.
- 2.2.8 It is recognised that this document has been produced in the context of current technology and that some criteria may need to be revised if future developments occur in the field of railway braking technology.

2.3 Guidance for rail vehicle applications

2.3.1 CR LOC & PAS TSI and BS EN 15595:2009

- 2.3.1.1 The CR LOC & PAS TSI [currently awaiting publication] mandates the design and verification of WSP equipment in accordance with BS EN 15595:2009. The performance testing of WSP equipment for GB applications therefore requires compliance with BS EN 15595:2009 for:
 - a) A new WSP product.
 - b) Application / implementation of a WSP system to a new or retrofit rail vehicle.
 - c) Where there is a significant change to the WSP software.
- 2.3.1.2 BS EN 15595:2009 sets out requirements for type testing and for rail vehicle implementation tests. BS EN 15595:2009 also identifies the possibility of additional testing specific to the member state or route the WSP system is intended to be used over.
- 2.3.1.3 BS EN 15595:2009 was principally published to cover the design and testing requirements for WSP systems that operate in conjunction with the friction brakes fitted to the rail vehicles. For those vehicles fitted with dynamic brake systems BS EN 15595:2009 sets out some additional requirements for the WSP system.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

2.4 Supplementary WSP testing

2.4.1 Supplementary WSP performance testing should be considered for the following reasons:

- a) To optimise the behaviour of the WSP system for the adhesion characteristics of the GB mainline network.
- b) To demonstrate that the optimised WSP system in low adhesion conditions will:
 - i) Minimise the extension of stopping distance.
 - ii) Minimise wheel tread damage.
 - iii) Minimise air consumption.
 - iv) Minimise railhead damage.

Note: The priority assigned to each of the factors is dependent upon the type of rail vehicle on which the equipment is intended to be used, and the design performance of the rail vehicle in terms of the operation and maintenance that is agreed between the railway undertaking, train manufacturer, equipment suppliers and procurement organisation.

- c) To evaluate the implications of other factors that could affect train braking behaviour in low adhesion conditions, for example sanding, dynamic brake.
- d) To monitor and evaluate the behaviour of the signals generated by the WSP system that influences other train systems in low adhesion conditions, for example the traction interface, speedometer, auto-sanding, speed switches.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

Part 3 Requirements for WSP Testing

3.1 BS EN 15595:2009 type test

- 3.1.1 Type test performance limits of BS EN 15595:2009 assume a rail vehicle has been designed to comply with the braking demands and stopping distance criteria consistent with continental Europe, typically as set out in UIC 541-05. These type tests can be satisfied by a combination of track and simulation tests. The type tests assume that the low adhesion is generated by a detergent solution as set out in BS EN 15595:2009.
- 3.1.2 BS EN 15595:2009 section 6.3.1 sets out criteria for simulator testing to replicate the criteria of track testing using a detergent solution. The acceptance criteria set out in BS EN 15595:2009 section 6.3.2 assumes that the simulated adhesion is in the range 0.06 and 0.08.

3.2 BS EN 15595:2009 rail vehicle implementation tests

- 3.2.1 The rail vehicle implementation tests set out in BS EN 15595:2009 specify testing of the WSP system using low adhesion generated by a detergent solution. The acceptance criteria are set out in terms of required stopping distances for a rail vehicle designed to European (formerly UIC 541-05) braking requirements.
- 3.2.2 The performance requirements set out in BS EN 15595:2009 assume that a rail vehicle is designed to European (formerly UIC 541-05) braking requirements. These generally have shorter stopping distances compared to rail vehicles designed to comply with GB mainline network signalling distances. The CR LOC & PAS TSI [currently awaiting publication] recognises this and therefore mandates the verification of the performance of all WSP systems is assessed in accordance with the criteria set out in BS EN 15595:2009 section 6.2.3.
- 3.2.3 BS EN 15595:2009 section 6.2.3 sets out acceptance criteria in terms of a permitted extension in the stopping distance, when braking on the specified detergent film, compared to the stopping distance on normal dry rail.
- 3.2.4 BS EN 15595:2009 section 6.3.3 recognises that additional testing could be required to assess the performance of the WSP system. The GB good practice WSP testing for passenger rail vehicles is an example of this additional assessment to check that the friction braked WSP system has been optimised for GB operating conditions.

3.3 GB good practice tests

- 3.3.1 GB experience shows that rail vehicles operating in GB can experience low adhesion conditions that could be significantly lower than simulated by the detergent solutions set out in BS EN 15595:2009.
- 3.3.2 The supplementary tests for 'good practice' for GB mainline operation are based upon conducting simulation tests on naturally occurring variable adhesion (NOVA) and on sustained low adhesion conditions (SLAC). Both of these conditions represent contamination arising from leaf film and are intended to recreate the range of conditions that could be experienced on the GB mainline network. Some tests are also required on dry rail as part of simulation validation prior to low adhesion testing.

3.4 GB optional tests

- 3.4.1 GB optional tests are intended to evaluate the performance of additional braking systems, low adhesion mitigation systems and the impact that these systems have on the friction braked WSP system in low adhesion conditions. Examples of these systems are dynamic brakes and auto-sanders.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

- 3.4.2 Dynamic brakes and auto-sander systems typically interface with the friction braked WSP system and where this occurs there is an opportunity for these systems to influence the behaviour of the friction braked WSP system.
- 3.4.3 The GB optional tests should consider the impact of the operation of the auto-sander and dynamic brake systems on the friction braked WSP system in terms of:
- a) Their effect on stopping distance.
 - b) The effect upon the stability of the friction braked WSP internal reference speed (V_{ref}).
 - c) Demonstrating that the friction braked WSP system is able to make use of the improved adhesion level (auto-sander).
 - d) Their impact on air consumption as an input to determine the total air capacity requirements on a rail vehicle to deliver an effective braking system.
- 3.4.4 The performance criteria for a dynamic brake WSP system should be consistent with the performance of a friction braked WSP system for low adhesion conditions that could occur on the GB mainline network.
- 3.4.5 The performance criteria for a WSP controlled sanding system should be such that the sanding system demonstrates an improvement in stopping distance without causing any instability in the friction braked WSP control for the dynamic / friction braked systems.
- 3.4.6 A sudden increase in adhesion at the wheel / rail interface could cause instability in the friction braked WSP system control and increase air consumption. This instability can be further exacerbated on GB multiple units where sand is delivered ahead of the third wheelset on the leading vehicle. The friction braked WSP system on the leading vehicle should be capable of controlling the braking forces on the leading pair of wheelsets running on low adhesion whilst permitting higher braking forces on the wheelsets running on improved adhesion after sand has been delivered.
- 3.4.7 Optional testing of the dynamic brake / auto-sander should recreate as much of the system functionality as is practicable for testing purposes. This is particularly important for dynamic / friction braked blending in low adhesion conditions.
- 3.4.8 If the dynamic brake control algorithm in low adhesion conditions is poorly optimised it could result in increased stopping distances and an increased potential for wheelset lock-up. A dynamic brake typically controls wheels in pairs (bogie level) or at vehicle level. The response time of the dynamic brake is typically faster than the friction braked system, however a friction braked WSP system generally uses individual wheelset control which provides better braking performance.
- 3.4.9 Poor blending of the dynamic brake control and the friction braked WSP system control could in some cases significantly delay the onset of the friction brake in low adhesion conditions. This would give rise to increased stopping distances and wheel damage. This is particularly the case if the dynamic brake control permits a deep slide to occur prior to transferring control to the friction braked WSP system.

Guidance on Testing of Wheel Slide Protection Systems Fitted on Rail Vehicles

- 3.4.10 Auto-sanders have been fitted to most GB multiple units and are configured to operate in conjunction with the friction braked WSP system when low adhesion conditions are detected to deliver sand. The delivery of sand will generate an increase in adhesion for the wheelsets after the active sander and thereby should permit higher levels of braking performance.

3.5 WSP testing decision process

- 3.5.1 The WSP testing decision process that should be undertaken for WSP system performance testing for use on the GB mainline network is shown in Figure 1.

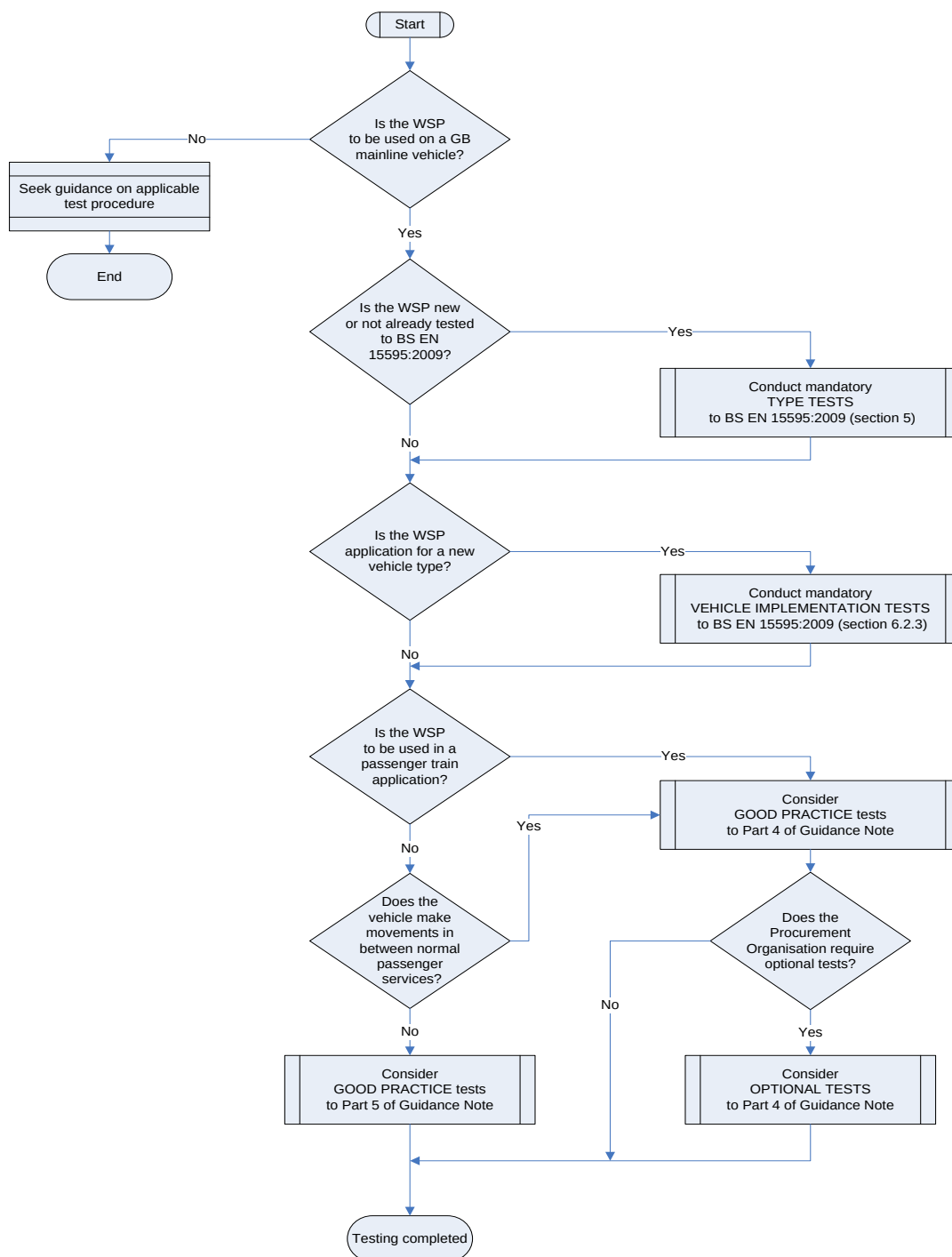


Figure 1 WSP testing decision process flow chart